COST-BENEFIT ANALYSIS OF SEDIMENT MANAGEMENT IN SUTAMI DAM, EAST JAVA, INDONESIA

DIDIK ARDIANTO

UNIVERSITI TEKNOLOGI MALAYSIA

COST-BENEFIT ANALYSIS OF SEDIMENT MANAGEMENT IN SUTAMI DAM, EAST JAVA, INDONESIA

DIDIK ARDIANTO

A Thesis submitted in fulfillment
of the requirements for the award of the degree of
Master of Science (Construction Contract Management)

Faculty of Built Environment
Universiti Teknologi Malaysia

JULY 2011

To my beloved wife and daughter

Thank you for being wonderful to me

ACKNOWLEDGEMENT

Alhamdulillah I prayed to Allah SWT, because only upon His mercy and grace, this thesis can be completed. Greetings and Shalawat, I wish upon the Prophet Muhammad, may his Shafa'at help us.

In preparing this thesis, I was in contact with many people, academicians and practitioners. They have contributed towards my understanding and opinion. In particular, I am sincerely grateful to my project supervisor, Associate Professor Dr. Fadhlin Abdullah, for the encouragement, critics and guidance throughout my thesis writing. I am also very thankful to all lecturers for their support and advice.

I am truly indebted and thankful to the Ministry of Public Works and Perusahaan Umum Jasa Tirta I for giving me an opportunity to enhance my knowledge in Universiti Teknologi Malaysia. In particular, I would like to show my gratitude to all officers in BP Konstruksi Dep. PU, Board of Directors of Perum Jasa Tirta I, Ir. Adi Santoso Dipl. HE., Drs. Syaiful Hidayat and Kuswinoto, SE., for supporting me during my study in UTM. It is a great pleasure to thank to everyone; however, it is not possible to list all of them in this limited space.

I would also thankful to my fellow postgraduate students, especially the fifteen students from Indonesia, for the support and encouragement during this year. Last but not least, I am grateful to "Keluarga Blimbing" and "Keluarga Sentani" for boosted me morally. Love U all.

ABSTRACT

The impacts of global climate change (i.e. floods, sedimentation, etc.) have been recognized as the main threat of the sustainability of water resources infrastructures (i.e. dams, barrages, etc.). In the basin level, reservoir is the most susceptible infrastructure to the impacts, particularly to sedimentation. It will progressively reduce the reservoir storage and in many cases threatens the economic life of reservoir. Sediment management is one of the techniques to enhance the economic life of reservoir. However, most of sediment management projects were conducted based upon the necessity to remove the sediment only 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 study aims to determine the economic feasibility of sediment management project in Sutami dam by using the Cost-Benefit Analysis. Based upon several secondary data and assumptions, five (5) possible project alternatives were simulated in this study. The differences among those projects are on the method of sediment disposal and the volume of sediment dredged. The analysis found that among those alternatives, the most desirable project is alternative project 2, whereby 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 sufficiently recover by the benefits gained. A basic framework of the Cost-Benefit Analysis application in sediment management has been developed in this 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.

TABLE OF CONTENTS

LIST OF TABLES

LIST FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The Intergovernmental Panel on Climate Change (IPCC) on their 4th Assessment Report has presumed water to be the main instrument through which early climate change impacts will be suffered by human, environments and economics (Bates, Kundzewicz, Wu, & Palutikof, 2008). The predicted impacts of climate change on water resources include the prediction of much greater hydrological variability, more floods, longer and more severe droughts, storms, glacial melt, greater evapo-transpiration, and also increasing heavy precipitation events. Those impacts will significantly increase the probability of landslide, erosion and also sedimentation in the river basin. The functions and operations of existing water infrastructure will be affected.

Indonesia which is one of the largest archipelagos in the world has over 17,000 islands spreading along 6,400 km from Sabang in Sumatera island until Merauke in Papua island and located between two continents – Asia and Australia/Oceania. This makes Indonesia as one of the most changing geological region in the world. The surface water in Indonesia is supplied by more than 5,000 rivers. The annual rainfall intensity in Indonesia is approximately 2,500 mm/year, with more than 75 percent of it occurs during October until March (Rammu, 2004). Unfortunately, the watersheds conditions in most places in Indonesia suffer badly from excessive soil erosion, deforestation, uncontrolled land conversion, and declining land productivity. Without an appropriate climate change adaptation plans, Indonesia is highly vulnerable to climate change (Hayes, 2010).

