142
250
THS

THESIS

LIBRARY
Michigan State
University

This is to certify that the
thesis entitled

COST-BENEFIT ANALYSIS OF MEI-NONG DAM
PROJECT: A CASE STUDY

presented by

YUAN YAO LEE

has been accepted towards fulfillment
of the requirements for the

Master of Science degree in Community Agricultural Recreation and Resource Studies

Major Professor's Signature

9/24/09

Date

MSU is an Affirmative Action/Equal Opportunity Employer

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.
MAY BE RECALLED with earlier due date if requested.

DATE DUE	DATE DUE	DATE DUE

5/08 K:/Proj/Acc&Pres/CIRC/DateDue.indd

COST-BENEFIT ANALYSIS OF MEI-NONG DAM PROJECT: A CASE STUDY

By

Yuan Yao Lee

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Community Agricultural Recreation and Resource Studies

2009

ABSTRACT

Cost-Benefit Analysis of the Mei-Nong Dam Project: A Case Study

By

Yuan Yao Lee

The question of whether hydro-electric or irrigation dam projects are an efficient, long-term option in managing public water resources is increasingly controversial. Although dams serve many functions, they also drastically change the hydrological landscape, leading to significant environmental and social impacts. Therefore, sound investigation and objective analysis are needed to identify real cost and estimate future benefits. However, dam feasibility studies are usually limited for many reasons, and analyses and results do not necessarily reflect real impacts. Several issues impede a realistic Cost-Benefit Analysis (CBA) of dam projects, including 1) the complexity of factors, 2) the influence of temporal factors on future benefits and cost, and 3) the existence of uncertainty. Consequently, these factors often lead to estimates that are overly optimistic. This study aims to address these issues by identifying the potential effects of dam, estimating their monetary value, and discounting cost and benefits to present time values. Furthermore, sensitivity analysis is applied to recognize the potential effects of uncertainty. In this case study, the Net Present Value (NPV), using a 6 percent discount rate, of the Mei-Nong Dam (MND) in Taiwan is estimated to be a negative 15.778 billion New Taiwan Dollar (NTD) Further analysis indicates that the Internal Rate of Return (IRR), the interest rate at which the cost of a public investment results in a positive benefit, is estimated at 3.49% which is lower than interest rate (6%) in 1992. These results suggest that the project is undesirable and should not be carried out.

ACKNOWLEDGEMENTS

I am grateful for the support from many people while I completed this thesis. I am especially indebted to my mother and father who always gave me the most encouragement and love, and my grandfather who unconditionally assisted me to pursue my dream. I am also thankful for the support that my sister, Yuan Ting, provided while I studied away from home.

I would like to thank my advisor, Dr. Gerhardes Schultink, for his guidance and support on my thesis and my graduate life. It was my pleasure to be his advisee. I also want to recognize those remarkable supports from who has granted me the most precious knowledge. Thank Dr. Eric Crawford and Dr. Robert Richardson for their significant comments and advices on my thesis, Dr. Tawa Sina give me the strength to let me complete this thesis.

I deeply appreciate the support and concern that my friends, Ying Hsuan Lin, Eric Kuo and Yi Hsun gave to me. You are the main reason I am still here and I finally achieve this tough goal. I also want to thanks for the support from Chia Wei Chao, Yu Hsiang Wang, Clair Chiang, Andy Tsai, Jamie Wu, Yu Mei Tsai, Allen Tse, Chen Teng and Wei Ying Wu. All of your company, support, and friendship I will always cherish.

TABLE OF CONTENTS

LIST OF TABLES.................... vi

LIST OF FIGURES.................... vii

CHAPTER I
INTRODUCTION.................... 1
Problem Statement.................... 1
Study Background.................... 2

CHAPTER II
LITERATURE REVIEW.................... 4
Positive Impacts of Dams.................... 4
Impacts of Dams on Society.................... 5
Impacts of Dams on Environment.................... 7
Relevant Research in Taiwan.................... 9
Cost-Benefit Analysis.................... 11
Structure of CBA.................... 12
Reason To Use CBA.................... 14
Externality.................... 14
Discount Future Events.................... 15
Summary.................... 17

CHAPTER III
CASE STUDY: MEI-NONG DAM PROJECT.................... 19
Socio-Economic and Environmental Status.................... 19
Purpose of Mei-Nong Dam Project.................... 22
Potential Impacts of MND.................... 24

