ECONOMIC ANALYSIS OF ENVIRONMENTAL IMPACTS FOR THE APPRAISAL DECISION OF ODA PROJECTS: A CASE STUDY OF A KOREAN EDCF DAM PROJECT

By

KIM, Kihwan

THESIS

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KDI School of Public Policy and Management

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Committee in charge:

Professor Baran HAN, Supervisor ______________

Professor Sungsu CHOI ______________

Professor Kye Woo LEE ______________

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ABSTRACT

ECONOMIC ANALYSIS OF ENVIRONMENTAL IMPACTS FOR THE APPRAISAL DECISION OF ODA PROJECTS: A CASE STUDY OF A KOREAN EDCF DAM PROJECT

By

Kihwan Kim

This research aims to check that how valuation of socio-environmental impacts in a cost-benefit analysis (CBA) affects the investment decision of official development assistance (ODA) project. A dam construction project gives significant impacts to the surrounding sites. The assessment of the impacts is important because it can save potential ex-post costs to prevent any opposition and enhance aid effectiveness from the incurred overrunning costs of large dam projects. With conventional CBA for direct costs and benefits, indirect impacts such as biodiversity losses are quantified by revealed references and inserted into the CBA. The alternative case is analyzed if it deserves to be invested, and compared with the original case. Together sensitivity analyses are performed with NPV, B/C Ratio, and EIRR. As a result, both of the cases indicate that the project is economically feasible. Although environmental costs reduce the net benefit, the sales benefit is strong enough to promote the project, which is sensitive to the benefit. If all the indirect variables are additionally valuated in the CBA and incorporated with other methods including the environmental impact assessment (EIA), the project decision could be made more accurately. Now it is inevitable to apply the adjusted CBA to fully understand the reality.

Keywords: Cost-Benefit Analysis, Environment, Economic Analysis, Net Present Value, Benefit-Cost Ratio, Economic Internal Rate of Return

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AMDAL	Analisa Mengenai Dampak Lingkungan (Environmental Impact Assessment)
B/C Ratio	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CEA	Cost-Effective Analysis
CIF	Cost Insurance and Freight
DAC	Development Assistance Committee
EDCF	Economic Development Cooperation Fund
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
F/S	Feasibility Study
FAO	Food and Agriculture Organization
FIRR	Financial Internal Rate of Return
FOB	Free on Board
GIS	Geographical Information System
GNI, PPP	Gross National Income, Purchasing Power Parity
ICT	Information and Communication Technology
IUCN	World Conservation Union
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
K-Water	Korea Water Resources Corporation
KEXIM	The Export-Import Bank of Korea
KOICA	Korea International Cooperation Agency
MDB	Multilateral Development Bank
NPV	Net Present Value
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
Rp.	Indonesian Rupiah
SCF	Standard Conversion Factor
SERF	Shadow Exchange Rate Factor
SI	Sensitivity Indicator
SV	Switching Value
TEPSCO	Tokyo Electric Power Services Company Limited
USD	US dollar
VAT	Valuable Added Tax
WB	The World Bank
WCD	The World Commission on Dams

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INTRODUCTION

This study aims to investigate how the valuation of environmental impacts in cost-benefit analysis (CBA) would influence on the decision of investment of a development project. In this paper, I am going to focus on Korean ODA projects for showing in what extent the CBA is affected. Many projects by Korean government have been concentrated on social and economic infrastructure and service. Transportation and logistics recorded high at approximately 240 million US dollars in 2014, the first portion of the bilateral Korean ODA sectors. In water resources and sanitation, about 155 million US dollars were invested.[1] In short, multi-purpose dam construction and road expansion are one of the largest parts of Korean ODA projects.

The civil work projects inevitably gave rise to various socio-environmental problems including involuntary resettlement and environmental pollution in recipient countries. Currently, Korean aid agencies have guidelines for environment impact assessment (EIA) or environmental safeguard, but it is not well known on public that they are complying with the guidelines. Also it is problematic if the Korean donor institutes objectively evaluate the EIA reports examined by recipient countries. Therefore, quantitative assessment of the environmental impacts needs to be taken into account in the *ex-ante* evaluation before the appraisal procedure.

According to the Development Assistance Committee (DAC) Peer Review of Korea report in 2012 by the Organisation for Economic Co-operation and Development (OECD),

[1] "Results and Data - Sector," Office for Government Policy Coordination in Korea, 2017, http://odakorea.go.kr/eng.result.Sector.do.

Korean ODA programs had been promoted by insufficient impact evaluations and the evaluations were still pilot or in the early stages. The report also points out the necessity of strengthening evaluation capacity to bring expected project results and to increase the ODA effectiveness for the Paris Declaration commitments. As a project size is bigger and mega projects are more increased, consideration of environmental concerns is more important as one of major factors for success.

Mega projects such as large dam construction need large investments. The large investments can bring large benefits. But the large investments also can give rise to large costs. The World Commission on Dams (WCD) examined the compiled data of economic analyses from the appraisal to the completion of projects done by the World Bank (WB) and Asian Development Bank (ADB), and the average economic rate of internal return (EIRR) at the post-evaluation phase was strikingly lower than it at the appraisal phase (2000, 47-58).[2] In other words, comprehensive effects in nature were not incorporated with the analyses, and regarding the social and environmental impacts as minor factors were accounted for the differences. The WCD pointed out that the multilateral banks conservatively undertook the CBAs that only considered direct costs and benefits.

The reality was not rigorously applying the estimation of the non-conventional costs and benefits into the CBA. In Korea, public investment projects for construction of multi-purpose dams only include economic and financial expenses in the cost estimation of the CBA, exclusive of environmental costs (Yeo et al. 2003, 1). Silva and Pagiola (2003, 3) states that it has been a challenging task to include environmental impacts, since they are

[2] For 14 irrigation dam projects reviewed, the average EIRR at appraisal was above 15%, while it was 10.5% at evaluation. Twelve projects, having expected returns of over 12% at appraisal, were dropped to 5 by evaluation, and 4 cases fell below the 10%, which could invert to the decision at appraisal. According to the WCD's study, the WB's irrigation projects showed that the average EIRR had been dropped from 17.7% at appraisal, 14.8% at completion, and 9.3% at the time of impact evaluation, 6 to 8 years after completion. Projects in different type's dams were also in same patterns. In case of hydropower dams, the half of 63 samples failed the estimated target of power generation because of soil sedimentation in water reservoirs. In case of water supply dams, the EIRRs of 4 dams fell by over 6%.

not easily quantified in physical properties and valued in money terms. The WCD also revealed that efforts to interpret the environmental and social costs of large dams as economic terms have not been enough to account for the actual profitability of the dams (2000, xxxi). A project in developing countries is probably more difficult to estimate costs and benefits on the indirect impacts due to a lack of data.

In early 2000s, Indonesian government requested the Korean government to promote the Karian Multipurpose Dam project, planned to solve the water shortage problem in the national capital areas including Jakarta, Bogor, Tangerang, and Bekasi (collectively called "Jabotabek").[3] Korea International Cooperation Agency (KOICA) conducted a feasibility study for the project, and completed a detailed design of the dam in 2006. In fact, a previous study for the same project was already done by Japan International Cooperation Agency (JICA) in 1985. Some Korean papers indicate the reason that the project resumed in about 20 years was because Indonesian government could not procure the budget of 100 million US dollars for concessional loan due to the currency crisis in 1997 (Ryu 2007, 57; Yoon 2008, 91; Lee 2009, 79; Ryu and Ahn 2013, 55-57). But it was not well known why Japan did not continue to promote the project, although they previously experienced the feasibility study for the dam construction and concluded that the project was "worthy to implementation" (JICA 1985).

In order to proceed with the feasibility study, the both sides, Korea and Indonesia as a donor country and a recipient country, seemed to comply with social and environmental assessment guidelines required at the international level. According to Ryu and Ahn (2013), Indonesia realized that a dam project raised social issues such as resettlement problems and environmental deterioration. The recipient government implemented an environmental

[3] The Export-Import Bank of Korea, "EDCF Projects Approved In 2010 - Southeast Asia," *EDCF Annual Report 2010*, 20-21.

impact assessment (AMDAL)[4] in 2005 and prepared the Karian Land Acquisition Resettlement Plan (LARP) in 2008 for minimizing social and environmental impacts in the project site. In 2011, Indonesian government concluded an EDCF (Economic Development Cooperation Fund) loan agreement with Korean government. The Karian Dam project was started from the end of 2015, scheduled for completion by 2019.

But there were many questions to be granted. I hardly see any improvement in the Karian Dam project from the other large dam cases. Cho et al. (2011, 21) already pointed out that the implemented AMDAL report lacked substantial countermeasures against the predicted risks in environmental areas and the accompanying social effects. For example, destruction of the spawning places in the water reservoir impacts on decline of fish quantity, devastation of the ecosystem and adjacent fisheries. Also reduced water flow in the downstream causes increase of soil salinization, which leads to deteriorate paddy fields and damage crops. Hence, the project was temporarily suspended to reinforce social impact assessments for resolving conflicts (Lee 2014, 58). Nevertheless, the Export-Import Bank of Korea (KEXIM), as an implementation body of the EDCF loan, has tended to overlook social and environmental impacts in the feasibility study. As one of major tools to remove negative effects on environment, an environmental impact assessment (EIA) is stated in the Bank's EDCF Feasibility Study (F/S) Manual (2010, 23-28). But the assessment result is not critically discussed as a determining factor for a project investment.

In the EDCF F/S Manual (2010, 22), the KEXIM mentions that it is difficult to estimate indirect benefits such as reduction of environmental pollution or noise because of two reasons; first, the effects on public investment projects are not solely composed of goods and services, so intangible benefits are not readily quantified. Also estimation of the

[4] AMDAL (Analisa Mengenai Dampak Lingkungan in Indonesian): Environmental Impact Assessment for significant impact activities, equivalent to the EDCF 'Category A' project identified as environmental threats are likely to be severe and influencing on broad areas (e.g. Large dam project with more than 15 meters height and 3 million cubic meters impoundment capacity)

benefits is different for a project’s type, location, and size. Second, the lack of objective and concrete data in developing countries acts as a hindering factor to estimate the non-conventional benefits. Because environmental impacts are intertwined with public health, leisure, and aesthetical values, they cannot be calculated by the equation of price (P) × quantity (Q).

The Karian Dam project was categorized in the highly environment-impacted “Category A” projects by the manual, so that a question has arisen that how the KEXIM handled the relevant issues in the appraisal procedure. I requested disclosure of information about the EIA report for the dam project to the bank, but the loan lender declined to open the document on account of the recipient government’s objection. In the meantime, the ADB posted a draft of review for acceptability assessment of the Karian dam project. The study indicates that vulnerable groups including women are still susceptible to socio-economic impacts, and scoping in the AMDAL report does not cover post-operational impacts (ADB 2017).

The KEXIM needs to take a more progressive approach considering valuation of environmental impacts. An assessment of environmental impacts is important because it could save potential *ex-post* costs to make up negative impacts. Counting on the impacts, the ODA project would be effective for the donor and the recipient country. In this research, I suggest that environmental impacts in the Karian Dam project to be quantified and inserted into the cost-benefit analysis (CBA). As a result, I am going to check whether the result makes the original decision in the project appraisal to be reverted or not. For that, I set up a hypothesis that the project would remain economically viable, even though the CBA result is influenced on socio-environmental impacts as indirect costs.

LITERATURE REVIEW

In 1980s, the World Bank's two projects, Polonoroeste Highway Project in Brazil and Narmada Dam Project in India, were promoted without sufficient discussion on socio-environmental impacts (Clapp and Dauvergne 2008, 202). And it aroused fierce opposition and criticism from local residents and the international society for numerous socially and environmentally-adverse effects. The two cases evidently show that reflection of the non-conventional factor is crucial for promoting an ODA project. As a donor country in ODA since joining in the Colombo Plan in 1954, Japanese government provided a bilateral concessional loan to Indonesia to construct the Koto Panjang Dam in 1980s to solve demands for electricity in the central region of Sumatra.[5] But the dam project was recorded as a failure case that the social impacts were not thoroughly internalized in the early phase of the project.