The Indonesian National Action Plan Addressing Climate Change prepared by Ministry of Environment, has identified the following sectors as most at risk: water resources; agriculture; coastal, marine and fisheries; infrastructure; health; forestry and biodiversity. The Plan then describes briefly what needs to be done to increase resilience (and thereby reduce risk) in each sector (Hayes, 2010). According to Indonesia Adapting to Climate Change website, the Government of the Republic Indonesia has proposed short-term and long-term respond actions of climate change adaptation on water resources, which is aimed to directly control land and water use, as well as to enhance the water resources management. Other adaptation actions include projects to maintain flood plains (including reservoir's sediment removal), watershed protection, river channels restoration, and reduce water pollution (Susandi, 2010).

Related to the economics perspective of water resources projects, Kuiper (1971) stated that the economic studies in the field of water resources development (as a part of the climate change adaptation) may be divided into two broad categories, which are the micro-economics study and the economics of project evaluation. However, it is rather difficult to evaluate or analyze, in economic terms, the feasibility of those adaptation projects, due to its nature as a non-profit project. The determination of its social benefit and then comparing it with the project's cost are considered as the key step to evaluate the project's feasibility.

One of the tools that can be used to solve the problem is by performing the Cost-Benefit Analysis (CBA). CBA has been known as an economic analysis method that generally engaged to social projects because the merits and demerits of the project are defined in terms of social gain and detriment (Dasgupta & Pearce, 1978). Zerbe Jr & Bellas (2006) in their research noted that CBA may assign a financial value to each inputs and each output resulting from the project. Relevant with the Dublin Statement of the International Conference on Water and the Environment (ICWE) in 1992, which is stated that "water has an economic value in all its competing uses and should be recognized as an economic good", CBA can also

presumes that each good that have value to people can be measured or mapped into monetary values (Zerbe Jr & Bellas, 2006)

1.2 Problems Statement

The Brantas river basin, one of the biggest river basin on the Java Island, is situated between 110^{O} 30' and 112^{O} 55' East Longitude and 7^{O} 01' and 8^{O} 15' South Latitude. It covers an area of about 11,800 km^2 (which includes six (6) municipalities (Batu, Malang, Blitar, Kediri, Mojokerto, and Surabaya) and nine (9) regencies (Malang, Blitar, Tulungagung, Trenggalek, Kediri, Nganjuk, Jombang, Mojokerto, and Sidoarjo) (Rammu, 2004; Perum Jasa Tirta I, 2010).

The Brantas river basin geological formation is comprised of Pleistocene and Neogene Tertiary with various volcanic materials (Rammu, 2004). The area has two active volcanoes, which are Mt. Semeru (3,676 m) to the East, and Mt. Kelud (1,724 m) at the middle of the basin. Mt. Semeru erupts continuously and produces pyroclastic flow frequently in the southern slope. Mt. Kelud erupted five times in the twentieth century an average of once every 15 years, and the average amount of erupted materials was predicted at 200 million m^3 per eruption and becomes the major source of sedimentation in reservoirs within the basin (Rammu, 2004).

Sutami Dam (also known as Karangkates Dam) is the biggest reservoir within this basin. The multipurpose dam was built from 1962 until 1972, with an initial gross storage of 343 million m^3 and effective storage of 253 million m^3. Besides its main purpose for flood control, the dam also provides services for power plant, raw water for irrigation, municipal and industrial water supply, fisheries and tourism (Perusahaan Umum Jasa Tirta I, 2010). Unfortunately, due to the sedimentation, according to the last storage measurement in 2009 done by Perusahaan Umum Jasa Tirta I (PJT I), the gross storage of the Sutami Dam has decreased to 165.45 million

m^3 (or 48.24 percent from its initial gross storage) and the effective storage decreased to 141.16 million m^3 (55.8 percent from its initial effective storage). This situation will be at risk considering the impact of global climate change on water resources, such as flood, drought, etc.

In line with the national adaptation on climate change proposed by the Government, PJT I, as a state owned company that is obligated for the operation and maintenance of water resources infrastructures in Brantas river basin, has done several sediment management approaches, both vegetative (i.e. reforestation, reboisation, etc.) and civil approaches (i.e. reservoir dredging, gully plugs, etc.) to cope with the problem. Generally, these approaches were conducted based on the necessity to reduce the sedimentation rate in reservoir; therefore, most of the approaches are technical-based project. However, in the perspective of construction economics, there is a problem in analyzing the economic feasibility of these sediment management projects, since the project is a "non-monetary profit" project. The profit of the sediment management project usually are non-monetary benefit, such as for flood control, irrigation, higher production of power plant, etc., makes it difficult to evaluate the feasibility of the technical approach. Moreover, if there are several alternatives of sediment management approaches, problem will arise in selecting the most feasible project to be done, in terms of economic perspectives.