CHAPTER IV
ANALYTICAL METHOD.................... 28
Valuation of the Dam Project.................... 28
Measure Benefits and Costs.................... 29
Discount Factor.................... 33
Sensitivity Analysis.................... 34
Data Collection.................... 36

CHAPTER V
RESULTS AND DISCUSSION.................... 37
Benefits of MND Project.................... 37
Costs of MND Project.................... 44
Discussion of Results.................... 47
Sensitivity Analysis.................... 51

CHAPTER VI
CONCULSIONS AND SUGGESTIONS.. 53
Conclusions.. 53
Limitation of the Study.. 54
Suggestions.. 55

APPENDICES... 58
Appendix 1: Economic Analysis of MND (6% Discount Rate)............ 59
Appendix 2: Scenario 1... 64
Appendix 3: Scenario 2... 69
Appendix 4: Scenario 3... 74

REFERENCES... 79

LIST OF TABLES

Table 1 Positive and Negative Impacts of Dams.................................... 9

Table 2 Valuation Methods for Impacts of Dam Construction. 30

Table 3 Consumer Price Index and Adjustment Factors............................ 34

Table 4 Benefits Provided by Ecosystem Services.................................. 39

Table 5 Income From Sold Water.. 40

Table 6 Income from Sold Power and Saving From Clean Water................. 42

Table 7 Construction Costs of Water System.. 45

Table 8 Construction of Power System.. 46

Table 9 Maintenance, Replacement and Operation Costs.......................... 48

Table 10 NPV of the MND Project at variable Discount Rates...................... 50

Table 11 Sensitivity Analysis of the MND Project.................................. 52

LIST OF FIGURES

Figure 1	Map of Kaohsiung City ………………………………………….….	20
Figure 2	Estimated Increase of Water Demand in Kaohsiung City …………...	23

CHAPTER I: INTRODUCTION

Dams have been used to manage water resources for a long time. Although large irrigation and hydro-electric dam projects can effectively stimulate economic development, and specifically increase performance of the agricultural, manufacturing and tourism sectors, many negative dam impacts are easily ignored. Increasingly various environmental groups, government institutions and the public-at-large are beginning to question their real long-term public utility. Some countries such as Taiwan, still focus on the positive effects of dams and keep using them to address water and energy needs. This clearly shows the rationale for a more objective project evaluation that involves all stakeholders' concerns as well as comprehensive project impacts.

The official assessment for the MND project is a classical case that ignored comprehensive dam impacts. Most intangible impacts were glanced over without further analyses or evaluations, and most opinions of those possibly affected were not taken into consideration. As a result, an over-optimistic and limited report was presented without considering some possible societal impacts. To prevent this biased evaluation, this study re-evaluates the overall impacts of the dam on society by applying an extended cost-benefit analysis (CBA). It includes more comprehensive impacts of the dam and by the application of extended CBA seeks to provide better information for the public decision making and the selection of dam construction alternatives.

1. Problem Statement

The question of how to evaluate the potential impacts of dams is always a complicated issue. There are many direct and indirect factors to consider and the impacts of these factors and their economic value is difficult to quantify. For many of the non-market goods and services associated with dam projects no value or price exists, because they are not formally traded in the market place. Therefore, many evaluations of public dam projects focus on the tangible expenditures and incomes, and may define the dam as a public necessity with positive net benefits. In addition, these assessments fail to account for the uncertainties (e.g. the long-term capacity of the dam reservoir that may be reduced by increased sedimentation rates due to lack of soil conservation practices) and risk (e.g. the possibility of dam failure as a result of earth quakes), both reducing the validity of benefit estimation.

These concerns are especially important for dam projects with an estimated long project time. For example, almost all dams in Taiwan have not achieved their best performance due to sedimentation problems while the negative impacts still exist (Cheng, 2004). Unfortunately, project analyses often put little emphasis on this issue and lead to a mistaken expectation on dam performance when significant uncertainties are misrepresented. By disregarding these issues, the assessment results become overly optimistic and undesirable. Therefore, it is necessary to provide a closer review of the MND project to ensure that it will indeed bring more benefits to society than costs.

