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RISK IMPACT ANALYSIS ON THE INVESTMENT OF DRINKING WATER SUPPLY SYSTEM DEVELOPMENT USING PROJECT RISK MANAGEMENT

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ABSTRACT

The development of a water supply system requires a high investment cost, and financial, environmental, and institutional aspects need to be considered. As major projects involving many stakeholders, drinking water supply projects become vulnerable to risks. A risk-based analysis is required to reduce the likelihood of failure in both the operational and financial aspects of such projects. This study describes the process of risk management planning for a drinking water supply system construction project in South Bali. The case study is based on the project risk management method with the value at risk to calculate the impact of risks in project investment. The purpose of this study is to obtain a financial risk model that maps potential risk factors and calculates the financial impact of risks on the project. This is used to create alternative strategies to reduce the impact of risks on investment made during the development of the project. The analysis showed that of the three priority risk factors, production capacity has the greatest influence on the net present value of the project.

Keywords: Drinking water supply system; Financial risk model; Project risk management; Risk; Value-at-risk

1. INTRODUCTION

The development of a water supply system requires a high investment cost, and financial, environmental, and institutional aspects need to be considered as well. As major projects involving many stakeholders, drinking water supply projects are vulnerable to risks. Elkington and Smallman (2002) have argued that projects in the utilities sector, including water, power, and telecommunication, are less predictable and perceived to be riskier than common business activities. This leads to the need for a risk management approach in water industries, including water treatment plant design, operations, and better integration within the core business, to provide safe and decent drinking water for consumers (Hrudey et al., 2006).Risk analysis has become an important approach in engineering economics to suggest the existence of risk and uncertainty in engineering decisions and to quantify that risk (Smith, 1999). The Project Risk Management Handbook (2003) defined risk management as a systematic process of planning for, identifying, analyzing, responding to, and monitoring project risks. Risk management has been widely applied in various types of projects, particularly on large construction projects to reduce uncertainties and achieve project success (Wyk et al., 2008).

This study describes the process of risk management planning for a drinking water supply

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system construction project in South Bali. The construction of a water supply system in South Bali will be carried out as an effort to develop new water sources to meet future needs. This has become a concern because, as a center of tourism in Bali, Bali's southern region, which roughly consists of Denpasar, Tabanan, Gianyar, Tabanan, and Klungkung, continues to grow, both in terms of population- and tourism-supporting facilities, it has resulted in an increasing need for drinking water every year. In practice, drinking water supply system development requires very high investment costs, which leads to a problem in financing the project, as water utilities (PDAM) have a limited investment capacity to develop new water sources. Therefore, the local government and PDAM in South Bali are currently conducting a review of the merger with private sector in managing, regulating, and financing the water supply in the form of Build Operate Transfer (BOT). With such a high value of investments and the involvement of many stakeholders, drinking water supply projects pose many risks. The existence of various kinds of risks that may not have been fully mapped out can reduce investors' level of confidence when investing in a project.

Several studies have been done on risk analysis and management in the utility sectors. Wyk et al. (2008) presented and documented the process of managing risk associated with a project from risk identification until risk response implementation (Wyk et al., 2008). Other studies have focused on analyzing and assessing how risk management could affect a project's success (Elkington & Smallman, 2002; Teller & Kock, 2013). Specifically for water utilities, research related to risk management has included the review of frameworks and the analysis of tools and techniques (Pollard et al., 2004), as well as the identification of the hazards that could result from operational activities as a preventive means of ensuring safe drinking water (Hokstad, et al., 2009; Hrudey et al., 2006). However, only a few studies have examined risk management practices from a financial and investment perspective, as highlighted in this study. The current writings about risk in financing water supply projects mainly describe the theoretical frameworks, such as risk types (Khoe, n.d.), and the strategies used to manage them (Haarmeyer & Mody, 1998). Thus, this paper is an attempt to fill in this gap by presenting the use of risk management to analyze and measure the impact of potential risks to project investment.

The purpose of this study is to obtain a financial risk model that maps potential risk factors and calculates the financial impact of risks on the project to create alternative risk impact reductions of investments made during the development of the water supply system project in South Bali. To this extent, the research could contribute to engineering economy knowledge by examining the risk management application in such a wide-scale construction project, specifically in water supply system development. Another aim of the paper is also to demonstrate how certain risk analyses and tools could be performed to resolve an engineering economy problem. By mapping all the risk factors and conducting a risk analysis of the project financing, the paper also represents how risk management could be a significant tool to formulate alternative plans in handling the risks (Risk Responses Planning) that could significantly hamper a project.