The construction of the Koto Panjang Dam necessarily caused resettlement of the region's habitants, and about 20,000 people resided in the inundation area were relocated. As a socio-economic impact, more than 5,000 households inevitably changed their primary income source, 60% them from rubber plantation (JBIC 2004, 41). In the third party ex-post evaluation report by the Japan Bank for International Cooperation (JBIC), the involuntary re-settlers were not only losing their economic bases, but most of them failed to transfer industrialized labors from agriculture. It led to exacerbate the living conditions of them. In September 2002, 3,861 local people affected by the project filed a lawsuit in the Tokyo

[5] Rivers Watch East and Southeast Asia, International Rivers Network, and Friends of the Earth Japan, "Development Disasters: Japanese-funded Dam Projects in Asia," 2003, 1-6.

District Court as plaintiffs for destroying their inhabitation against Japanese government.[6]

Also the dam project was accused for ecosystem destruction and adverse impacts of biodiversity around the site. Deforestation in the catchment area swept away the habitats of wildlife such as Sumatran elephants, designated as an endangered species by the World Conservation Union (ICUN) in 1988. The whole flora and fauna in the area was irreversibly damaged by the dam construction. Later, the JBIC conceded that the plans for environmental management and monitoring of the sites lacked adequate implementation.[7] Without efforts to count on environmental information, the project's benefits could be zero or lessened by indirect costs in socio-environmental aspects in the future. This case evidently shows two lessons; first, causes that oppose the project (e.g. hardships of resettlement villages) were not equally treated with supportive projection for promotion (e.g. profits from power generation). Second, the conflictive factors need to be properly internalized in the project design.

The poor economic performance for large dam projects is consequentially concluded to incur overrunning costs in the long run. Yeo et al. also introduced a Korean case study of valuation on damages of water quality degradation in the Soyang-gang River Dam project that the estimation with the indirect costs significantly lowers the B/C ratio in comparison with the original case (2003, 155-156). The previous dam studies in Korea mainly considered the expected benefits by 50 years after the construction in the CBA, while the costs for environmental damages were tended to only focus on the present which the damages occurred. However, there are several cases reported that the degrees of environmental damages expected at the time of a dam construction differ from the actual level of the negative impacts after the construction. Hence, it becomes critical to obviously add the

[6] The resettled residents accused Japanese government including Japan Bank for International Cooperation (JBIC), Japan International Cooperation Agency (JICA), and Tokyo Electric Power Services Co., Ltd. (TEPSCO) to restore rivers destroyed by the project and demand 5 million yen (about 42,000 USD) per a plaintiff for compensation cost.

[7] JBIC, 9-35.

indirect costs as well as the derived benefits by a project's decommissioning time (Ibid., 1).

Emerging from the 1950s and the 1970s, CBA becomes the dominant economic tool that supports decision-making on investment projects, as the WB used the economic analysis method in a project appraisal procedure since 1970s (WCD 2000, 180-181; Chutubtim 2001, 3). Now the CBA is generally used for checking the validity of a project that will be economically viable. While performed at the stage of feasibility study (F/S), which reviews feasibility on technical, environmental, economic, and financial perspective, it is a very comprehensive analysis for policy or project evaluation that integrates the other techniques such as environmental impact analysis (EIA), economic impact analysis, regulatory impact analysis, cost-effective analysis (CEA), risk assessment, etc. (Kim et al., 2003, 21). Steps for the F/S are like on the below (Table 1).

Table 1. The Procedure of a Feasibility Study in the EDCF

Step 1	Basic Survey & Review on Background Information	· Survey on recent meteorology, economy, humanity and society, etc. in recipient sites · Study on current status and demand prospect · Review on local laws & relevant plans
Step 2	Review on Technical Validity	· Comparison review w/ a previous detailed design · Adequacy review of facility planning
Step 3	Socio-environmental Analysis	· Social/Environmental Impact Analysis · Study for resettlement plan, managing organizations and systems
Step 4	Economic/Financial Feasibility Review	· Economic and financial analysis (B/C ratio, NPV, EIRR, FIRR, etc.) by scenarios · Sensitivity analysis by parameter changes
Step 5	Supplementary Task	· Final review including risk assessment before project appraisal · Financing methods
Step 6	Report Writing & Submission	· Final reporting for project decision

Source: Lee (2009) "Feasibility Study of Follow-up Project on Karian Dam in Indonesia." pg.80

Now the valuation of external impacts is increased in economic analysis and it would be unavoidable in order that the CBA remains as an efficient tool in practice to appropriately envisage a project's future. Of course, as Vaughn and Ardila (1993, 7-8) say, a robust outcome in the CBA is decided by precise estimation, neither overestimating conventional benefits, nor underestimating 'unquantifiable' costs, or vice versa. With sensitivity analysis to help the CBA's decision figure out on changing a parameter's conditions, 'unquantifiable' is no longer acceptable and 'lack of data' is not insoluble in many cases by progress in methodology on observing the relevant behaviors. And more we know about the sources, more we get confidence on the results (Dixon, Talbot and Le Moigne 1989; Dixon 2008, 4).

In general, physical impacts are readily identified and quantified as monetary terms, and they are represented as economic prices. In a totally competitive market where only demand and supply simply exists without externalities such as government intervention (e.g. taxation, subsidization), market prices can exactly reflect on economic prices. But in an imperfect competition state, the market prices are inevitably distorted and it influences on deducting inaccurate costs and benefits (Chutubtim 2001, 17-18). For that, a 'shadow price' is introduced for increasing accuracy in economic estimation. But again, the calculation of shadow prices is complicated, so that it is hard to use in developing countries due to the lack of information on the prices.

Repeatedly including social and environmental impacts in the CBA is required since cost and benefit categories in ODA projects are closely related to the social welfare in the national economy. If the CBA is done for a corporate's investment project, the valuation of externality might be regarded as a minor category. But the impacts such as improvement or deterioration of environmental quality affect the national economy, so the impacts occurring social costs and benefits are necessarily included in the analysis as a major category.

So far, expanding efforts of the CBA's scope have been made to address social and environmental issues, and they are leading to the valuation of social and environmental impacts. The WB increased environmental valuation from one in 162 projects in 1990s to average of 6 to 9 projects per year in 2000s (Silva and Pagiola 2003, 47). Especially, dam projects need to be incorporated with social and environmental aspects into the CBA because the impacts could lessen the net social benefit and invert the large investment. For instance, Kwak and Yoo (1999) introduced an alternative case in the Dong-gang River Dam project that a net social benefit turned to a negative value by adding environmental damage costs from biodiversity losses and deprivation of recreational activities. Thus, economic viability of the project fell so much that it was not supposed to make investment decisions.

According to the F/S report for the Karian Dam in 2006 (KOICA et al. 2006, 11), the purpose of the dam construction is to supply water for household, urban and industrial needs in the recipient areas. The project also has a benefit of controlling floods in the downstream area where a toll-road to Jakarta and an industrial complex are located. Now the project, valued at 74 million US dollars (equivalent to 1.07 trillion Indonesian Rupiah), was completed at 39% as of 2017 and is expected to be finished in May 2019. As the results of the economic analyses were shown in the report, the dam project was concluded as 'economically feasible' by assessment of the estimated values, NPV, B/C ratio, and the EIRR. And here I am going to show that why the alternative case of environmental valuation needs to count on the analysis and how it can be included in the CBA in comparison with the original case.

METHODOLOGY

A. Procedure of the Cost-Benefit Analysis (CBA)

Basically the CBA procedure is followed with 9 steps (Boardman et al. 1996, 7). Here, in the sequential steps (Table 2), valuation of the indirect impacts will be also considered.

Table 2. Steps for Cost-Benefit Analysis (CBA)

(Step 1)	Identify stakeholders to the analysis.
(Step 2)	Identify alternative policies to be included.
(Step 3)	Identify potential physical impacts.
(Step 4)	Predict the impacts over the lifespan of the project.
(Step 5)	Monetize all the impacts.
(Step 6)	Find the present value with the discount rate.
(Step 7)	Add up the costs and benefits.
(Step 8)	Perform a sensitivity analysis of the results.
(Step 9)	Select the preferred alternative.

Source: Boardman, Greenberg, Vining and Weimer. (1996) "Cost Benefit Analysis: Concepts and Practice." 2nd ed., pg.7.

(Step 1) Identify stakeholders to the analysis.

First it is necessary to decide whose costs and benefits 'stand' for the project. The Karian Dam project, for example, needs to count on groups of people who live in the dam inundation area and the neighboring areas. The population in the downstream can expect a dam construction for flood control. Households and factories near the dam can gain a benefit from a 'stable' water supply. But the recipient nation would face a problem of losing tropical forests in the area as derived costs including biodiversity losses and carbon storage losses.

(Step 2) Identify alternative policies to be included.

A potential alternative project is evaluated relative to the status quo. The net costs and benefits of the project are compared with those of a hypothetical project. In this paper, this step applies the two cases - 'without' (original) and 'with environmental valuation' (alternative) to the CBA.

(Step 3) Identify potential physical impacts.

Once all the cases are set, all the expected impacts in positive and negative sides are identified and quantified. Because of the limit of information and practical consideration, my study is confined to some of the categories on the below.

Direct Costs	**Direct Benefits**
• Construction Cost (including compensation cost for resettlement) • Operation Cost (O&M, replacement, pumping cost)	• Water Supply Tariff (Municipal, Industrial)
Indirect Costs	**Indirect Benefits**
• Resettlement compensation (agricultural products loss) • Biodiversity Loss • Carbon Storage Loss	• Flood Control

(Step 4) Predict the impacts over the lifespan of the project.

It is difficult to predict impacts during the lifespan of the project and after, if the project still incurs costs or brings benefits. The Karian Dam will also have impacts over extended periods of time. Especially, impacts relative to indirect costs and benefits will residually exist after the project and will not be readily quantified. Here I am going to narrow the time horizon to the longevity of the dam, 50 years only.

(Step 5) Monetize all the impacts.

All the expected costs and benefits are monetized, so that the costs and benefits can be compared. Direct costs for construction, operation and maintenance (O&M) and a water supply benefit are valued for market price. Resettlement costs and flood control benefits are assessed as replacement value estimation, which is to calculate prices of goods and services replacing the effects of the dam project. For environmental costs, secondary data in existing studies are used as 'benefit transfer' in case of a similar environment of a specific site. If the values of cost or benefits are hardly monetized, an alternative method such as cost-effective analysis[8] can be used.

(Step 6) Find the present value with the discount rate.

Before adding up, future costs and benefits are discounted to get present values by a discount rate, because the monetary values at different time periods need to be adjusted for comparison on the same time base.

(Step 7) Add up the costs and benefits.

The net present value (NPV) equals the present value of benefits (PV(B)) minus the present value of costs (PV(C)):

$$NPV = PV(B) - PV(C)$$

When the NPV is greater than zero, the project is said to be viable. This study will check if the NPV of the original case without the valuation is higher than that of the alternative case with environmental valuation. Benefit-Cost (B/C) Ratio and Economic Internal Rate of Return (EIRR) are subsidiarily used for helping an investment decision. Also I am going to

[8] It is a technique to comparatively analyze costs and outputs of each alternative to find the most effective one. In the technique, costs are transferred to monetary values but not for benefits. It is used in cases of evaluating projects that outputs are not easily monetized. For example, planning a policy to prevent air pollution, the reduction result is not quantified as monetary terms. For that, a case of the lowest cost to reduce a same contaminant level is selected as the most effective one.

compare the results of the EIRR and B/C Ratio of the original case with those of the alternative case.

(Step 8) Perform a sensitivity analysis of the results.

A sensitivity analysis is to find an uncertainty of a project. It clarifies for decision makers how they affect the CBA results. I can know that the Karian Dam project is sensitive to which variables in costs and benefits. And the time and resource constraints will lead to focus on the most important variables.

(Step 9) Select the preferred alternative.