2. Study Background

Limited access to water resources is a critical restriction to economic development and industrial output in Taiwan. Even though typhoons and monsoons generate large amounts of precipitation each year, Taiwan's mountainous geography makes it difficult to retain water. To effectively utilize water, more than a hundred dams have been constructed and approximately 12% of Taiwan is covered by reservoirs (Cheng, 2004). In the early 1990s, Taiwan planned the construction of another large dam, the

Mei-Nong Dam (MND) on the Lau-Nong River, to prevent water loss by run-off and provide water for irrigation and industrial growth. The construction for the MND project was completed in seven years and sold sell water to Kaohsiung for industrial and municipal use. Although the Taiwanese government claimed the project as multi-purpose and environmentally friendly (WRA, 1984), the dam project significantly altered the landscape and prevents people from accessing natural resources. These drastic changes not only affected local people's lives, but also lead to the displacement and/or extinction of many species over a wide geographical area, primarily within the watershed. Since the dam bring both positive and negative impacts, whether the project should have been executed should depend on an integrated investigation and evaluation.

In Chapter II, previous research and studies related to the dams advantages and disadvantages are presented. The principle indices of CBA and the selection of a proper discount rate are also discussed in this chapter. Chapter III describes the MND project area and provides background information including the history, the purpose of MND project and the potential impacts. The analysis method and the results presentation are discussed in Chapter IV and V. Chapter VI provides a conclusion about the feasibility of MND and suggestion for more efficient water management.

CHAPTER II: LITERATURE REVIEW

This Chapter focuses on the impacts of dam projects and how they affect the environment and people. Using information provided by a series of thematic reviews conducted by the World Commission on Dams (WCD), dams all over the world, as well as relevant research in Taiwan, provided the boundaries for this analysis. This chapter also discusses the application of cost-benefit analysis by taking another look at its basic principles and criteria used to judge the acceptability of a project. Consequently, this chapter also examines why CBA is important in project evaluation and reviews scholarly opinions regarding its pros and cons (Adler, 2006; Boardman, et al., 2001; Hanley & Spash, 1993).

Last but not least, the final part of this chapter emphasizes the selection of discount factors. The methods by which the discount factor is chosen as well as the issue of whether future events should even be discounted all directly influence the credibility of CBA. A close review of the opinions of scholars from different perspectives is needed in order to ensure the best outcome for the study site.

1. Positive Impacts of Dams

One of the fundamental requirements for socio-economic development is the availability of water of appropriate quality. Historically, the main sources of domestic and industrial water are aquifers or rivers (Adams, 2000; Wang, 2003). Today, many of these sources are overused and no longer provide a consistent supply. Consequently, other options such as reservoirs are pursued to satisfy the demand for water. The reservoirs formed by dams can effectively collect rainfall during wet seasons for use during periods of drought. This is especially critical in arid regions of the world (Adams, 2000; ICOLD, 1999).

In addition to providing clean water, dam projects can also provide multiple benefits. First, dams can adjust the river flow and prevent flooding downstream, reducing the loss to people's properties and assets. Second, the cascade created can be used to generate power. Moreover, the newly created reservoir can provide a setting for various recreational activities such as fishing, boating, jogging, hiking, or camping (ICOLD, 1999).

Additionally, some positive externalities but not easily observed are also considered as the benefits. For instance, hydropower reduces the emission of greenhouse gas emission and lowers the concentration of carbon dioxide in the atmosphere. It is the multipurpose appeal that makes dams a popular option for water and energy management policies (ICOLD, 1999). One famous example is the abundant power provided by the Three Gorges Dam in southwestern China. This huge dam provides massive amounts of power for industry and improves the standard of living of its local residents (Cheng, 2004; ICOLD, 1999; Pong, 1994; Morimoto, 2004).

2. Impact of Dams on Society

Although dams are often seen as an effective tool for national economic development, their macroeconomic benefits tend to be highlighted while their local economic and social consequences often remain inadequately evaluated. The thematic reviews of the World Commission on Dams (WCD) point out that the emergence of large dams has drastically changed the landscapes within the watershed and poses serious problems to both society and the environment (Adams, 2000; Bartolome, et al., 2000).

Rosenberg's review on dams in Canada concludes that while local residents may benefit from some developments, dams often cause serious interruptions to activities such as harvesting, hunting, and fishing, and consequently, the livelihoods of many of these people (Rosenberg, et al., 1995). Additionally, the construction of large dams has inevitably resulted in the displacement and resettlement of several millions of people across the world.