2. LITERATURE REVIEW

At this time, many companies engaged in the water supply sectors still have weak performances, both internally (organizational) and externally (regulatory) (Haarmeyer & Mody, 1998). The shortcomings in water supply systems are commonly characterized by low operational efficiency, the amount of water losses or non-revenue water, the excess charge of human resources, poor water quality, low service coverage, etc (Baietti & Raymond, 2005). The low quality of management, accompanied by the high costs incurred, leads to the emergence of privatization in the drinking water supply sectors, which was previously dominated by the public sector. Financing a project through the private sector involves many obstacles in terms of regulations, the determination of tariffs, and so on. However, more funding support from the private sector can significantly benefit water supply systems by helping them to improve the efficiency of their operations and services.

Water assets often last 30–50 years, with a depreciation of 3–5% per year; to keep tariff levels low, the payback period (PP) of the investment is usually amortized over 15–30 years (Haarmeyer & Mody, 1998). The World Panel on Financing Water Infrastructure also reported that the ratio of investment to income worth is 70% higher for water than electricity, which means it takes a long time to return the investments made (Khoe, n.d.). This could affect the attractiveness of investing in these water supply projects. Therefore, understanding the high risk of investing in the water sector thus leads to the need for risk management strategies that can help investors to decide whether to finance a certain project.

Decision making is fraught with risk and uncertainty (Sullivan et al., 2012), which makes risk analysis and management an important approach in engineering economics, particularly for making project investment decisions. Hartman and Enke (2007) broadly defined engineering economy as being concerned with the time value of money and economic decision analysis. Studies are generally tied to capital budgeting decisions and may utilize decision criteria, such as the present worth or the internal rate of return, sensitivity analysis, simulation, and even mathematical programming (advanced studies) to make investment decisions (Hartman & Enke, 2007). Engineering economics courses and textbooks have typically acknowledged the existence of the role of risk in economic decision making (Smith, 1999). Sullivan, Wicks, and Koelling (2012) found that there are four major sources of uncertainty in engineering economy studies. These include the possible inaccuracy of cash-flow estimates, the type of business involved in relation to the future health of the economy, the type of physical plant and equipment involved, and the length of the study period used in the analysis (Sullivan et al, 2012).

In drinking water supply projects, the risks that have been identified are essentially concerned with the quality of drinking water produced. Hrudey et al. (2006) revealed that the potential danger that becomes the key factor in the water sector is the failure to provide safe drinking water for communities. In fact, there have been many cases of microbial and chemical contamination in drinking water that have resulted in diseases and many deaths. This has motivated water companies to continually monitor water quality by minimizing the risk of contamination in drinking water supplies (Hamilton et al., 2006). In addition, risk management is needed not only in the context of ensuring safe drinking water, but also in maximizing the availability, serviceability and life of their assets and minimizing expenditures on energy, chemicals, and processes (Hrudey et al., 2006). Therefore, risk management should be applied to the entire drinking water supply process, starting from the catchment, treatment, distribution, and ending at the customer plumbing system.

In the context of project financing in the water sector, Khoe (Khoe, n.d.) suggested six significant risks that must be considered, namely the completion risk, market risk, operational risk, currency exchange risk, political risk, and environmental risk. The thing to note is that a high investment in water supply projects also entails a high risk for the lenders, particularly political risks if the projects are located in developing countries (Khoe, n.d.). This is also exacerbated by the fact that water is an essential requirement for life; as such, water suppy projects have extensive social benefits, which then also has an impact on the low financial rates of return in this sector.

The application of risk management to a drinking water supply project could be assessed through a qualitative analysis, consisting of the lists of project risks and their impacts, as well as a quantitative analysis, including a financial risk model and risk assessment of the project. This analysis would show the maximum loss that may occur as a result of the potential risks identified in the project. Shortly, the study tried to implement project risk management in a water supply system construction project in Bali and find out how this method can show the impact of identified risks to the financial value of the project.