In the final step, a recommendation is made with an alternative that gives the highest positive net benefit value. As stated, the conventional CBA has a shortage not to represent intangible costs and benefits. Now various valuation techniques help account for them in monetary terms. But the CBA is still not perfect since it can be biased by a tendency to overestimate benefits and underestimate costs (Chutubtim 2001, 6).

B. Criteria for Project Justification

1. Net Present Value and Discount Rate

Costs and benefits differ with time. It means that a today's occurring cost is not same with the cost in 5 or 10 years. Therefore, the future values are adjusted to present values to be compared each other. And the adjustment is done by a 'discount rate', which is based on the fact that the value of a future's consumption is less than that of a present's consumption by time preference and the opportunity cost of capital over time.

Let B_t and C_t be the benefits and costs that occur in the year t after start of the project, respectively. If the project ends in n years, the sum of the net present value (NPV) of the project is as follows.

$$\text{NPV} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where B_t = Benefit at time t

C_t = Cost at time t

i = Discount rate

n = Number of years

If the NPV of a project is greater than zero, it is worthy to go on. To the contrary, the project should not be implemented if the NPV < 0. In addition, if there are several different cases, the case with the largest NPV should be given to the priority. Therefore, the NPV helps decide whether a project should be implemented or not, but also which one is the most efficient in multiple cases.

2. Benefit-Cost (B/C) Ratio

When evaluating a project using the B/C Ratio criteria, the sum of the present value of the benefits is divided by the sum of the present value of the costs. And if the ratio is greater than 1, the project is implemented. Conversely, if the number is less than 1, the project will not be feasible.

$$\frac{\text{B}}{\text{C}} = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}$$

Where B_t = Benefit at time t

C_t = Cost at time t

i = Discount rate

n = Number of years

The B/C Ratio cannot be used to decide the priorities among different alternatives because the scales of the welfare effects on projects are different.

3. Economic Internal Rate of Return (EIRR)

The third method for decision of a project in the appraisal procedure is to use the internal rate of return (IRR). The EIRR is the discount rate at which the NPV is zero. The economic internal rate of return (EIRR) tells a society if a project increases the overall economic welfares by appraisal of the net benefits (benefits - costs), while the financial internal rate of return (FIRR) is intended to know if a project is profitable (revenue - expenditure). In this research, the EIRR is only used for the economic analysis.

$$0 = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

Where B_t = Benefit at time t

C_t = Cost at time t

r = Economic internal rate of return

n = Number of years

The only internal rate of return at the NPV equal to zero is the point that the net social benefit, B_t - Ct, once turns a negative to a positive value.

$$r \geq i \rightarrow \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} \geq 0$$

$$r < i \rightarrow \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} < 0$$

Where B_t = Benefit at time t

C_t = Cost at time t

r = Economic internal rate of return

i = Discount rate

n = Number of years

If the EIRR (r) is greater than the social discount rate (i), the project can be implemented and cannot be promoted in the opposite. The EIRR, like the B/C Ratio, has a limitation to determine project priorities.

4. Sensitivity Analysis

With the three criteria for the CBA, an additional task is done for helping an investment decision, a sensitivity analysis. The sensitivity analysis is mainly used for reducing the uncertainties of the project outputs. It changes the values by applying various assumptions to uncertain variables, which have a crucial effect on benefits and costs, and then examine changes in cost and benefit estimates under each assumption. The analysis has limitations because it does not reflect the probability of each possible outcome, but it has the advantage that it can be used even when the probability of each result is not known accurately. 'A sensitivity indicator (SI)' measures the sensitivity of a project:

$$SI = \frac{dNPV/NPV}{dV/V} = \frac{(NPV_b - NPV_s)/NPV_b}{(V_b - V_s)/V_b}$$

Where SI = Sensitivity indicator
dV = Net change in a key variable
NPV_b = Value of NPV in the base case
NPV_s = Value of NPV in the sensitivity test
V_b = Value of a key variable in the base case
V_s = Value of a key variable in the sensitivity test

If the SI value is greater than 1, the project is 'sensitive' to the variable. By contrast, it is 'insensitive' to the variable when the SI value is less than 1. If the SI is equal to 1, the project is 'neutral' to the variable. That is, higher SI value means that the NPV is subject to changes on variables, and the risk of the project is higher on the variable. Also anther approach is 'switching value (SV)'. As an inverse of the SI, it is the percentage change in a variable needed for the NPV to be zero.

$$SV = (1/SI) \times 100$$
$$= \frac{dV/V}{dNPV/NPV} \times 100$$

For interpretation of the SV, if the value is smaller than 100%, the project is sensitive to the variable. If it is larger than 100%, the project is insensitive to the variable.

C. Measures for Non-Monetary Costs and Benefits

Besides the direct costs and benefits that are explicitly priced in the market, the values of social and environmental impacts are difficult to measure in monetary terms. In order to compensate for these shortcomings, it has been used efforts to monetize the implicit values that can be applied by such a market valuation method. Even though they are non-market values, various methods were sought to quantify them through insertion into a surrogate market, replacement to the similar monetary units, or survey for ‘willingness to pay or accept’.

Environmental Assessment Sourcebook of the World Bank indicates that “in spite of these difficulties, a greater effort needs to be made now to ‘internalize’ environmental costs and benefits by measuring them in money terms and integrating these values in economic appraisal” (1991, 138). In the case of overseas countries, studies on environment-related cost and benefit analysis have already been conducted since the 1970s (Dixon, Talbot and Le Moigne 1989, iii). Up to date, several inference methods such as hedonic pricing approach[9],

[9] (Hedonic Pricing Approach) Estimation of an implicit price for non-tradable environmental values by regarding it as tradable market attributes. For example, a house placed near a river is supposedly higher-priced than the other house far from the river under the same conditions. The values brought by the river are measured by a difference of the property value. But this approach has the multicollinearity issue that two variables are interconnected.

travel cost approach[10], and contingent valuation method[11] have been introduced to estimate the non-marketed goods (Kwak, Jeon and Kim 2012, 59-61) and interpolated not to commit a foreseeable fallacy heavily depending on the results of the CBA *per se*.

The Karian Dam project has various costs and benefits directly and indirectly. The KOICA's F/S report (2006) counted on the raw water supply for household and industry only as the project benefit, while the feasibility study excluded flood control benefits and supply of irrigation water as indirect benefits (Ibid., 101). In fact, numerous articles and documents in Korea and Indonesia promoted that the dam would bring various benefits that were not estimated in the CBA; irrigation water supply and the derived economy growth by increased yields of agricultural products, generation of electrical power, prevented damage from floods, and even recreational benefits around the dam.

However, I could not find any quantified analysis results about the introduced indirect benefits and my attempt to quantify all the impacts reached a limit by the absence of background information. Social and environmental costs could be approximated by using estimates based on existing data, although they are not accurate. Of course, there may be differences between regions and time periods for each category of costs, but the approximate estimates could be used as a reference for the cost estimation. Here I am going to indicate possible costs and benefits for the dam project and introduce the added categories in this study.

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[10] (Travel Cost Approach) Estimation of a sum of expenditure on travel by substituting values of environmental resource (e.g. a benefit to visit a recreational site) The benefit to enjoy leisure at a recreational site can replace a total travel cost of a round-trip transportation costs (i.e. fuel cost, parking fees, toll fares), entrance fees, and opportunity cost for the travel time. But it has a defect to become unaware of information on a non-travel group as an omitted variable.

[11] (Contingent Valuation Method) Estimation of a customer's preference transferred to a market value in a hypothetical market. Through a survey, an environmental feature is responded to the 'willingness to pay' or 'willingness to accept'. But the method has a limit as the customer's behavior is based on the surrogate market, not a real market.

1. Costs by Inundation

a) Agricultural Product Losses

The present income for agricultural crop production in farmlands submerged due to the Karian Dam construction would be inferred to the future losses of income in the affected area. To calculate the losses, the areas of crop fields multiply with average crop price per unit area and year. In the KOICA (2006)'s F/S report, these losses were counted once as a compensation cost for the resettlement, but the economic productivity losses could not be offset by a one-time expenditure in the resettlement cost category. So I am going to count on the losses as an indirect cost for the lifespan of the project. Here I assume that a unit price of a crop (e.g. rubber, bamboo, palm oil, etc.) is fixed at the data in the F/S report, although the price would be fluctuated. According to the FAOSTAT's[12] data from 2006 to 2016, the prices of relevant crops in Indonesia have been changed (Refer to Figure 1).

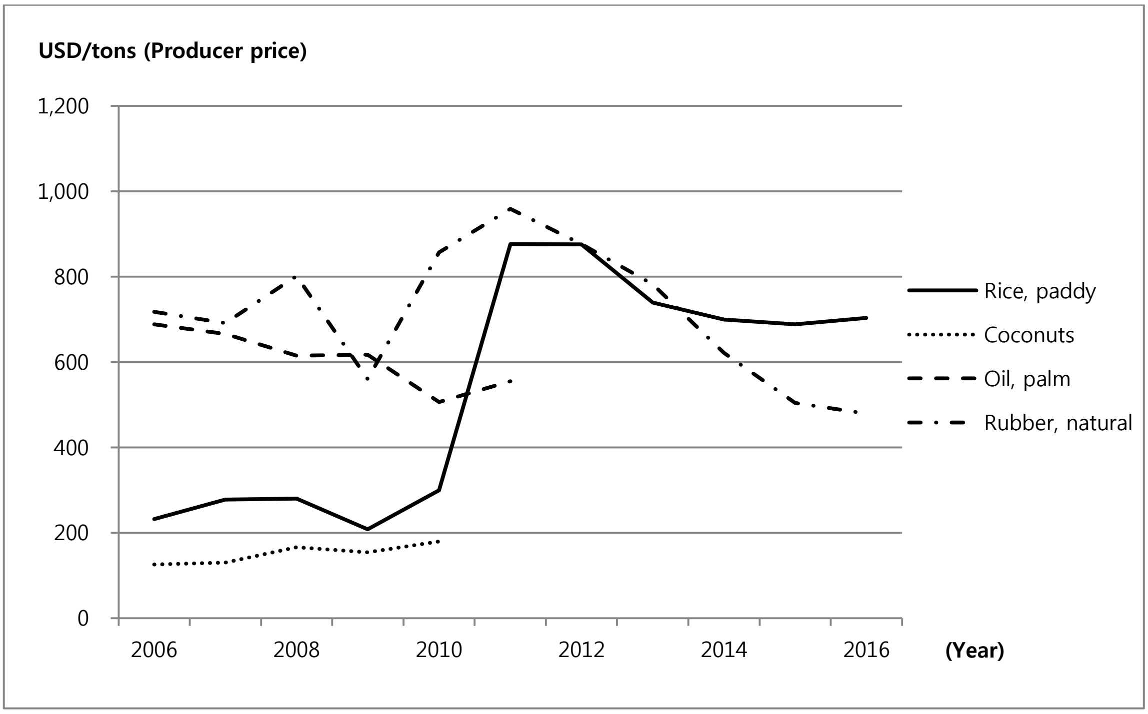

Fig. 1. Change of Crop Prices in Indonesia (2006-2016)

12 FAOSTAT, Producer Prices – Annual. (http://www.fao.org/faostat/en/#data/PP). The Food and Agriculture Organization (FAO) of the United Nations.

With the FAO's data, I tried to substitute the prices of crops introduced in the F/S report, but there were some limitations; first, the price of bamboo cultivated in the inundation area was not listed in the FAO. Second, the FAO indicated not a basic price, but a producer price, which is a sum of the price given for the producer, i.e. a border price equivalent to a CIF or FOB price[13], plus taxes on commodities except valuable added tax (VAT) and subsidies on them. For the reason, it was not possible to transfer to a border price. Hence, I am going to convert the current prices of crops from the KOICA report to constant prices, and then calculate the damage costs for 50 years, the lifespan of the project, by using the discount rate. Compared with the composition of crops at the time of the F/S study, it is unclear what crops are being cultivated in the downstream of the Karian Dam and in what composition they are cultivated.