From the above discussion, the main question that arises related to the economics of sediment management is "How to determine the feasibility of reservoir sediment management approaches, which is a non-monetary profit project, in terms of economic perspectives?"

Therefore, a study on the use of CBA for a "non-money profit" project, such as sediment management, is necessary to determine the feasibility of the project itself. Furthermore, this study can be used by the water resources manager as a decision support tools to decide the appropriate sediment management in Sutami Dam.

1.3 Objectives of the Study

The objectives of the study are:

1. To determine the most feasible sediment management alternatives in Sutami Dam by using the CBA method.

2. To develop a basic framework of decision making analysis in determining the most desirable sediment management alternatives.

1.4 Scope of the Study

The scope of this study is limited to the following:

1. The scope of the study is Sutami Dam located in East Java Province, Indonesia.

2. The sediment management discussed in this study focus on the current sediment management project conducted in Sutami dam, which is using the hydraulic sediment removal methods.

3. The costs and benefits discussed in this study are limited only on the tangibles and those directly caused by the project, which are:
   a. Cost elements, that is incurred from:
      - The project costs
      - Additional equipments costs
      - Additional land acquisition costs
   b. Benefit elements, that is resulted from:
      - Reservoir's flood control
      - Energy generation from hydropower plant
      - 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:
   a. The method of disposal, whether using off-stream disposal method or riverine disposal method.
   b. The volume of sediment dredged

1.5 Significance of the Study

One of the most important roles of a project manager is to ensure the project stays within the quality target, time performance and budget allocation. This indicates the importance of an equal determination of technical and economic approaches in a project. However, most of the sediment management projects were conducted based upon the necessity to remove the sediment only without considering the profitability of the project. This makes the technical approach is more dominant in such projects.

This condition may bring some consequences to the project itself, either it is budget related problems or non-appropriate project selection. This shows the paramount importance of economic approach in technical projects whereby it can be used to ensure the accountability of the project, as well as to alleviate a rational comparison of available alternatives.

Most of sediment management projects were categorized as “non-monetary profit” projects, whereby it is difficult to assess the accountability and profitability, in monetary terms, of such project. This study discusses the use of CBA as an economic approach in sediment management project in Sutami dam, in a purpose to answer those difficulties. By having this approach, the sediment management project

will be more accountable, the profitability of such project will also can be analyzed, and the important part is that it can also be used by the water resources manager to choose the most desirable project of the available project alternatives.

1.6 Thesis Organization

Chapter 1 will present the introduction of the study. This chapter will focus on the background of the study, the issues related to the research problem, the objectives of the study, and the scope and limitation of the study.

Chapter 2 will present the literature review by analysis of relevant matters from previous literatures and studies. This chapter will provide the basic concepts of the study, which will be used as the basis of the analysis.

Chapter 3 will present the methodology to be used in this study.

Chapter 4 will discuss the problems, the alternatives approaches and the analysis based on the relevant basic concepts as presented in chapter 2.

Chapter 5 will present the conclusion of the analysis discussed in chapter 4 and this chapter will also present suggestions drawn from the whole study.

REFERRENCES

Agudelo, J. I. (2001). *The Economic Valuation of Water: Principles and Methods*. Delft: IHE Delft.

Bates, Bryson, Kundzewicz, Zbigniew W., Wu, Saohong, Palutikof, Jean. (Eds.) (2008) *IPCC Technical Paper VI: Climate Change and Water*. Geneva: Intergovernmental Panel on Climate Change.

Brouwer, Roy and Pearce, David (Eds.) (2005) *Cost-Benefit Analysis and Water Resources Management*. Cheltenham: Edward Elgar Publishing Limited.

Briscoe, J. (2005). Water as an Economic Good. In Brouwer, Roy and Pearce, David (Eds.) *Cost-Benefit Analysis and Water Resources Management* (pp. 46 – 70). Cheltenham: Edward Elgar Publishing Limited.

Boardman, Anthony E., Greenberg, David H., R. Vining, Aidan, and Weimer, David L. (2006) *Cost-Benefit Analysis Concepts and Practice, Third Edition*. New Jersey: Pearson.

Dasgupta, Ajit K., and Pearce, D.W. (1978) *Cost-Benefit Analysis Theory and Practice*. Hong Kong: The MacMillan Press Ltd.

Dei-Tutu, Viewu Afua. (2002). *Flood Hazards, Insurance, and House Prices – A Hedonic Property Price Analysis*. Research Paper. East Carolina University.

Dubgaard, Alex, Kallesoe, Mikkel F., Petersen, Mads L., Ladenburg, Jacob. (2002). *Cost-Benefit Analysis of the Skjern River Restoration Project*. Research Paper. Copenhagen: Royal Veterinary and Agricultural University.