While a number of those dams may appear to have achieved their main goals, such as the provision of hydro-electricity or irrigation, they have also caused severe socio-economic hardship for those forced to move (Bartolome & Danklmaier, 1999). These displaced persons experience higher levels of homelessness, unemployment, debt, and hunger (Adams, 2000; Bartolome, et al., 2000).

Dams do not just have consequences for people living upstream. Adverse effects of dams also take place downstream. The riverside communities who rely on the natural resources provided by the rivers are also affected to varying degrees by altered river flows and ecosystem degradation. A great number of residents use the water from the rivers to irrigate their farms. A dam would limit their access to water and other resources (Berkamp, et al., 2000; Wang, 2003).

In addition to the changes in the landscape of the watershed, dams pose a serious threat to the success of cultural heritage. For example, the Three Gorges Dam in China inundated the large number of historical and cultural sites within Si-Chun province, and consequently led to a huge loss in recreational value (WCD, 2000). However, those who are most adversely affected often remain ignored (Pong, 1994; Wang, 2003; WCD, 2000).

3. Impacts of Dams on Environment

Society and the environment are very closely related; a change in one can cause a change in the other. Studies have indicated that dams dramatically change the environment upstream, downstream, in the floodplain, delta, and even in the coastal regions (ADB, 2002; WCD, 2000; IDRC, 2001). These changes usually lead to loss of flora and fauna and interrupt the natural balance of the ecosystem.

During the dam's construction, a reservoir is created and turns the terrestrial ecosystem upstream into lake. Large-scale impoundment eliminates unique wildlife habitats and leads to the extinction and/or displacement of species which used to live in this ecosystem (Berkamp, et al., 2000; Nilsson & Dynesius, 1994; WRA, 1984).

Dams also significantly change the ecosystem downstream by altering the river flow. Since the temperature and nutrient concentrations change with the river flow volume, aquatic creatures are significantly affected by any change in the flow pattern. For example, the construction of the Glen Canyon Dam on the Colorado River reduced daily average flows during the annual September peak from about 2000 m^3/sec to 700 m^3/s (Berkamp, et al., 2000; WCD, 2000). This change in flow has fundamentally altered the water temperature, threatening the livelihood of some aquatic creatures.

Additionally, the fluctuation of sediment and nutrient concentration within the watershed alter the aquatic animals and reduce their population (ICOLD, 1999; WCD, 2000). A reduction in sediment moving downstream from the dam invariably results in an increased rate of erosion to the coastal deltas. The slow accretion of the Nile Delta was reversed with the construction of the Delta barrage in 1868. Today, other dams on the Nile, including the Aswan High Dam, have further reduced the amount of sediment reaching the delta. As a result, much of the delta coastline is eroding by up to 5-8 meters per year (WCD, 2000).

However, it is not just the presence of the dam that damages the environment; the physical impact by transmission cords and access roads during construction are often overlooked. Roads leading to the dam increase the depletion of natural resource by providing passage to previously remote areas to settlers and hunters. By clearing land and changing the habitat, access roads disrupt the lives of animals in the watershed affected. Its effects are even more acutely felt during crucial developmental periods in the life cycle such as calving, mating, and gestation (WCD, 2000).

In addition, the installation of power transmission lines, through the use of chemical substances, pollutes the dam site. In order to set up the power cords, shrubs and trees are typically cleared off by cutting or herbicides. The residual herbicide will either penetrate into groundwater aquifers or discharge into runoff and flow into the rivers. The polluted body of water consequently results in the death of aquatic creatures and even causes health problems in people (WCD, 2000).

Last but not least, while the combustion of coal, oil, or natural gas in thermal power plants yields mainly carbon dioxide (CO_2), bacterial decomposition (both aerobic and anaerobic) of organic matter and other processes in tropical water reservoirs produces both CO_2 and methane (CH_4). An increase of methane in the atmosphere will lead to more serious greenhouse effects (Rosa & dos Santos, 2000). Table 1 describes the potential impacts based on experience from different dam projects around the world.