3. METHODOLOGY

This study used the project risk management method with the value-at-risk (VaR) tool to calculate the impact of risks on investment. Project risk management is a part of risk management. In project risk management, a company or organization is usually focused on reducing the risks of overtime and over budget. In the implementation of project risk management, there are two main processes involved: risk management planning and risk monitoring and control (Caltrans, 2003). This study focused on the process of risk management planning, which involves four activities: risk identification, qualitative and quantitative risk analyses, as well as risk response planning. As many prior studies in the water utilities sector have explored risk identification and the mitigation strategies, we attempted to measure the impact of priority risks based on a qualitative analysis of the financial value of the project. Thus, the results will form the basis for planning risk response actions, which are urged to be carried out in this project.

In the early stages of project risk management, risk identification was conducted to collect information about the risks that may occur during the process of construction of the water supply system in South Bali. The process of risk identification involved a literature review and interviews with water supply personnel and the owner of the project (the project stakeholders). The risks identified were grouped into the following five typologies: completion risk, political and social risk, financial risk, operational risk, and environmental risk.

Qualitative risk analysis aims to prioritize risks that have been identified for further analysis or mitigation planning (Caltrans, 2003). Risk priority is arranged based on the severity (low, medium, or high), which is determined based on their probability and impact. Tools used in this qualitative risk assessment are the risk register and risk matrix. The main benefit of this process is that managers can reduce the level of uncertainty and focus on the high-priority risks (Project Management Institute, 2013).

Quantitative risk analysis is a way to estimate the effect of risks on the time and cost aspects of a project (Caltrans, 2003). The impacts are determined by calculating the value of a risk into the project feasibility analysis. The financial model is used to calculate the net present value of this project as a parameter determining its financial feasibility. The risk value is calculated using the VAR tool and then simulated into the financial risk model of the water supply project. As this project has not yet started, meaning it has no historical data, the various random input variables were processed using Monte Carlo Simulation to obtain the desired output distribution. The financial model was built in an Microsoft Excel spreadsheet, while the VaR was calculated using @Risk Palisade DecisionTools Suite. One of the outputs of financial models is the annual net cash flow during 20 years of this project economic life, which was determined as the expected period when the assets will still be in a good condition and the system can operate well. The value of this cash flow was used to calculate the desired output parameters of the financial model, such as the NPV, IRR, and PP. The graph of cumulative NPV values of the project is shown in Figure 1.

While building the financial model, all income and expenditures related to the project should be included in the calculations, including investment, operational, and financing income and expenses. After identifying the cost and revenue structures, then the project financial statements were arranged in the form of an income statement (profit and loss) and cash flow.

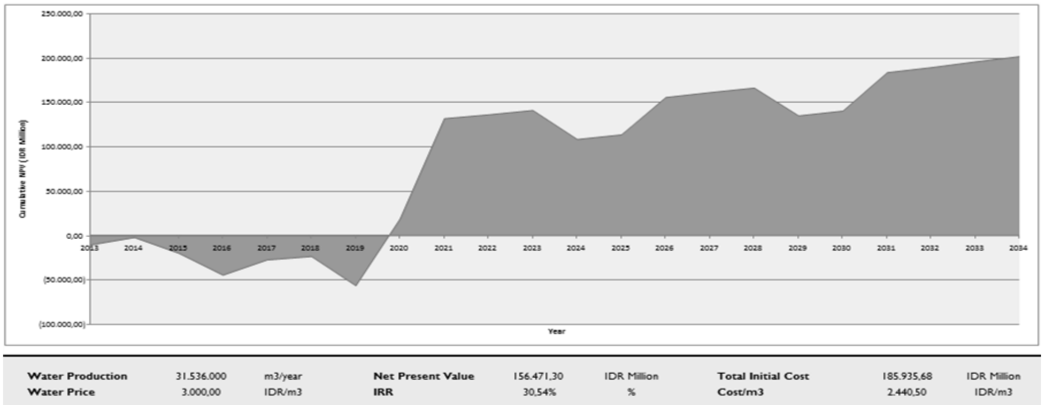

Figure 1 Cumulative NPV graph of the water supply project in South Bali

In this stage, we also needed to determine some assumptions regarding the project profile and the national economic conditions at this time to support the calculations in the financial model. Table 1 shows the assumptions that had previously been determined in this water supply project based on the literature review and project fact sheets.