Hamby, D. M. (1994). A Review of Techniques for Parameter Sensitivity Analysis of Environmental Models. In *Environmental Monitoring and Assessment 32* (pp 135 – 154). Netherlands: Kluwer Academic Publisher.

Hayes, Adrian C. (2010). The Governance of National Climate Change Adaptation Startegies: An Indonesian Case Study. *Conference on Democrating Climate Governance*. 15-16 July. Australian National University.

Hearn, Katherine., Flander, Jon., and Phillips, Tamzin. (2002). *Sediment Management and Dredging in Lakes*. Cirencester: The National Trust.

Indonesia (2004). *Undang-Undang tentang Sumber Daya Air*. UU. No. 7/2004.

Indonesia (2008). *Peraturan Pemerintah tentang Pengelolaan Sumber Daya Air*. PP. No. 42/2008.

Indonesia (2010). *Peraturan Pemerintah tentang Perusahaan Umum (Perum) Jasa Tirta I*. PP. No. 46/2010.

Kenney, Douglas S. (Ed.) (2005). *In Search of Sustainable Water Management*. Northampton, MA: Edward Elgar.

Kuiper, Edward. (1971) *Water Resources Project Economics*. London: Butterworths

Morris, Gregory L., and Fan, Jiahua (1998) *Reservoir Sedimentation Handbook*. New York: McGraw-Hill.

Nippon Koei Co. Ltd. (2005). *Engineering Studies for The Brantas River and Bengawan Solo River Basins*. Jakarta: Nippon Koei

Nor Azliza binti Akbar. *Flood Damage Assessment Model Using Cost-Benefit Analysis*. Master Degree. Thesis. Universiti Teknologi Malaysia: 2006.

Oehy, Ch. D., and Schleiss, A.J. (2004). Management of Reservoir Sedimentation Due To Turbidity Currents By Technical Measure. In Yazdaandoost and Attari (Eds). *Hydraulics of Dams and River Structures* (pp. 263 – 270). London: Taylor & Francis Group.

Perusahaan Umum (Perum) Jasa Tirta I and Cap-Net (2010). *The Financing of Water Resources Management in the Brantas and Bengawan Solo River Basins Indonesia*. Malang: Perum Jasa Tirta I.

Project Management Institute (2008). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fourth Edition.* Atlanta, GA: Project Management Institute Inc.

Rammu, Kikkeri V. (2004). *Brantas River Basin Case Study Indonesia* – Background Paper. World Bank.

Russell, Clifford S., and Baumann, Duane D. (Eds.) (2009) *The Evolution of Water Resource Planning and Decision Making*. Cheltenham: Edward Elgar Publishing Limited.

Slob, A.F.L., Eenhorn, J., Ellen, G.J., Gomez, C.M., Kind, J., and van der Vlies, J. Costs and Benefits of Sediment Management. In Owens, P. N. (Ed) *Sustainable Management of Sediment Resources: Sediment Management at the River Basin Scale* (pp. 175 – 197). Amsterdam: Elsevier B.V.

Snell, Michael (1997). *Cost-Benefit Analysis for Engineers and Planners*. London: Thomas Telford Services Ltd.

Susandi, Armi (2010). National Adaptation Strategy for Climate Change. *International Workshop on: Methods and Tools for Water-Related Adaptation to Climate Change and Climate Proofing*. 8 – 9 March. Bandung.

Treasury Board of Canada Secretariat. (1998). *Benefit-Cost Analysis Guide*. Ottawa: Treasury Board of Canada Secretariat.

U.S. Department of Interior - Bureau of Reclamation (2006). Erosion and Sedimentation Manual. Denver: USBR

Yeoh, J. S., Loveless, J. H., and Siyam, A. M. (2004). New Approach in Determining Useful Life of Reservoirs. In Yazdaandoost and Attari (Eds). *Hydraulics of Dams and River Structures* (pp. 263 – 270). London: Taylor & Francis Group.

Young, R.A., (2005). Economic Criteria for Water Allocation and Valuation. In Brouwer, Roy and Pearce, David (Eds.) *Cost-Benefit Analysis and Water Resources Management*. Cheltenham: Edward Elgar Publishing Limited.

Valiant, Raymond. *Nilai Manfaat Air dan Tarifikasi Layanan Air di Daerah Aliran Sungai (DAS) Kali Brantas*. Master Degree. Thesis. Universitas Brawijaya: 2007.

White, Rodney (2001) *Evacuation of Sediments From Reservoir*. London: Thomas Telford Ltd.

Zerbe Jr., Richard, and Bellas, Allen S. (2006) *A Primer for Benefit-Cost Analysis*. Cheltenham: Edward Elgar Publishing Ltd.