Table 1 Positive and Negative Impacts of Dams

	Positive Impact	Negative Impacts
Social Aspect	• Provide water and power • Prevent flood • Create tourism value	• Displace and Resettle indigenous people • Destroy domestic culture and reduce the recreation value • Prevent access to the river by indigenous people • Damage the grazing industries and fishery
Environmental Aspect	• Replace the thermal power plant and reduce the emission of carbon dioxide	• Destroy the habitats of animal • Clear the land • Change the temperature and nutrient contents of the stream • Block the movement of fish • Emit methane due to the decomposition of bacteria in reservoir • Erode the river bank

Source: WCD, 2000

4. Relevant Research in Taiwan

Previous research had mainly focused on two categories: 1) the life cycle of dams, and 2) the potential effects on Taiwan's environment and society.

Considering that the average annual soil deposit problem, Cheng (2004) indicates that the average life span of a dam in Taiwan is mainly decided by the soil deposit rate. Considering that the average annual soil deposit rate, in Taiwan, is between 0.1% and 1%, the average life is about 70 years.

Pong (1992) tried to use the Contingent Valuation Method (CVM)[1] to estimate the

[1] The Contingent Valuation Method is survey-based and estimates people's intended future behavior in constructed markets. Through an appropriately designed questionnaire, a hypothetical market is described where the good in question can be traded at an estimated price.

opportunity cost[2] of the MND project's selected site. Based on her study, the willingness to accept compensation (WTA)[3] for constructing the dam project, or opportunity cost, is 899.4 New Taiwan Dollars (NTD)[4] per person every month. The population of Mei-Nong Township is approximately fifty thousand, and therefore the opportunity cost for the dam project will be 54 million NTD, around 1.8 million USD, per year by multiplying the WTA to the population of Mei-Nong town.

Despite the social and environmental effects, Wang (2003), in his dissertation proposal about the social movement opposing the dam project, mentioned that there are two issues raised by the dam project in Taiwan.

First, Dams designed to deliver irrigation services or other consumption uses have typically fallen short of physical targets, did not recover their costs, and have been less profitable in financial terms than expected. As for the dams which were built to deliver hydropower, they tend to perform close to but still below the target for power generation.

Second, in the past, dam proponents have rarely invited the participation in decision making. Proponents and opponents alike argue that participation is essential for democracy, and that participation greatly improves project selection and design. However, the most affected stakeholders remain excluded from most large scale projects and are usually informed of the project at the last minute before they were implemented. By disregarding the opinions of the stakeholders the dam project draws a lot of resistance,

---

2 Opportunity cost or economic opportunity loss is the value of the next best alternative foregone as the result of making a decision.

3 WTA is the amount that a person is willing to accept to abandon a good. It is the minimum monetary amount required for purchase to be accepted by an individual. WTP, which is the maximum amount an individual is willing to sacrifice to procure a good.

4 The 2006 exchange rate is approximately 1 US dollar for 30.695 NTD

and consequently, a lot of controversy. The earlier the stakeholders step in, the easier a consensus will take place. It is an essential process to reduce any possible conflict among stakeholders.

5. Costs-Benefit Analysis

CBA is an important tool in examining the efficiency of public projects as well as in the decision making process itself (Adler, 2006; Boardman, et al., 2001; Hanley & Spash, 1993). CBA was first applied by the U.S. Army Corps of Engineers, the U.S. federal water agencies, and the Bureau of Land Reclamation. In 1936, the Flood Control Act required the U.S. Army Corps of Engineers to evaluate the benefits and costs of all water resource projects. Since then, federal water projects involving public investment have been required to go under formal economic assessments (Hanley & Spash, 1993). The use of CBA received increased attention and consequently spread to other countries. The application of CBA also expanded into the transportation industry, urban planning, and even heath programs. Nearly all Western countries have widely implemented the use of CBA as a decision making approach to judge the feasibility of public projects (Boardman, et al., 2001).

However, the extent of monetary evaluation sometimes has been limited especially when some non-market benefits and costs present such as environmental impacts, cultural loss or human health. In order to prevent an inaccurate calculation of CBA, many international funded projects involving external impacts are required to incorporate the non-market benefits and costs in the analysis or to undergo additional non-monetary assessment of these impacts (ADB, 2002; Hanley & Sapsh, 1993; UNEP, 2007).