Table 1 Summary of the assumptions used in the financial risk model

Key Variables	Value	Units
Expected Project Life time	20	year
Project Completion	2	year
Water Supply	1.00	m^3/s
Poduction Capacity	31,536,000	m^3/year
Corporate Tax	30%	%
Depreciation Method	Straight line	
Depreciation	5%	%
Water price	3,000.00	IDR/m^3
Water Price Increased	10%	every 2 year
Electricity price	629.00	IDR/kWh
Exchange Rate	12,000.00	IDR/USD
Inflation Rate	6.96%	%
Minor Refurbishment	20%	of initial investment
Salvage Value	0%	of initial investment
Loan Interest Rate	12%	%
Discount factor	12%	%
MARR	14%	%
Debt Term	5	year

4. RESULTS

We applied the project risk management process to a drinking water supply system project. The risk identification process produced three major risks classified as high risk in the water supply project's construction, which were then be the focus of both in qualitative and quantitative risk analyses. The three risks are production capacity, fluctuations in the Indonesian Rupiah (IDR) exchange rate against the U.S. Dollar (USD), and electricity price changes. The results of the feasibility study on the project's financial model are provided in Table 2. From the data shown, the project seems to be profitable in normal conditions. With a positive NPV, which is 156,471,300,000.00 IDR million, and when the calculated internal rate of return (IRR) 30.54% is greater than the discount rate, the investment will be returned in 5.75 years. Then, the three major risks would become testing variables on the financial model to examine how they affect the project's NPV. After the results were analyzed, an alternative plan was drawn up in response to the risks, which could reduce their impact on the investment made in the water supply system's construction in South Bali.

Table 2 Summary of the financial feasibility parameters of the water supply project in South Bali

Financial Feasibility		
IRR	30.54	%
Payback Period	5.75	yr
Net Present Value – NPV	156,471.30	IDR Million
Annual Life Cycle Savings	20,948.19	IDR Million
Total Cash In	1,595,381.82	IDR Million
Annual Cash In	213,587.77	IDR Million
Total Cash Out	548,510.26	IDR Million
Annual Cash Out	73,433.88	IDR Million
Benefit-Cost (B-C) ratio	2.91	
Debt Term	5.00	Yr
Project debt	251,013.17	IDR Million
Total Debt & Interest Payments	461,864.24	IDR Million

5. DISCUSSION

The world of financial decision making includes many powerful tools and techniques for risk management (Smith, 1999). Several probabilistic methods have been considered useful in analyzing risk and uncertainty associated with engineering economy studies (Sullivan et al., 2012). O'Donnell et al. (2002) stated that investment decisions are typically based on some form of cash-flow analysis, such as the NPV or IRR. The analysis was first performed using the predicted performance of the project over the project life, which can then be handled using a variety of risk analysis techniques, such as the best case/worst case scenarios, Strauss plots, Monte Carlo Simulation, and many others (O'Donnell et al., 2002). This paper further explores risk analysis not only quantitatively, but also qualitatively. Qualitative analysis was performed using a risk register model to map risks that may occur in the project, producing three classifications of risk (high, medium, and low) based on the probability and impact of each risk identified. Quantitative analysis was also conducted by building a financial model with VaR and Monte Carlo Simulation to calculate the impact of risks on investment. The selected methodology is aimed to develop risk response planning to mitigate the potential risks while financing and operating the project.

5.1. Qualitative Risk Analysis

The aim of qualitative risk analysis is to obtain a list of priority risks. Priority is determined according to a risk's classification, whether the particular risk is categorized as low, medium, or high based on its probability of occurrence and impact on the project. We used the risk register and risk matrix to conduct this analysis. The risk register provides the details of all identified risks, along with the results of the risk analysis and risk response planning (Project Management Institute, 2013). There are 20 kinds of risks that might occur in the water supply project in South Bali, with 6 risks categorized as high, 5 categorized as medium, and 9 classified as low risks.

There are three priority risks considered high risks, which are the focus of the analysis, including the risk of the drinking water production capacity (ID 12), fluctuations in the IDR exchange rate against the USD, (ID 08) and electricity price increases (ID 20). The three other high risks are not further analyzed in this paper, as they are out of the scope of this study, which concerns only risks that directly influence the project's financial value. Before performing quantitative calculations, we also needed to explore the possible impact of these three priority risks on the project's operational and financial activities. Thus, all the important variables for the financial model could be identified clearly in advance.