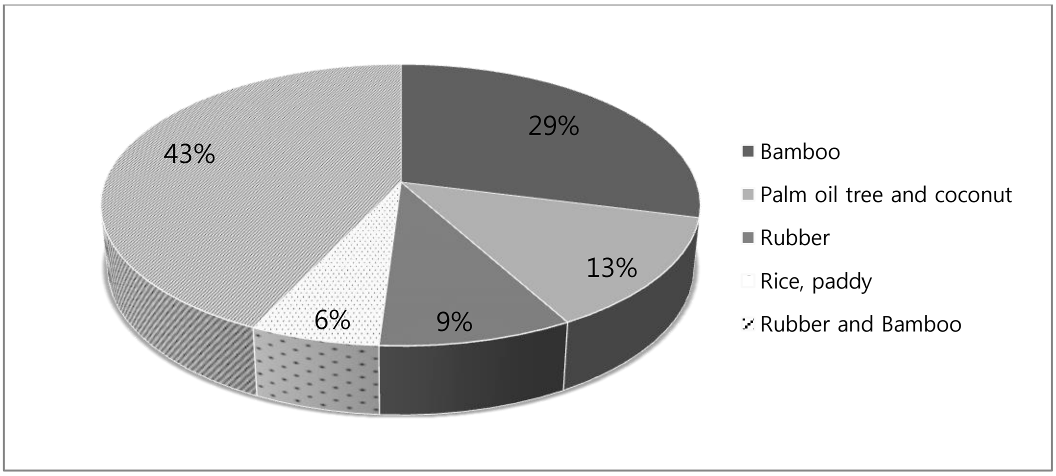

Fig. 2. Land Use of Inundation Area by Karian Dam[14]

Therefore, I am going to check how the changes of the indirect costs affect the project in the sensitivity analysis.

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[13] C.I.F price means a cost that a seller pays with freight including insurance to the port of destination. It can be used for an adjusted supply price or opportunity cost in the imported country. On the other hand, F.O.B (Free on Board or Freight on Board) price is a cost that delivers the goods to the nearest port (border) as the export price or demand price.

[14] Fig 2 reprinted from KOICA, K-Water, and Korea Rural Community & Agriculture Corporation, Final Report on the Feasibility Study and Detailed Design of the Karian Dam Project 2006; 36.

b) Carbon Storage Losses

Indonesia has a tropical monsoon climate annually and tropical forests are developed in the inundation area of the Karian dam sites. By inundation of tropical forests in the area, the impacts of climate change are expected in the long term. According to Sharma et al. (1992), tropical forests and forest soil have a function of capturing carbon owing to the highly dense biomass. The study says an estimation that the tropical forests can contain up to three times of carbon in the atmosphere. The carbon storage losses contribute to stimulation of global warming, and the increased emission of greenhouse gases including carbon dioxide is regarded as one of the main culprits.

Because the basic surveys of the Karian Dam done by the JICA (1985) and the KOICA et al. (2006) did not mention any timber logging activities in the area, I would disregard losses of income by the tropical land use such as forestry and manufacturing industry of non-timber forest products. But clearing the tropical forests would cause the absence of biomasses to sequester carbon in the atmosphere. I would count them on as the climate change losses and use a 'benefit transfer'[15] method to obtain an economic value from a past study done in a similar site.

Here I assume that the 'replacement cost' would not exceed the sum of the individual's 'willingness to pay'. The willingness to pay or accept tends to be estimated in inflated in comparison with the individual's income (Kim et al. 2003, 39). I would borrow a number of the estimated values from the sources of Pearce and Warford (1993). The paper had two assumptions; first, one hectare of deforestation contributes to release 100 tons of atmospheric carbon in a year. Second, the damage is estimated to 13 US dollars per ton of carbon. In other words, the opportunity cost would be 1,300 US dollars per hectare a year.

[15] Benefit transfer is an estimation of indirect costs or benefits of interests by replacing the values developed in a similar site to the valuation study. It will be proper when funds or time are absent to undertake the valuation (OECD 1995).

c) Biodiversity Losses

Dam construction refers to the transition from a river ecosystem to a lake ecosystem that divides upstream and downstream. Therefore, by the manipulation of the human activity, the diversity and population of the fish in the ecosystem will be inevitably affected due to changes on the surrounding environment. Also the flora and fauna in the area would lose their habitation by inundation, and the cut-off of the river ultimately would destroy the natural preservation. Costs for the damage can be broadly categorized by two items; one, the losses of intrinsic values for biodiversity *per se*; two, the losses of derived benefits from recreational activities (e.g. eco-tourism, camping, etc.) and market activities (e.g. fishery, reprocessing industry using rubber, palm oil, coconut, etc.).

In this study, I focus on the losses of biodiversity value itself. The F/S report for the Karian Dam decided to neglect the impacts on fishery because the economic activity in the Ciberang River around the dam site was carried out in a very small scale (KOICA et al. 2006, 106). Related to the tourism, the previous study mentioned that some historic remains and temples were located near the Banten port and a vast tourist attraction were placed in the Banten Bay. Because they are distant from the dam site and would not be affected by the construction project, the values are not estimated for the economic analysis. And the market activities will be also excluded from the valuation.

Like the carbon storage losses, biodiversity damage costs would be estimated with a value by the 'benefit transfer' from a previous study. Ruitenbeek (1990) indicated that a potential benefit captured by "ecologically important and diverse ecosystem" in a tropical forest would be approximately 3,000 US dollars/km^2 per year from an analysis of transfers for 1987-1990 periods. And I am going to apply the price value into the CBA as an indirect cost.

2. Indirect Benefits

a) Flood Control Benefit

From the past studies, the benefits of the flood control are based on direct benefits from lessening flood damages such as reduction of physical damages lost by flooding, increases of crop yields, and efficient utilization of assets (e.g. rise of land price). In addition, indirect benefits can be valuated such as sales growth due to continuation of production, reduction of other incidental expenses, reduction of loss of life, and improvement of social welfare. However, all the flood control benefits by dam construction projects are rarely quantified, and most have accounted for direct benefits of the damage mitigation (Kim et al. 1995; Yeo et al. 2003). If necessary, other benefits clearly quantifiable are additionally included.

Generally, the annual flood control benefit is calculated as the amount of damage costs after the dam construction deducted from the costs before the investment. And the annual damage cost is assessed by the sum of costs that the average damage values at the flood level multiplied by the probability (or frequency) of flood occurrence in a year. But, in the past, the conceptual process was very hard to be real for the lack of statistical data and analyzing technology to integrate them. Now the unknown field is unveiled by the help of development of information and communication technology (ICT). The flood analysis has become feasible with the application of two-dimensional hydraulic models and distributed rainfall runoff models. And development of the geographical information system (GIS) made the estimation more accurate (Korea Development Institute 2008).

Rivers in Indonesia are prone to floods because of the steep slopes in the upstream, which is subject to frequent encroachment on the floodplains (ADB 1996). Despite the flood control benefits, dam construction becomes an unwelcome policy to local residents around the site because of the safety. The recent accident, collapse of a saddle dam under construction in Laos financed by South Korea, issued the negative side of the civil construction for whatever reasons, either flooding or collapse. By that, it might be additionally necessary to subtract the corresponding cost of ‘willingness to accept’ the concerns from the benefits. The benefit could be reduced by the discounted interests of future generation against the mega project. To the contrary, a high discount rate could lessen environmental costs such as biodiversity losses and it acts on reducing a negative impact (Turner et al. 1994; Bann 1998, 36). Therefore, it is necessary to adjust the discount rate for the over-appropriated benefits and to lower the discount rate for environmental effects.

In this study, I would only refer to the flood control benefit as it was excluded in the F/S report for the Karian Dam (KOICA et al. 2006). The report did not include benefits from flood control and supply of irrigation water as indirect benefits. Meanwhile, the previous report done by the JICA in 1985 estimated that the Karian Dam would have a flood control benefit, Rp. 2.57×10^{6} (constant price), by prevention of the whole damage costs on houses, household articles, stock assets of markets and business buildings, agricultural crops, and public facilities. But the calculated value would not be used for the extended estimation because there are, after the last measurement, no concrete data about flood damage in the region, the frequency of floods, floodwater level, etc.

Valuation methods applied in this study are summarized as below.

Category	Impacts	Valuation Method
1. Cost		
(a) Construction cost	Capital Goods, Materials, Labor	Market price, Revealed preferences
(b) Land acquisition	Land, Compensation for Inundation	
(c) Operating cost	O&M, Replacement, Pumping	
(d) Externality	Agricultural Product Loss	Revealed preferences
	Biodiversity Loss	
	Carbon Storage Loss	
2. Benefit		
(a) Raw water supply	Water Supply Tariff (m^3)	Revealed preferences

RESULTS & DISCUSSION

A. General

As stated before, my research is to check if the Karian Dam project is still economically viable when environmental impacts are valuated and inserted into the CBA. So I will do an economic analysis with a dataset of an alternative case 'with' environmental valuation and an original case 'without' that. This analysis will be conducted under the following assumptions based on the F/S report for the EDCF (KOICA et al. 2006).

(1) The longevity of the dam facility would be 50 years from 2012.

(2) The duration of the project would be total 7 years, 3 years for the preparation period including resettlement and fund security, and 4 years for the construction.

(3) The exchange rate would be applied to the average rate of the Bank of Indonesia, 1 USD = Rp. 9,300 (as of June 2006).

(4) The GNI per capita and GNI per capita, ppp (purchasing power parity) would be applied to the values from the World Bank[16], 1,390 USD and 6,300 USD, respectively.

(5) From the (4) data, shadow exchange rate factor (SERF) [17] can be acquired as below. The SERF can be also explained as an inverse value of a standard conversion factor (SCF).

$$Shadow\ Exchange\ Rate\ Factor\ (SERF) = \frac{1}{Standard\ Conversion\ Factor\ (SCF)}$$

$$= \frac{GNI\ per\ capita, ppp}{GNI\ per\ capita} = \frac{6{,}300\ (USD)}{1{,}390\ (USD)} = 4.53$$

[16] World Bank Databank - http://databank.worldbank.org/data/home.aspx

[17] SERF is a ratio of economic price of foreign currency to its market price. It is used for border prices (e.g. prices for traded input or output) to convert to the domestic prices.

(6) Social discount rate in the study is applied to 12% in terms of the economic analysis criteria of the KEXIM for the EDCF loan.

B. Scenario 1 – Without a Case of Environmental Valuation

1. Economic Costs and Benefits

The F/S report for the Karian Dam (2006) showed the categories of the following direct costs and benefits; (i) construction cost of the dam and appurtenant, (ii) administration expenses, (iii) physical contingency fees, (iv) operation and maintenance (O&M) cost, (v) compensation cost for resettlement, and (vi) raw water supply benefit for municipal and industrial water. The total project costs are estimated at Rp. 1,267,121 million as summarized in a table below. All the costs are converted to border prices by using a conversion factor.

Table 3. Summary of Cost Estimates for the Karian Dam (Scenario 1)

Description of Works		Total Amount (Rp.)	Remarks
1	**Karian Dam**		
1.1	Construction of Dam & Appurtenant	187,085,433,313	
1.1.1.	Engineering Service	24,321,106,331	13% of 1.1.
1.1.2.	Administration Expenses	9,354,271,666	5% of 1.1.
1.1.3.	Physical Contingency	18,708,543,331	10% of 1.1.
Subtotal 1.		**239,469,354,641**	
2	**Water Conveyance System**		
2.1.	Construction of Waterway	351,249,011,949	
2.1.1.	Engineering Service	45,662,371,553	13% of 2.1.
2.1.2.	Administration Expenses	17,562,450,597	5% of 2.1.
2.1.3.	Physical Contingency	35,124,901,195	10% of 2.1.
Subtotal 2.		**449,598,735,294**	
3	**Compensation for Resettlement**		
3.1.	Resettlement Assistance	58,166,204,762	
Subtotal 3.		**58,166,204,762**	
4	**Operation Costs**		
4.1.	O&M for 1&2 (for 50 yrs.)	269,167,222,631	1% of 1.1., 2.1.
4.2.	Replacement Cost	45,010,000,000	.
4.3.	Pumping Cost	205,709,000,000	
Subtotal 4.		**519,886,222,631**	
Total		**1,267,120,517,328**	

In the meantime, the total project benefits by raw water supply are estimated at Rp. 23,579,266 million for 50 years. For the estimation, three assumptions are made as follows;

(1) The sales water price is 5,744 Rp./ton and the raw water price is 2,156 Rp./ton as of 2005.