6. Structure of CBA

Welfare economics assumes that individuals have preferences, and that an individual's welfare or utility increases when preferences are satisfied. A project that benefits one without hindering another is, thus, considered socially desirable (Adler, 2006). However, a project may be accepted if it fulfills the potential Pareto improvement criteria, which is, as long as the gains are more and can compensate for the losses of those affected, only then is a project considered feasible to the whole society.

Based on this assumption, CBA is used to decide if a project can contribute to economic efficiency. In fact, the steps of CBA can be defined based on previous studies: 1) net benefits with or without the project are compared, 2) different alternatives are compared 3) all possible impacts are expressed in present values and 4) all the impacts are measured in monetary terms (Belli, 2001, Hanley & Spash, 1993).

Other studies point out that certain steps need to take place in any CBA including: 1) define the project, 2) identify the change of welfare if the project were to proceed or not, 3) determine the impacts caused by the project, 4) conduct monetary valuation of relevant effects, 5) compare the project to potential alternatives, 6) assess of the risk and uncertainty involved, and finally, 7) make a decision based on the selection criterion (ADB, 2002; Belli, 2001; Hanley & Spash, 1993; UNEP, 2007).

Once the above procedures have been completed, the results are examined to determine if the project is feasible. Three common measures are used in cost-benefit analysis: Net Present Value (NPV), Benefit-Cost ratio (B/C ratio), and Internal Rate of Return.

Net Present Value (NPV). NPV is defined as the total present value (PV) of a time series of cash flows. It is a standard method for using the time value of money to appraise long-term project. The NPV has been the most frequently used of all economic measures of efficiency. NPV can be defined as:

$$NPV = \sum_{t=0}^{N} \frac{(Bt - Ct)}{(1+i)^t}$$

(Source: ADB, 2002)

Where Bt = Benefit at time t; Ct = Cost at time t; i = Discount rate; n = Number of years

A project is acceptable to the government if the NPV is larger than zero. Similar to the B/C ratio, the magnitude of the NPV cannot be used to rank projects, because the NPV does not provide direct information about the costs of the project.

Benefit-Cost Ratio (B/C ratio). Benefit-cost ratio is an indicator, used in cost-benefit analysis, which attempts to summarize the overall value for money of a project or proposal. B/C ratio is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms. The B/C ratio can be defined as:

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

(Source: ADB, 2002)

Where Bt= Benefit at time t; Ct= Cost at time t; i = Discount rate; n = Number of years

B/C ratio has often been used as a measurement of economic feasibility for government projects in the water resource field. The B/C ratio shows the ratio between present benefits and present costs. A project is acceptable to the government if the B/C ratio is equal or higher than one.

Internal Rate of Return (IRR). The IRR is the discount rate at which the net present value is equal to zero. It can be defined as r:

$$NPV = \sum_{t=0}^{N} \frac{(Bt - Ct)}{(1+i)^t} = 0$$

(Source: ADB, 2002)

Where Bt = Benefit at time t; Ct = Cost at time t; i = Discount rate; n = Number of years

A project is acceptable if its IRR exceeds some specified interest or discount rate. In terms of two mutually exclusive projects, this criterion indicates that the project with the highest IRR should be selected.

7. Reasons to Use CBA

When a project is proposed to the public, the question of how to decide whether the project should be implemented is always a controversial issue. The decision is often a difficult one because the project will inevitably involve many aspects and there, currently, lacks a standard method to evaluate and account for all of them (Boardman, et al., 2001).

A good way to solve this problem is to evaluate based on market values. Although the value of many goods or service may not be easily deduced, monetary evaluation is still a widely accepted method in the decision making process.

8. Externalities

One problem of CBA is that it seldom considers the external effects of a project, such as the environmental and social effects. It is because several factors, particularly the project's externalities, do not have any trading market. Thus, the results of a CBA are often overly optimistic by ignoring certain intangible costs.

Some practical methods can be applied for different categories of factors. The valuation methods depend on the nature of each individual factor and the availability of information. The following are the most common ways used to evaluate non-market benefits and costs (Boardman, et al., 2001; Hanley & Spash, 1993; Pearce, et al., 2006).

Hedonic Price Method. The Hedonic Price Method (HPM) estimates the value of non-market goods by observing behavior in the market for a related good. Specifically, the HPM uses a market good in which the non-market good is implicitly traded (ADB, 2001; Farber et al., 2002; OECD, 2006).