A production capacity reduction is considered a critical issue for the investors (as fund owners) and water utilities (as consumers of the project). For investors, the production capacity is very influential on the margins obtained, as the only source of income for the drinking water supply project is from the sales of water. For water utilities, a reduction in the drinking water supply can result in a shortage in a community's required water supply. This can then inhibit the operational activities of the taps. A declining production capacity can be caused by several factors. In terms of the installation of water supply systems, a reduction could appear due to low-quality materials, resulting in leaky distribution pipes. Meanwhile, from an operational perspective, it can be caused by damage to the machine or human error in the process of metering the flow of water coming out of the pipe.

Changes in exchange rates, particularly the IDR against the USD, are one of the risks considered to have a high probability of occurring and a major impact on the project's financial value. The reason this risk could have a large effect on the investment made is that all investment costs (CAPEX) and operational costs (OPEX) are incurred mostly in the form of USD. Meanwhile, the revenue generated from water sales to the taps is obtained in Rupiah. Therefore, if there are fluctuations in the exchange rate that weakens the value of the Rupiah in USD, it will increase the price of CAPEX and OPEX components. In addition, this project requires a high investment and high operating costs; thus, increasing expenditures can greatly affect the value of the project's cash flows.

Electricity price increases is one example of financial risk. A significant increase in electricity prices is actually not highly likely. However, a drinking water supply project in South Bali requires a very large level of power consumption, which reached 1.5768 million kWh/year, so a small increase in the electricity tariff per kWh may significantly increase operating costs. For the drinking water supply projects, the price of electricity used is the electricity tariffs for industries (I-4/TT group), which has a power limit of 30,000 kVA or more. In the last five years, the electricity tariff for industries has increased approximately 10% per year. However, the increase in the value of electricity in subsequent years is difficult to predict because it is influenced by policies and subsidies from the government. This is certainly a potential risk that should be considered in the cost calculations in the financial analysis of the drinking water supply project in South Bali.

5.2. Quantitative Risk Analysis

For the quantitative risk analysis, all key risk factors, namely production capacity reductions, IDR exchange rate fluctuations against USD, and electricity tariff increases, which had previously been analyzed qualitatively, became variable values calculated on financial risk models using the VaR. The aim of measuring the risk value using the VaR is to determine the maximum loss that can be obtained when the risk actually occurs. In this study, the output parameters calculated were the NPV, IRR, and PP. However, the analysis was performed only on the impact of risk on the project's NPV. This is because this study only focused on assessing how much the maximum loss derived from the risks on investments made. Thus, the comparison of the NPV values before and after the emergence of risk can directly describe the loss that may be obtained by investors. In addition, the NPV, IRR, and PP always have a fixed relationship; if the NPV increases, the IRR increase, and PP becomes shorter. Thus, if we know the trend of change in the NPV, the trends for the IRR and PP can also be predicted. The summary results for the risk value and the maximum percentage loss in the NPV due to the risk of the three variables are shown in Table 3.

The calculation of the risk values of the production capacity to the financial value of the water supply project is performed using a sensitivity range of -10% to +10%. The graph in Figure 2a shows the effect of changes in the production capacity on the NPV. The figures in the left boundary of the graph show the risk values of the production capacity for the NPV, meaning the worst possible NPV values obtained from the risk of a reduced production capacity of up to 10% is 121,114 IDR million. Or in other words, the maximum loss that may be obtained is 35,357.30 IDR million. The value of this loss is quite large, reaching 22.6% of the value of the NPV in normal circumstances. This shows that a production capacity reduction of up to 10% can result in a twofold decrease in the NPV; therefore, this risk has a considerable influence on the project's financial value.

Table 3 Summary of the losses obtained from each risk on the NPV

Risk event	Maximum losses on NPV (IDR Million)	% losses on NPV
Production capacity	35,357.30	22.60%
Exchange rate	16,696.30	10.67%
Electricity price	6,700.30	4.28%
Production capacity and exchange rate	31,230.30	19.96%
Production capacity and electrycity price	38,813.30	24.81%
Exchange rate and electricity price	20,344.30	13.00%
Prod. Capacity, exchange rate, and electricity price	38,944.30	24.89%

The calculation of the risk value for the exchange rate was carried out using a sensitivity range of 9,000.00 IDR as a minimum value to a maximum value of 13,000.00 IDR. The effect of exchange rate fluctuations on the NPV is shown in Figure 2b. The maximum loss that may be obtained from this risk is 16,696.30 IDR million. The value of this loss is still sufficiently large, equivalent to 10.67% of the normal value of the NPV. Fluctuations in the value of the IDR against the USD can be considered a risk that could have a significant impact on the project. Due to the slight increase in the USD exchange rate, the costs involved will go up, particularly the values of CAPEX that are high, and all of which need funding in USD. When a sensitivity analysis was conducted on these variables, the exchange rate of 20,000.00 IDR worth resulted in a negative NPV; in other words, this project is no longer profitable for investors.