(2) The planned water supply is planned as on the below. The total water-flow is same with 14.6m^3/s.

- (2012-2015) 9.1m^3/s in Tangerang, 5.5m^3/s in Serang, Cilegon, and Banten areas
- (After 2016) 12.4 m^3/s in Tangerang, 2.2m^3/s in Serang, Cilegon, and Banten areas

(3) The water tariff increases 0.8% annually.

Table 4. Summary of Benefit Estimates for the Karian Dam (Scenario 1)

Sales Water Price (Rp./ton) (A)	**Raw Water Price** (Rp./ton) (B)	**Net Benefits** (A-B)	**Production of Water Supply** (million ton/yr.)	**Total Benefits of Water Supply** (million Rp.)
81,985	30,773	51,212	23,021	23,579,266

* All the values in the table are calculated as a sum of annual value for 50 years.

2. Economic Analysis

From the costs and benefits, the NPV of Scenario 1 is Rp. 1,231,840 million[18], which is considered to be economically feasible because the NPV is greater than zero (Refer to Figure 3 on the next page). With the NPV calculation, results of the CBA of the 'Scenario 1' are summarized (Table 5). The B/C Ratio is calculated at 18.61, which is more than 1 and it analyzed as having economic feasibility. The EIRR, a discount rate that the NPV is converged to zero, is analyzed as 31.13%, which is larger than the applied discount rate of 12%. As a result, the original project is proven to have an economic feasibility.

[18] In my calculation, construction costs are also discounted since the 2nd year of the cost-occurring periods. The other way of the discount is to apply it to costs and benefits after the construction. In other words, sum of the construction costs are not discounted and counted as one-time expenses regardless of the actual project period. As a result, the difference makes the values of NPV and EIRR changed. As the whole costs prior to operation are put at the 'zero' period in the cash-flow chart, the NPV is Rp. 2,595,055 at the discount rate, 12% and the EIRR is 51.13%. They also mean that the project is still an acceptable option for investment.

Table 5. Summary of the CBA Results for the Karian Dam (Scenario 1)

NPV at the discount rate, 12%	Rp. 1,231,840 million
EIRR	31.13%
B/C Ratio	18.61

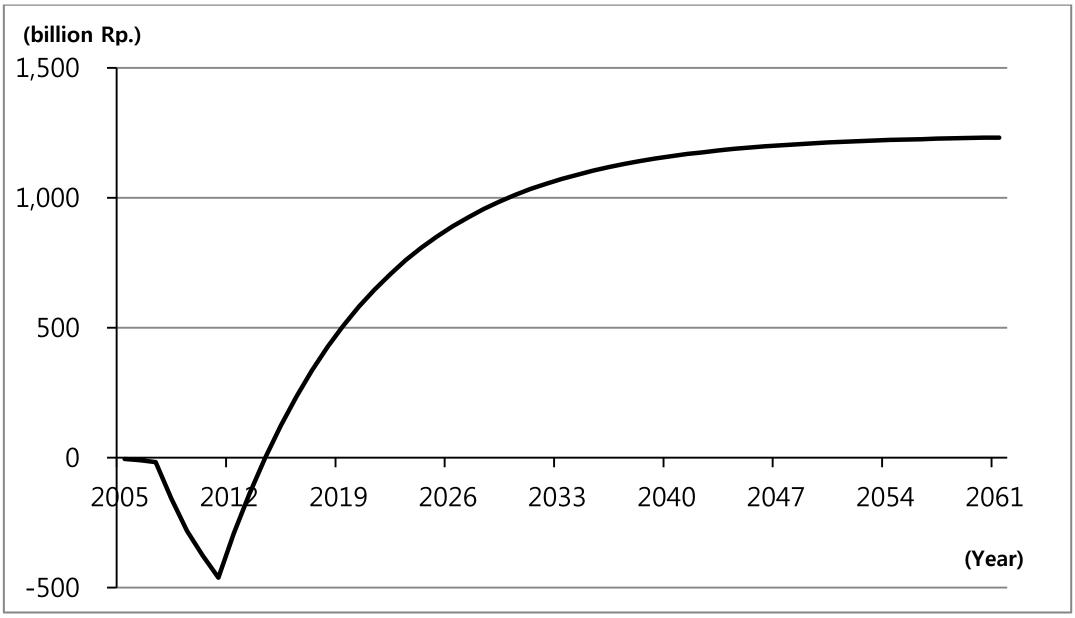

Fig. 3. Cumulative NPV Plot for Scenario 1 (2005-2061)

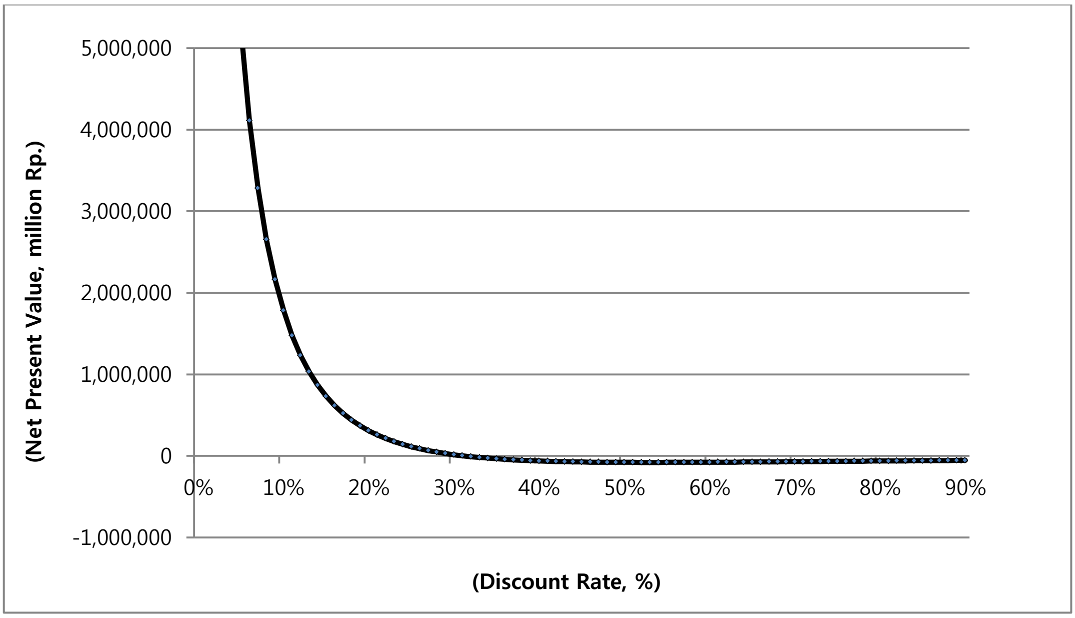

Fig. 4. NPV and EIRR Calculation in Scenario 1

In order to evaluate the soundness of the project to changes in future economic conditions, the sensitivity analysis is also conducted in the following conditions; (i) increases of operation costs by +10 ~ +20%, (ii) decreases of sales benefits by -10 ~ -20%, and (iii) combination of operation cost +20% and sales benefits -20%. Here are the results of the sensitivity analysis (Table 6).

Table 6. Sensitivity Analysis for the Karian Dam (Scenario 1)

Variations of Factor	EIRR (%)	NPV (million Rp.)	SI	SV (%)
Base Case	31.13	1,231,840	-	-
Operation Costs Increase by 10%	31.08	1,227,735	0.03	3,001
Operation Costs Increase by 20%	31.03	1,223,629	0.03	3,001
Sales Benefits Decrease by 10%	28.97	1,058,404	1.41	*71*
Sales Benefits Decrease by 20%	26.69	884,968	1.41	*71*
Operation Costs Increase by 20% and Sales Benefits Decrease by 20%	26.57	876,757	0.72	139

The results indicate that the projects are sensitive to change in the sales benefits because the SI values is more than 1 and the SV values are less than 100% (See *italic* values in the Table. 6). However, the variations do not change the projection decision because the EIRRs are still above the discount rate, which means economically viable.

C. Scenario 2 – With a Case of Environmental Valuation

1. Economic Costs and Benefits

In the scenario 2, quantified values of environmental impacts are inserted into the previously analyzed CBA results. As I stated in the methodology, I added limited categories of the following indirect costs; (i) agricultural product losses, (ii) biodiversity losses, (iii) carbon storage (sequestration) losses. The total project costs are estimated at Rp. 6,458,292 million as summarized in a table below.

Table 7. Summary of Cost Estimates for the Karian Dam (Scenario 2)

Description of Works		Total Amount (Rp.)	Remarks
1	**Karian Dam**		
Subtotal 1.		**239,469,354,641**	
2	**Water Conveyance System**		
Subtotal 2.		**449,598,735,294**	
3	**Compensation for Resettlement**		
Subtotal 3.		**58,166,204,762**	
4	**Operation Costs**		
Subtotal 4.		**519,886,222,631**	
5	**Indirect Costs**		
5.1	Agricultural Product Losses	520,583,000,000	
5.2	Biodiversity Losses	3,258,550,000,000	
5.3	Carbon Storage Losses	1,412,038,000,000	
Subtotal 5.		**5,191,171,000,000**	
Total		**6,458,291,517,328**	

In detail, for the losses of agricultural production, the existed data from the KOICA F/S report are applied and converted to the border prices.

Table 8. Cost Estimates of Agricultural Product Losses

Category	Crop Area (m^2)	Unit Price (Rp.1000/m^2)	Total, MP.* (Rp.1000)	SCF	Total, BP.* (Rp.1000)
Rice, paddy	56,000	1.5	84,000	0.22	18,533
Rubber	87,000	50	4,350,000		959,762
Bamboo	282,000	40	11,280,000		2,488,762
Rubber & Bamboo	406,000	50	20,030,000		4,478,889
Palm Oil Tree & Coconut	128,000	60	7,680,000		1,694,476
Total	**959,000**	**-**	**43,424,000**	**-**	**9,640,422**

* (MP.) = Market Price / (BP.) = Border Price

In case of the losses of biodiversity, I calculate a sum of a unit cost multiplied with the inundation area. I borrow a value of a biodiversity loss in a tropical forest of Indonesia by Ruitenbeek (1990). Here is how I got the total cost of the losses.

Table 9. Cost Estimates of Biodiversity Losses

21,628,500	m^2 (inundation area)
3,000	USD/km^2·year
27,900,000	Rp. /km^2·year
2,790	Rp. /m^2·year
60,343,515,000	Loss (Rp./year)
60,344	**Loss (million Rp./year)**

As a last category of indirect costs, carbon storage losses are estimated by a 'replacement cost' from an existed source. In the methodology, I mentioned two assumptions for the estimation; (i) 100 ton/yr. of carbon emitted by 1 hectare of deforestation, (ii) the damage cost of 13 USD/ton of carbon.

Table 10. Cost Estimates of Carbon Storage Losses

1,300	USD/ha.
12,090,000	Rp./ha.
1,209	Rp. /m^2
26,148,856,500	Loss (Rp./year)
26,149	**Loss (million Rp./year)**

In the meantime, the total project benefits in the Scenario 2 would be same with the result of the Scenario 1. Additional benefits from flood control and recreation are not included in the indirect benefits because of constraints of the relevant data.

2. Economic Analysis

From the net balance of the costs and benefits, the NPV of Scenario 2 is Rp. 827,379 million, which is considered to be economically viable because the NPV is above zero (Refer to Figure 4 on the next page). With the NPV calculation, results of the CBA of the 'Scenario 2' are summarized (Table 11). The B/C Ratio is calculated at 3.88, which is greater than 1 and it analyzed as having economic feasibility. Meanwhile, the EIRR is analyzed as 25.69%, which is larger than the discount rate, 12%. Therefore, it would be concluded to approve the alternative case, too.