Contingent Valuation Method. The Contingent Valuation Method is survey-based and estimates people's intended future behavior in constructed markets. Through an appropriately designed questionnaire, a hypothetical market is described where the good(s) in question can be traded (Farber et al., 2002; OECD, 2006).

Travel Cost Method. Service demand may require travel, whose costs can reflect the implied value of the service; recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it (ADB, 2001; Farber et al., 2002; OECD, 2006).

Replacement Cost Method. Services could be replaced with man-made systems; natural waste treatment can be replaced with costly treatment systems (ADB, 2001; Farber et al., 2002; OECD, 2006).

9. Discount Future Events.

As mentioned, some impacts of dams on the environment and society are long-term and not easily observed as to how to determine their present value in CBA. In fact, the debate about the selection of discount rate has not ceased because philosophers, economists, environmentalists, policy-makers and others view this question in different ways. Therefore, this section reviews relevant studies in order to find a reasonable discount factor and properly reflect the value of future events.

A dollar now is worth more than that same dollar several years from now and consequently, people would rather to use their money now than save it unless certain amount of compensation is granted (Aylward, et al. 2000; Belli, 2001; Hanley & Spash, 1993). Therefore, a discount factor is used to reduce the value of future benefits and costs to their present values. In Gittinger's (1982) opinion, there are two rates that are commonly chosen as a discount rate: 1) the opportunity cost of capital, and 2) the interest rate.

The opportunity cost of capital is the most ideal rate. Under the perfect market without distortion, if the opportunity cost of capital can be determined and all possible investments yield a reasonable amount of return, all of the capital in the economy can be more efficiently utilized. However, this rate is sometimes hard to apply because no one knows what the true opportunity cost of capital is (Gittinger, 1982).

The prevailing interest loan rate used in public projects is the most common discount rate used in project analysis. It is the interest rate that closely reflects the consumption rate of return. However, this rate can also be affected by the available financial funds and other factors irrelevant to the project, and sometimes cannot truly reflect the effect of time (Aylward, et al. 2000; Gittinger, 1982).

The discounts from 6% to 8% are commonly used in the public project in developed countries and it is usually the interest rate. In most developing countries, 8% to 15% percent is applied in the project because the relative higher inflation rate and is considered the appropriate discount rate in developing countries (Gittinger, 1982).

On the other hand, the issue of whether future benefits and costs should be discounted in CBA is another important controversy in much need of review. In fact, some scholars suggest that choosing a discount rate for future generations is unethical and will damage the environmental sustainability in the future (Markandya & Pearce, 1988). For example, Cline (1999) and Weitzman (1998) suggest that the necessity of a discount rate in the far future is uncertain. Therefore, future events need not to be discounted and the discount rate in the future should be very low or zero (Weitzman, 1999). Hanley and Spash (1993) note that a zero discount rate means that future generation is involved in the decision process, and can prevent the future damage to environment.

10. Summary

Past studies suggest that the incorporation of the effects of environmental degradation into public decision-making is not only an essential step towards achieving more economically efficient management of natural resources, but it also encourages practical strategies for sustainable development. As a result, an extended economic analysis of projects and policies can help a country with scarce resources make the best investments and contribute most to its overall public objectives.

In addition, evaluators also indicated that non-market goods and services which should be internalized to the largest extent have been frequently neglected in the past. In this regard, rough qualitative assessments early in the project cycle can generate valuable returns by identifying environmentally unsound options and focusing on those that are sounder overall.

CHAPTER III: CASE STUDY: MEI-NONG DAM (MND) PROJECT

In this section, more detailed information about the region affected by the MND project is discussed. The history, characteristics, and the impacts of the project are reviewed in turn.

1. Socio-Economic and Environmental Status

Kaohsiung City. Kaohsiung City harbor, once the second largest container transport station in the world, is at the center of well-developed transportation networks and prosperous industrial and commercial sectors in southern Taiwan.

According to the 2007 census, there were approximately 1.5 million people living in Kaohsiung City and the population is expected to continue to grow. The current major industries in Kaohsiung are steel, petrochemical, ship building, cement, and two export industrial zones in Kaohsiung and Nan-Tse. These industries have made Kaohsiung the most productive city in Taiwan for the past few decades (Kaohsiung City Government, 2009).