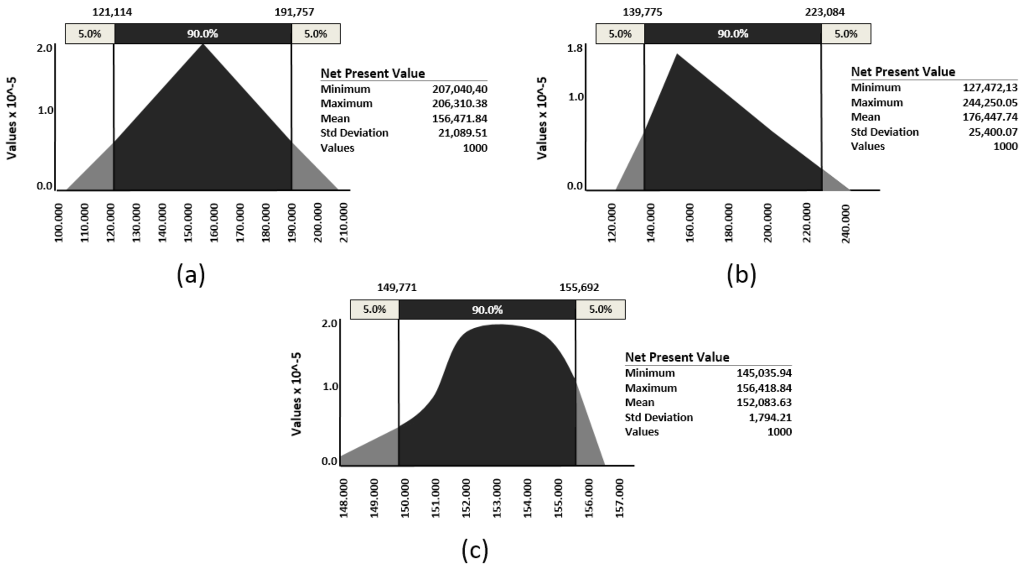

Figure 2 Impact of: (a) the production capacity; (b) the exchange rate; (c) the electricity price on the NPV

Electricity price increases is one of the risks that could have a major impact on the project, as the production of 31,536,000 m^3/year of drinking water and the electrical energy consumption of 0.05 kWh/m^3 result in the accumulation of significant electricity needs per year. In normal conditions, the price of electricity is assumed to be stable, as its value is not affected by fluctuations in exchange rates and inflation. In addition, the rate of electricity price increases in previous years was not insignificant due to the sizeable subsidies from the government. Therefore, the calculation used sensitivity values ranging from 0–15%, assuming the price of electricity is not going down. Figure 2c shows the probability distribution of the NPV values resulting from electricity price increases of up to 15%. The smallest possible NPV is 149,771.00 IDR million, which is 6,700.30 IDR million lower than the NPV when electricity prices are stable. The maximum value of the loss is relatively small when compared with the two previous risks. Thus, with a possible increase in the price of electricity of up to 15%, the value of this risk is not significant. However, the wider sensitivity range determined for the electricity price risk can also substantially reduce the NPV.

In addition to calculating the risk values for each variable, we also calculated the risk value for a combination of two or more risks. VaR calculations for a combination of two or more risks determine the extent of maximum loss that can be obtained if existing risks occur simultaneously or in adjacent time. Apparently, the cases where varieties of adverse events occur simultaneously is very likely to occur in the typical construction project. Logically, the decline in the project’s NPV when a combination of risks occur is certainly greater than when only one occurs.