Table 11. Summary of the CBA Results for the Karian Dam (Scenario 2)

NPV at the discount rate, 12%	Rp. 827,379 million
EIRR	25.69%
B/C Ratio	3.88

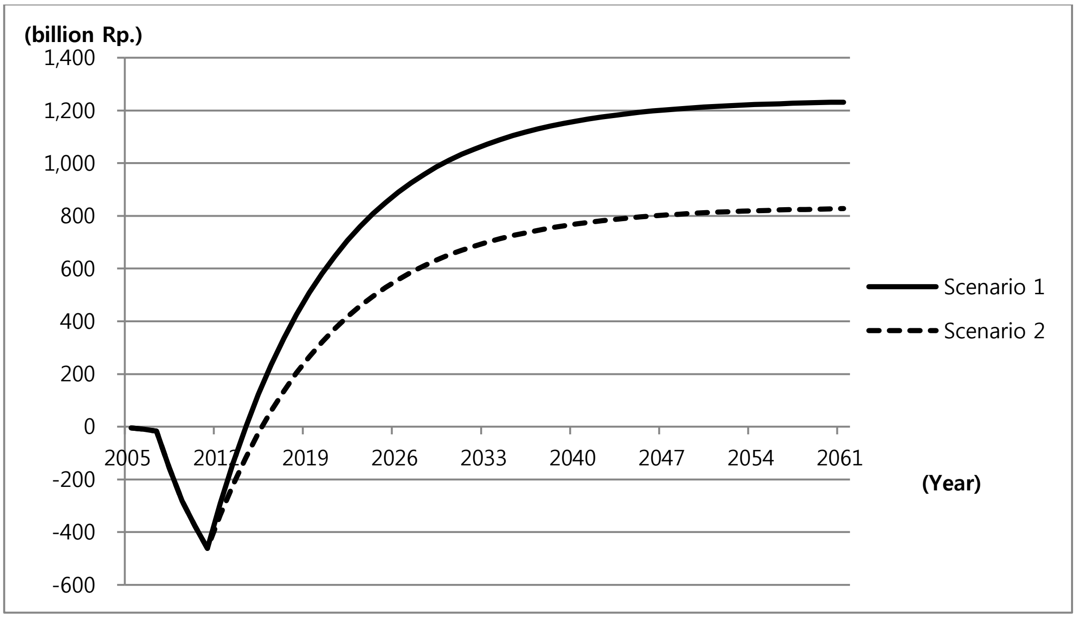

Fig. 4. Comparison of Cumulative NPV Plot for Scenario 1 & 2 (2005-2061)

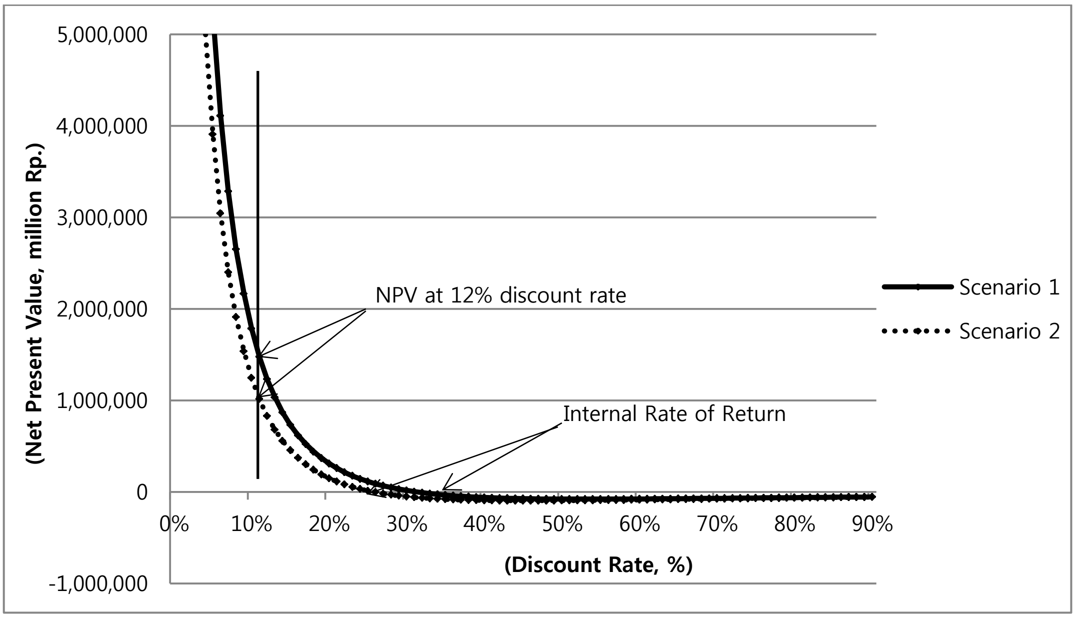

Fig. 5. Comparison of NPV and EIRR Calculation in Scenario 1 & 2

Throughout the Figure 5, the NPVs of the Scenario 1 and 2 can be obtained by the intersection points with the vertical line of the discount rate of 12%. Also the discount rates of the NPV that equal to zero are placed on the x-axis as the EIRR.

For the sensitivity analysis of the Scenario 2, I change the variables in the indirect costs in the following conditions; (i) increases of indirect costs that comprises agricultural product losses, biodiversity losses, and carbon storage losses by +10 ~ +20%, (ii) decreases of sales benefits by -10 ~ -20%, and (iii) combination of indirect costs +10 ~ +20% and sales benefits -10 ~ -20%. Here are the results of the sensitivity analysis (Table 12).

Table 12. Sensitivity Analysis for the Karian Dam (Scenario 2)

Variations of Factor	EIRR (%)	NPV (million Rp.)	SI	SV (%)
Base Case	25.69	827,379	-	-
(Case 1) Indirect Costs Increase by 10%	25.11	786,933	0.49	205
(Case 2) Indirect Costs Increase by 20%	24.51	746,487	0.49	205
(Case 3) Sales Benefit Decrease by 10%	23.21	653,943	2.10	48
(Case 4) Sales Benefit Decrease by 20%	20.55	480,507	2.10	48
(Case 5) Case 1 + Case 3	22.58	613,497	1.29	77
(Case 6) Case 2 + Case 4	19.21	399,614	1.29	77

The results indicate that the Karian Dam project is insensitive to all the changes of indirect costs. But the changes of sales benefit and the combination with the benefit are influential to the project because of SI > 1 or SV < 100%. Along with the Scenario 1, the sales benefit profoundly surpasses environmental costs as well as construction and operation costs. Insertion of the environmental damage costs in the CBA obviously deflates the net benefits of the project, although the impacts do not reverse the investment decision. The sensitivity analyses prove that the benefit of raw water supply needs to be accurately estimated because the NPV is changed negative if the benefit declines by 50%.

D. Discussion

The results of the above CBA show that the Karian Dam project has an economic feasibility. Compared to Scenario 1, Scenario 2 reflects environmental costs in the CBA. And all the indices of the economic analysis say that the project is still sound for investment. Both cases have a positive NPV, respectively. B/C ratios are more than 1, and EIRRs exceed the discount rate. Environmental values affect to reduce the net benefits. But the SI and the SV indicate that the project is not sensitive to the indirect costs, but to the sales benefit of raw water in the dam reservoir. The effect by the benefit from water supply is so powerful that acceptability of the Scenario 2 is same with that of the Scenario 1.

It is uncertain whether the benefit overwhelms other variables, either by the high priced water tariffs or massive flows of the supply. Therefore, the benefit would be subject to adjustment if there are no follow-up actions such as in control of water leakage and connection of water transmission pipelines. In addition, the indirect costs reflected in the losses of environmental values should not be limited to those occurring during the operation period. But they need to be analyzed to include the construction period or the post-project period in the CBA to fully understand the reality.

Finally, it is necessary to consider what discount rate would be applied to future environmental costs. A dam project has long-term impacts around the site, so that a lower rate would be applied to conversion of the indirect costs in the future to the present values. According to the Guideline of Economic Analysis on KOICA Projects (2017), multilateral development banks (MDB)[19] have recently adopted different discount rates beside conventional discount rates, 10-15%, to reflect the real effects of projects, especially projects that highly generate social and environmental benefits and costs.

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[19] In 2017, ADB revised the discount rate from 12% to 9% because it attributes to improved income levels in Asian developing countries and lowered borrowing costs. Also the application was made by increases of the projects that give long-term impacts in social and environmental aspects (Ibid. 2017, 35).

CONCLUSION

For this research, I examined the economic feasibility of the Korean ODA funded dam project in progress with a hypothesis that environmental impacts valuated in the CBA are not powerful enough to reject the original decision for investment. My hypothesis is proved by the positive NPV, EIRR greater than the applied discount rate, and B/C ratio more than 1 in the alternative case. But the net benefit is reduced by 21% with insertion of the indirect costs. If the flood control benefit could be measured and counted in the CBA, the result would be close to the status quo. Furthermore, afforestation or a recreational spot development in the riparian area would make the project scheme increase indirect benefits leading to expansion of economic welfare.

The Karian Dam project has also significant impacts at the social perspective. The KOICA's F/S report (2006) indicates that costs of compensation for the losses of livelihood and of job training for rehabilitation are included for the resettled villages. Although these are highly appreciated, the disbursement or operation of the programs should be implemented and managed in a sustainable and systematic manner. According to the JICA's F/S report (1985), most of the residents as farmers, were reluctant to leave their economic bases. Accordingly, it is necessary to involve an extra program fostering their economic abilities such as manufacturing or service skills in the secondary or tertiary industries, in case that the farming in the relocated area cannot be secured as an income source in the future.

Throughout the study, I hope that the CBA used in the economic analysis of ODA projects will be conducted more accurately in terms of socio-environmental costs and benefits. In the time and money constraints, I showed a way to apply the cost and benefit items quantified in other similar cases. In spite of limits to be directly applied for the differences of the estimated time and regions, a total exclusion of environmental applications by ecosystem complexity, uncertainty, and ignorance will detract the reliability of the CBA results. In particular, projects that have significant social and environmental impacts, such as dam construction, should apply a proper valuation method to quantify the values in association with other analyses including the CEA or risk assessment. Otherwise, the donor agencies can face future problems because of the factors that threaten the aid effectiveness.

In conclusion, the Karian Dam remains economically sound for investment since the CBA with environmental valuation has a same result with the original case. However, it is not clear if the project would be continuously acceptable when all the variables in social and environmental aspects are counted in the CBA. As one of critical factor in the project appraisal, mainstreaming the indirect impacts already becomes important. Finally, as a policy implication, attempts to accommodate the EIA (environmental impact assessment) into the CBA are needed. If so, qualitative EIA results are incorporated with the quantitative cost and benefit information, allowing a more comprehensive CBA that does not depend solely on the NPV or B/C ratio.

APPENDICES

Summary of Construction Costs for Karian Dam

No.	Description of Works	Total Amount (Rp.)	Local (%)	Foreign (%)	Local Amount	Local → BPV (A)	Foreign Amount (B)	Total (A+B)
1	**Karian Dam**							
1.1	Construction of Dam & Appurtenant							
1.1.1.	General Items	5,897,244,843	87%	13%	5,130,603,013	1,131,990,189	766,641,830	1,898,632,018
1.1.2.	River Diversion	56,840,890,468	87%	13%	49,451,574,707	10,910,744,261	7,389,315,761	18,300,060,022
1.1.3.	Main Dam & Saddle Dam	215,577,029,725	87%	13%	187,552,015,861	41,380,524,134	28,025,013,864	69,405,537,999
1.1.4.	Spillway	107,216,707,777	87%	13%	93,278,535,766	20,580,502,336	13,938,172,011	34,518,674,347
1.1.5.	Intake & Outlet Facilities	12,969,947,028	87%	13%	11,283,853,914	2,489,612,213	1,686,093,114	4,175,705,326
1.1.6.	Hydromechanical Works	47,895,000,000	87%	13%	41,668,650,000	9,193,559,286	6,226,350,000	15,419,909,286
1.1.7.	Road Works	63,028,285,500	87%	13%	54,834,608,385	12,098,429,469	8,193,677,115	20,292,106,584
1.1.8.	Building Works	5,924,346,000	87%	13%	5,154,181,020	1,137,192,320	770,164,980	1,907,357,300
1.1.9.	Electrical Works	59,566,379,585	87%	13%	51,822,750,239	11,433,908,386	7,743,629,346	19,177,537,732
1.1.10.	Telecommunication & Control	3,857,267,146	87%	13%	3,355,822,417	740,411,613	501,444,729	1,241,856,342
1.1.11.	Landscape Works	1,500,000,000	87%	13%	1,305,000,000	287,928,571	195,000,000	482,928,571
1.1.12.	Operation & Maintenance Equipment	823,500,000	87%	13%	716,445,000	158,072,786	107,055,000	265,127,786
Subtotal 1.		**581,096,598,072**	87%	13%	**505,554,040,323**	**111,542,875,563**	**75,542,557,749**	**187,085,433,313**
2	**Water Conveyance System**							
2.1	Construction of Waterway							
2.1.1	General Items	31,244,260,296	86%	14%	26,870,063,855	5,928,474,406	4,374,196,441	10,302,670,847
2.1.2	Ciuyah Tunnel & Intake Shaft	89,029,297,363	86%	14%	76,565,195,732	16,892,955,884	12,464,101,631	29,357,057,515
2.1.3	Waterway Pipeline System	832,170,527,717	86%	14%	715,666,653,837	157,901,055,370	116,503,873,880	274,404,929,251
2.1.4	Booster Pump Station	73,644,595,578	86%	14%	63,334,352,197	13,973,769,770	10,310,243,381	24,284,013,151
2.1.5	Electrical Works	39,122,051,344	86%	14%	33,644,964,156	7,423,253,996	5,477,087,188	12,900,341,184
Subtotal 2.		**1,065,210,732,298**	86%	14%	**916,081,229,776**	**202,119,509,427**	**149,129,502,522**	**351,249,011,949**
Total								**538,334,445,261**

Summary of Project Costs for Karian Dam

No.	Description of Works	Total Amount (Rp.)	Rate (%)
1	**Karian Dam**		
1.1	Construction of Dam & Appurtenant	187,085,433,313	
1.1.1.	Engineering Service	24,321,106,331	13% of 1.1
1.1.2.	Administrative Expenses	9,354,271,666	5% of 1.1
1.1.3.	Physical Contingency	18,708,543,331	10% of 1.1
Subtotal 1.		**239,469,354,640**	
2	**Water Conveyance System**		
2.1	Construction of Waterway	351,249,011,949	
2.1.1.	Engineering Service	45,662,371,553	13% of 2.1
2.1.2.	Administrative Expenses	17,562,450,597	5% of 2.1
2.1.3.	Physical Contingency	35,124,901,195	10% of 2.1
Subtotal 2.		**449,598,735,294**	
3	**Compensation Cost**		
3.1.	Compensation for Resettlement	58,166,204,762	
Subtotal 3.		**58,166,204,762**	
4	**Operation &Maintenance Cost**		
4.1	Karian Dam	1,870,854,333	1% of 1.1
4.2	Water Conveyance System	3,512,490,119	1% of 2.1
Subtotal 4.		**5,383,344,453**	
Total		**752,617,639,149**	

Estimated Benefit from Municipal & Industrial Water Supply

Life Span	Year	Sales Water Price (A) (Rp./㎥)	Raw Water Price (B) (Rp./㎥)	Benefit of Raw Water Price (A-B) (Rp./㎥)	Production Water Supply per year (㎥)	Total Benefit of Water Supply (million Rp.)
Total		**81,985**	**30,773**	**51,212**	**23,021,280,000**	**23,579,266**
1	2012	1,340	503	837	460,425,600	385,398
2	2013	1,351	507	844	460,425,600	388,482
3	2014	1,362	511	850	460,425,600	391,589
4	2015	1,372	515	857	460,425,600	394,722
5	2016	1,383	519	864	460,425,600	397,880
6	2017	1,394	523	871	460,425,600	401,063
7	2018	1,406	528	878	460,425,600	404,271
8	2019	1,417	532	885	460,425,600	407,506
9	2020	1,428	536	892	460,425,600	410,766
10	2021	1,440	540	899	460,425,600	414,052
11	2022	1,451	545	906	460,425,600	417,364
12	2023	1,463	549	914	460,425,600	420,703
13	2024	1,474	553	921	460,425,600	424,069
14	2025	1,486	558	928	460,425,600	427,461
15	2026	1,498	562	936	460,425,600	430,881
16	2027	1,510	567	943	460,425,600	434,328
17	2028	1,522	571	951	460,425,600	437,803
18	2029	1,534	576	958	460,425,600	441,305
19	2030	1,547	581	966	460,425,600	444,836
20	2031	1,559	585	974	460,425,600	448,394
21	2032	1,572	590	982	460,425,600	451,981
22	2033	1,584	595	990	460,425,600	455,597
23	2034	1,597	599	997	460,425,600	459,242
24	2035	1,610	604	1,005	460,425,600	462,916
25	2036	1,622	609	1,013	460,425,600	466,619
26	2037	1,635	614	1,022	460,425,600	470,352
27	2038	1,648	619	1,030	460,425,600	474,115
28	2039	1,662	624	1,038	460,425,600	477,908
29	2040	1,675	629	1,046	460,425,600	481,731
30	2041	1,688	634	1,055	460,425,600	485,585
31	2042	1,702	639	1,063	460,425,600	489,470
32	2043	1,715	644	1,072	460,425,600	493,385
33	2044	1,729	649	1,080	460,425,600	497,333
34	2045	1,743	654	1,089	460,425,600	501,311
35	2046	1,757	659	1,098	460,425,600	505,322

36	2047	1,771	665	1,106	460,425,600	509,364
37	2048	1,785	670	1,115	460,425,600	513,439
38	2049	1,800	675	1,124	460,425,600	517,547
39	2050	1,814	681	1,133	460,425,600	521,687
40	2051	1,828	686	1,142	460,425,600	525,861
41	2052	1,843	692	1,151	460,425,600	530,067
42	2053	1,858	697	1,160	460,425,600	534,308
43	2054	1,873	703	1,170	460,425,600	538,582
44	2055	1,888	709	1,179	460,425,600	542,891
45	2056	1,903	714	1,189	460,425,600	547,234
46	2057	1,918	720	1,198	460,425,600	551,612
47	2058	1,933	726	1,208	460,425,600	556,025
48	2059	1,949	731	1,217	460,425,600	560,473
49	2060	1,964	737	1,227	460,425,600	564,957
50	2061	1,980	743	1,237	460,425,600	569,477

Cost & Benefit Flow (Scenario 1)

(Unit: million Rp.)

No.	Year	Cost		Total Cost	Total Benefit	Net Benefit
		Construction Cost	Operating Cost			
Total		**747,234**	**519,886**	**1,267,120**	**23,579,266**	**22,312,145**
1	2005	4,845	-	4,845	-	- 4,845
2	2006	4,845	-	4,845	-	- 4,845
3	2007	9,690	-	9,690	-	- 9,690
4	2008	196,505	-	196,505	-	- 196,505
5	2009	196,505	-	196,505	-	- 196,505
6	2010	167,422	-	167,422	-	- 167,422
7	2011	167,422	-	167,422	-	- 167,422
8	2012		9,498	9,498	385,398	375,901
9	2013		9,498	9,498	388,482	378,984
10	2014		9,498	9,498	391,589	382,092
11	2015		9,498	9,498	394,722	385,225
12	2016		9,498	9,498	397,880	388,382
13	2017		9,498	9,498	401,063	391,565
14	2018		9,498	9,498	404,271	394,774
15	2019		9,498	9,498	407,506	398,008
16	2020		9,498	9,498	410,766	401,268
17	2021		9,498	9,498	414,052	404,554
18	2022		9,498	9,498	417,364	407,867
19	2023		9,498	9,498	420,703	411,206
20	2024		9,498	9,498	424,069	414,571
21	2025		9,498	9,498	427,461	417,964
22	2026		9,498	9,498	430,881	421,383
23	2027		9,498	9,498	434,328	424,831
24	2028		9,498	9,498	437,803	428,305
25	2029		9,498	9,498	441,305	431,808
26	2030		9,498	9,498	444,836	435,338
27	2031		9,498	9,498	448,394	438,897
28	2032		32,003	32,003	451,981	419,979
29	2033		9,498	9,498	455,597	446,100
30	2034		9,498	9,498	459,242	449,744
31	2035		9,498	9,498	462,916	453,418
32	2036		9,498	9,498	466,619	457,122
33	2037		9,498	9,498	470,352	460,855
34	2038		9,498	9,498	474,115	464,617
35	2039		9,498	9,498	477,908	468,410

36	2040		9,498	9,498	481,731	472,234
37	2041		9,498	9,498	485,585	476,088
38	2042		9,498	9,498	489,470	479,972
39	2043		9,498	9,498	493,385	483,888
40	2044		9,498	9,498	497,333	487,835
41	2045		9,498	9,498	501,311	491,814
42	2046		9,498	9,498	505,322	495,824
43	2047		9,498	9,498	509,364	499,867
44	2048		9,498	9,498	513,439	503,942
45	2049		9,498	9,498	517,547	508,049
46	2050		9,498	9,498	521,687	512,190
47	2051		9,498	9,498	525,861	516,363
48	2052		9,498	9,498	530,067	520,570
49	2053		9,498	9,498	534,308	524,810
50	2054		9,498	9,498	538,582	529,085
51	2055		9,498	9,498	542,891	533,394
52	2056		9,498	9,498	547,234	537,737
53	2057		9,498	9,498	551,612	542,115
54	2058		9,498	9,498	556,025	546,528
55	2059		9,498	9,498	560,473	550,976
56	2060		9,498	9,498	564,957	555,460
57	2061		32,003	32,003	569,477	537,474

Cost & Benefit Flow (Scenario 2)

(Unit: million Rp.)

No.	Year	Cost				Total Cost	Total Benefit	Net Benefit
		Direct Cost	Agricultural Product Loss	Biodiversity Loss	Carbon Storage Loss			
Total		**1,267,120**	**482,021**	**3,017,176**	**1,307,443**	**6,073,760**	**23,579,266**	**17,505,506**
1	2005	4,845	-	-	-	4,845	-	- 4,845
2	2006	4,845	-	-	-	4,845	-	- 4,845
3	2007	9,690	-	-	-	9,690	-	- 9,690
4	2008	196,505	-	-	-	196,505	-	- 196,505
5	2009	196,505	-	-	-	196,505	-	- 196,505
6	2010	167,422	-	-	-	167,422	-	- 167,422
7	2011	167,422	-	-	-	167,422	-	- 167,422
8	2012	9,498	9,640	60,344	26,149	105,630	385,398	279,768
9	2013	9,498	9,640	60,344	26,149	105,630	388,482	282,851
10	2014	9,498	9,640	60,344	26,149	105,630	391,589	285,959
11	2015	9,498	9,640	60,344	26,149	105,630	394,722	289,092
12	2016	9,498	9,640	60,344	26,149	105,630	397,880	292,250
13	2017	9,498	9,640	60,344	26,149	105,630	401,063	295,433
14	2018	9,498	9,640	60,344	26,149	105,630	404,271	298,641
15	2019	9,498	9,640	60,344	26,149	105,630	407,506	301,875
16	2020	9,498	9,640	60,344	26,149	105,630	410,766	305,135
17	2021	9,498	9,640	60,344	26,149	105,630	414,052	308,421
18	2022	9,498	9,640	60,344	26,149	105,630	417,364	311,734
19	2023	9,498	9,640	60,344	26,149	105,630	420,703	315,073
20	2024	9,498	9,640	60,344	26,149	105,630	424,069	318,438
21	2025	9,498	9,640	60,344	26,149	105,630	427,461	321,831
22	2026	9,498	9,640	60,344	26,149	105,630	430,881	325,251
23	2027	9,498	9,640	60,344	26,149	105,630	434,328	328,698
24	2028	9,498	9,640	60,344	26,149	105,630	437,803	332,172
25	2029	9,498	9,640	60,344	26,149	105,630	441,305	335,675
26	2030	9,498	9,640	60,344	26,149	105,630	444,836	339,205
27	2031	9,498	9,640	60,344	26,149	105,630	448,394	342,764
28	2032	32,003	9,640	60,344	26,149	128,135	451,981	323,846
29	2033	9,498	9,640	60,344	26,149	105,630	455,597	349,967
30	2034	9,498	9,640	60,344	26,149	105,630	459,242	353,612
31	2035	9,498	9,640	60,344	26,149	105,630	462,916	357,286
32	2036	9,498	9,640	60,344	26,149	105,630	466,619	360,989
33	2037	9,498	9,640	60,344	26,149	105,630	470,352	364,722
34	2038	9,498	9,640	60,344	26,149	105,630	474,115	368,485
35	2039	9,498	9,640	60,344	26,149	105,630	477,908	372,278