Table 4 Regression and rank information of all three risks toward the NPV

Rank	Name	Regr	Corr
1	Exchange_Rate	-0.744	-0.778
2	Production Capacity / Bali Selatan	0.612	0.657
3	Electricity price increased / Value	-0.051	-0.062

Besides seeing the maximum loss of each risk and the combination of risks, valuing risks using the VaR calculation can also show the influence of each variable on the NPV using multiple regression with more than one independent variable. Table 4 shows that the exchange rate has the greatest influence on and the strong relationship with the NPV; the coefficient values of regression and correlation are 0.744 and 0.778. With regression and correlation coefficient values that do not considerably differ from the exchange rate, production capacity ranks second, with a 0.612 regression coefficient and a correlation of 0.657. This figure still shows the significant influence and strong relationship between production capacities and the NPV. On the other hand, electricity price increases have significantly less influence and much weaker relationships with the NPV than other risks, with a regression coefficient value of 0.051 and a correlation of 0.062. That is, changes in electricity price increases in the range of 0–15% do not have a significant impact on the project’s NPV changes. The positive and negative signs on the coefficients indicate that the exchange rate and electricity price have an inverse correlation with the NPV, while the production capacity has a positive relationship.

Risk Response Planning Alternatives. Risk response planning is the last stage of the process of risk management planning (Caltrans, 2003). In the whole process of project risk management, which is started with the risk management planning, then followed by risk monitoring and control, risk response planning aims to monitor the risk response and update the identification of future risk to the project. The creation of alternative responses to risks identified in the water supply project's construction in South Bali was based on the literature review of a risk identification survey related to Risk Management of Drinking Water Infrastructure System conducted by the Ministry of Public Works (2007), and project's profile collected from interviews. The proposed alternative responses to the risks include:

1) Transfer the risk to third parties
   This response is applicable to various types of risks. Risks associated with government policies or political instability can be transferred through political insurance instruments provided by national insurance agencies, multilateral institutions, or the Export Credit Agency. When facing financial risks such as a change in the interest rate on a loan, hedging instruments such as future and forward contracts can be used in the project.

2) Application of lenders' choices
   This alternative response seeks to determine the composition of the best loan option among several sources of loan funds to provide benefits to the investment made.

3) The implementation of a public-private partnership (PPP)
   The PPP mechanism aims to mitigate the impact of the risk of unavailability of sufficient funds for public projects. With the PPP, there is an agreement between the government and the private sector to cooperate in public service projects with the division in terms of revenue and risk ownership.

4) The establishment of a complete and clear standard operation procedure (SOP)
   This alternative risk mitigation aims to reduce the possibility of operational failures caused by human error, such as improper calibration, maintenance, etc. The application of clear standards also need to be made in the field of health, safety, and environment (HSE) to ensure there is no lack in water quality or environmental damage caused by the project.

6. CONCLUSION

Risk management is an essential action for the construction of a water supply system in South Bali. As a project that processes water into drinking water, it appears to have a high investment value and to be associated with the lives of many people involved, thus leading to a wide range of risks. In this study, we have successfully implemented a project risk management process consisting of both qualitative and quantitative analyses. The qualitative analysis was performed using a risk register model to map risks that may occur in the project, while the quantitative analysis was conducted by building a financial model with the VaR approach to calculate the impact of risks on investment. This analysis was only limited to determining how the high risks could affect the project's NPV.

Risk identification produced 20 kinds of potential risks in the water supply project in South Bali with 6 risks categorized as high, 5 categorized as medium, and 9 classified as low risks. Three priority risks were the focus of the analysis in this study, including the risk of the drinking water production capacity, fluctuations in the IDR exchange rate against the USD, and increases in electricity prices. The analysis was conducted to determine the impact of these risks on the project's value by examining the maximum loss (risk value) in the NPV that may be obtained when one or more risks affect the project. Of the three risks, production capacity has the greatest influence and the strongest relationship with the project's NPV.

From the results of the identification and analysis of risks in the construction of a water supply project in South Bali, the proposed risk response planning includes transferring the risk to third parties, implementing lenders' choices, implementing a PPP, and establishing a complete and clear SOP. The implementation of appropriate responses to each risk is expected to reduce the impact of risks on investments made in the development of the drinking water supply system project in South Bali.

This paper is still in need of further improvements. Future research can be done to expand the scope of this study, for example to calculate the residual risk value to analyze the impact of risk response actions on the project's value. Moreover, risk analysis could be conducted not only to assess the financial value of the project, but also the quality of drinking water produced.

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