36	2040	9,498	9,640	60,344	26,149	105,630	481,731	376,101
37	2041	9,498	9,640	60,344	26,149	105,630	485,585	379,955
38	2042	9,498	9,640	60,344	26,149	105,630	489,470	383,839
39	2043	9,498	9,640	60,344	26,149	105,630	493,385	387,755
40	2044	9,498	9,640	60,344	26,149	105,630	497,333	391,702
41	2045	9,498	9,640	60,344	26,149	105,630	501,311	395,681
42	2046	9,498	9,640	60,344	26,149	105,630	505,322	399,691
43	2047	9,498	9,640	60,344	26,149	105,630	509,364	403,734
44	2048	9,498	9,640	60,344	26,149	105,630	513,439	407,809
45	2049	9,498	9,640	60,344	26,149	105,630	517,547	411,916
46	2050	9,498	9,640	60,344	26,149	105,630	521,687	416,057
47	2051	9,498	9,640	60,344	26,149	105,630	525,861	420,230
48	2052	9,498	9,640	60,344	26,149	105,630	530,067	424,437
49	2053	9,498	9,640	60,344	26,149	105,630	534,308	428,678
50	2054	9,498	9,640	60,344	26,149	105,630	538,582	432,952
51	2055	9,498	9,640	60,344	26,149	105,630	542,891	437,261
52	2056	9,498	9,640	60,344	26,149	105,630	547,234	441,604
53	2057	9,498	9,640	60,344	26,149	105,630	551,612	445,982
54	2058	9,498	9,640	60,344	26,149	105,630	556,025	450,395
55	2059	9,498	9,640	60,344	26,149	105,630	560,473	454,843
56	2060	9,498	9,640	60,344	26,149	105,630	564,957	459,327
57	2061	32,003	9,640	60,344	26,149	128,135	569,477	441,341

Sensitivity Analysis (Scenario 1)

(Unit: million Rp.)

No.	Year	Base Case	Case 1 Operating Cost +10%	Case 2 Operating Cost +20%	Case 3 Sales Benefit -10%	Case 4 Sales Benefit - 20%	Case 2 + Case4
EIRR (%)		**31.13**	**31.08**	**31.03**	**28.97**	**26.69**	**26.57**
NPV		**1,231,840**	**1,227,735**	**1,223,629**	**1,058,404**	**884,968**	**876,757**
SI		**-**	**0.03**	**0.03**	**1.41**	**1.41**	**0.72**
1	2005	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845
2	2006	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845
3	2007	- 9,690	- 9,690	- 9,690	- 9,690	- 9,690	- 9,690
4	2008	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505
5	2009	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505
6	2010	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422
7	2011	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422
8	2012	375,901	374,951	374,001	337,361	298,821	296,922
9	2013	378,984	378,034	377,085	340,136	301,288	299,388
10	2014	382,092	381,142	380,192	342,933	303,774	301,874
11	2015	385,225	384,275	383,325	345,752	306,280	304,381
12	2016	388,382	387,433	386,483	348,594	308,806	306,907
13	2017	391,565	390,616	389,666	351,459	311,353	309,453
14	2018	394,774	393,824	392,874	354,347	313,920	312,020
15	2019	398,008	397,058	396,109	357,258	316,507	314,607
16	2020	401,268	400,318	399,369	360,192	319,115	317,215
17	2021	404,554	403,605	402,655	363,149	321,744	319,844
18	2022	407,867	406,917	405,967	366,130	324,394	322,494
19	2023	411,206	410,256	409,306	369,135	327,065	325,165
20	2024	414,571	413,621	412,672	372,164	329,757	327,858
21	2025	417,964	417,014	416,064	375,218	332,472	330,572
22	2026	421,383	420,434	419,484	378,295	335,207	333,308
23	2027	424,831	423,881	422,931	381,398	337,965	336,065
24	2028	428,305	427,355	426,406	384,525	340,745	338,845
25	2029	431,808	430,858	429,908	387,677	343,547	341,647
26	2030	435,338	434,388	433,438	390,854	346,371	344,471
27	2031	438,897	437,947	436,997	394,057	349,218	347,318
28	2032	419,979	416,779	413,578	374,781	329,583	323,182
29	2033	446,100	445,150	444,200	400,540	354,980	353,081
30	2034	449,744	448,795	447,845	403,820	357,896	355,997
31	2035	453,418	452,469	451,519	407,127	360,835	358,936
32	2036	457,122	456,172	455,222	410,460	363,798	361,898
33	2037	460,855	459,905	458,955	413,819	366,784	364,885

34	2038	464,617	463,668	462,718	417,206	369,794	367,895
35	2039	468,410	467,461	466,511	420,620	372,829	370,929
36	2040	472,234	471,284	470,334	424,061	375,887	373,988
37	2041	476,088	475,138	474,188	427,529	378,971	377,071
38	2042	479,972	479,022	478,073	431,025	382,078	380,179
39	2043	483,888	482,938	481,988	434,549	385,211	383,311
40	2044	487,835	486,885	485,936	438,102	388,369	386,469
41	2045	491,814	490,864	489,914	441,683	391,551	389,652
42	2046	495,824	494,874	493,925	445,292	394,760	392,860
43	2047	499,867	498,917	497,967	448,930	397,994	396,094
44	2048	503,942	502,992	502,042	452,598	401,254	399,354
45	2049	508,049	507,099	506,150	456,295	404,540	402,640
46	2050	512,190	511,240	510,290	460,021	407,852	405,953
47	2051	516,363	515,413	514,464	463,777	411,191	409,291
48	2052	520,570	519,620	518,670	467,563	414,556	412,657
49	2053	524,810	523,861	522,911	471,380	417,949	416,049
50	2054	529,085	528,135	527,185	475,227	421,368	419,469
51	2055	533,394	532,444	531,494	479,105	424,815	422,916
52	2056	537,737	536,787	535,837	483,013	428,290	426,390
53	2057	542,115	541,165	540,215	486,953	431,792	429,893
54	2058	546,528	545,578	544,628	490,925	435,323	433,423
55	2059	550,976	550,026	549,076	494,928	438,881	436,982
56	2060	555,460	554,510	553,560	498,964	442,468	440,569
57	2061	537,474	534,274	531,074	480,527	423,579	417,178

Sensitivity Analysis (Scenario 2)

(Unit: million Rp.)

No.	Year	Base Case	Case 1 Indirect Cost +10%	Case 2 Indirect Cost +20%	Case 3 Sales Benefit -10%	Case 4 Sales Benefit -20%	Case 1 + Case 3	Case 2 + Case 4
EIRR (%)		25.69	25.11	24.51	23.21	20.55	22.58	19.21
NPV		827,379	786,933	746,487	653,943	480,507	613,497	399,614
SI		-	0.49	0.49	2.10	2.10	1.29	1.29
1	2005	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845
2	2006	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845	- 4,845
3	2007	- 9,690	- 9,690	- 9,690	- 9,690	- 9,690	- 9,690	- 9,690
4	2008	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505
5	2009	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505	- 196,505
6	2010	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422
7	2011	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422	- 167,422
8	2012	279,768	270,155	260,541	241,228	202,688	231,615	183,462
9	2013	282,851	273,238	263,625	244,003	205,155	234,390	185,928
10	2014	285,959	276,346	266,733	246,800	207,641	237,187	188,415
11	2015	289,092	279,479	269,865	249,620	210,147	240,006	190,921
12	2016	292,250	282,636	273,023	252,462	212,674	242,848	193,447
13	2017	295,433	285,819	276,206	255,326	215,220	245,713	195,993
14	2018	298,641	289,028	279,415	258,214	217,787	248,601	198,560
15	2019	301,875	292,262	282,649	261,125	220,374	251,511	201,148
16	2020	305,135	295,522	285,909	264,059	222,982	254,445	203,756
17	2021	308,421	298,808	289,195	267,016	225,611	257,403	206,385
18	2022	311,734	302,121	292,507	269,997	228,261	260,384	209,034
19	2023	315,073	305,460	295,846	273,002	230,932	263,389	211,706
20	2024	318,438	308,825	299,212	276,032	233,625	266,418	214,398
21	2025	321,831	312,218	302,604	279,085	236,339	269,472	217,112
22	2026	325,251	315,637	306,024	282,163	239,074	272,549	219,848
23	2027	328,698	319,084	309,471	285,265	241,832	275,652	222,606
24	2028	332,172	322,559	312,946	288,392	244,612	278,779	225,385
25	2029	335,675	326,061	316,448	291,544	247,414	281,931	228,187
26	2030	339,205	329,592	319,979	294,722	250,238	285,108	231,012
27	2031	342,764	333,151	323,537	297,924	253,085	288,311	233,858
28	2032	323,846	314,233	304,619	278,648	233,450	269,035	214,223
29	2033	349,967	340,354	330,740	304,407	258,847	294,794	239,621
30	2034	353,612	343,998	334,385	307,687	261,763	298,074	242,537
31	2035	357,286	347,672	338,059	310,994	264,702	301,381	245,476
32	2036	360,989	351,376	341,762	314,327	267,665	304,714	248,439
33	2037	364,722	355,109	345,495	317,687	270,651	308,073	251,425

34	2038	368,485	358,871	349,258	321,073	273,662	311,460	254,435
35	2039	372,278	362,664	353,051	324,487	276,696	314,874	257,469
36	2040	376,101	366,488	356,874	327,928	279,755	318,314	260,528
37	2041	379,955	370,341	360,728	331,396	282,838	321,783	263,611
38	2042	383,839	374,226	364,613	334,892	285,945	325,279	266,719
39	2043	387,755	378,142	368,529	338,417	289,078	328,803	269,852
40	2044	391,702	382,089	372,476	341,969	292,236	332,356	273,009
41	2045	395,681	386,068	376,454	345,550	295,419	335,937	276,192
42	2046	399,691	390,078	380,465	349,159	298,627	339,546	279,400
43	2047	403,734	394,121	384,507	352,798	301,861	343,184	282,635
44	2048	407,809	398,196	388,582	356,465	305,121	346,852	285,894
45	2049	411,916	402,303	392,690	360,162	308,407	350,548	289,180
46	2050	416,057	406,443	396,830	363,888	311,719	354,275	292,493
47	2051	420,230	410,617	401,004	367,644	315,058	358,031	295,832
48	2052	424,437	414,824	405,211	371,430	318,424	361,817	299,197
49	2053	428,678	419,064	409,451	375,247	321,816	365,634	302,590
50	2054	432,952	423,339	413,726	379,094	325,236	369,481	306,009
51	2055	437,261	427,648	418,034	382,972	328,683	373,358	309,456
52	2056	441,604	431,991	422,377	386,881	332,157	377,267	312,931
53	2057	445,982	436,369	426,755	390,821	335,659	381,207	316,433
54	2058	450,395	440,781	431,168	394,792	339,190	385,179	319,963
55	2059	454,843	445,230	435,616	398,796	342,748	389,182	323,522
56	2060	459,327	449,713	440,100	402,831	346,335	393,218	327,109
57	2061	441,341	431,728	422,115	384,394	327,446	374,780	308,219

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