Currently, Kaohsiung City intends to develop the high value industry featuring advanced technology, automation, high return and low pollution. Once the MND project is completed, most of the water produced will be for the industrial and municipal uses in Kaohsiung City (WRA, 1984).

M*ei-Nong Township.* Mei-Nong Township is located in the southern part of Taiwan. It is 3 kilometers away from the large city, Kaohsiung City, where the economic, political, and industrial center of southern Taiwan is located. The total area of Mei-Nong County is 120.0316 km^2 and the population of Mei-Nong, approximately 50,000 people, has not changed much since 1990 (Mei-Nong Township Administration, 2004).

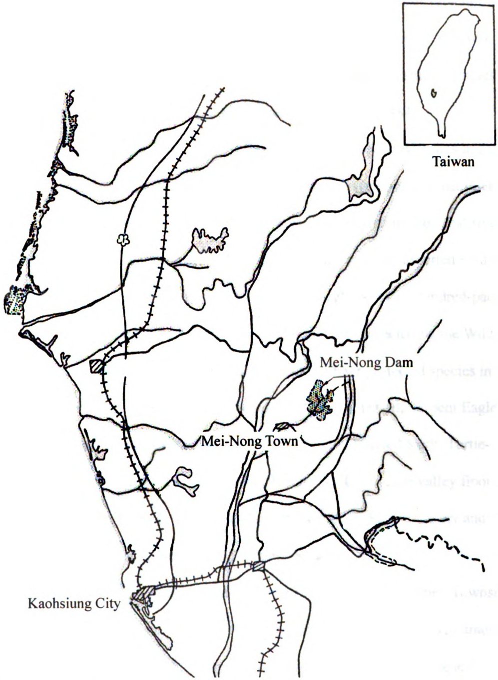

Figure 1 Map of Mei-Nong Dam Project

Since Japanese colonial rule, tobacco cultivation has dominated Mei-Nong's economy. This area is currently the most important tobacco plantation in Taiwan. Although tobacco production has gradually decreased since 1987, when the Taiwan government permitted the import of tobacco products, the small township continues to grow tobacco and preserve it as one of its local traditions (WRA, 1984).

The selected dam site, right in the Yellow Butterfly Valley (YBV), lies in the northeast corner of Mei-Nong Township and would be submerged under water once the project begins. The YBV is the only completely intact, low-elevation forest and river valley near the populated western part of Taiwan. It is home to many assorted wild flora and fauna, such as the Maroon Oriole, Hodgson's hawk-eagle, and the Hundred-pace snake, all categorized as the most endangered species and are protected by the Wildlife Conservation Law in Taiwan (MPA, 1999; WRA, 1984). Other protected species in this area include the precious and rare Crested Goshawk, Honey Buzzard, Serpent Eagle, Emerald Dove, Black-napped oriole, Formosan blue magpie, Banded Krait, Turtle-designed Snake, and the Brown tree frog (MPA, 1999). In addition, the valley floor contains over 90 species of birds and 110 species of butterflies. Such a variety and abundance of wildlife forms a precious and rare ecosystem.

Moreover, the Twin Creek Tropical Plant Nursery, next to Mei-Nong Township, was built in 1935 by the Japanese Taiwan Forestry Administration for an experimental species plantation. They imported 270 species of plants from the world's tropical areas, such as Southeast Asia, Australia, the Indian Subcontinent, South America, and Africa. These plants were mainly sold to Japanese for horticultural uses (MPA, 1999). Today, their collection includes 96 surviving species; 28 of which only exist in this nursery, and some are the only plants of their species in Taiwan (MPA, 1999).

Geography of the Project Area. The climates of Kaohsiung city and Mei-Nong Township are very similar and both are affected by monsoons, as well as their topography. Kaohsiung is located south of the Tropic of Cancer. The climate is tropical with average temperatures ranging from between 18.6 and 28.7 Celsius degrees, and average humidity between 60 and 81%. Average annual rainfall is 1134 mm. The topographies in these two areas are dominated by hills and mountains. The dry season typically lasts from October to April. In general, this area has a wet tropical climate with high temperatures and a relatively high humidity in the summer, followed by a dry climate in the winter (Kaohsiung City Government, 2009).

2. Purpose of the MND project

Since the 1960's, Taiwan has become an important processing and manufacturing location for world products. More recently, the growing industries have gradually expanded from northern Taiwan into the south. In order to make Kaohsiung become the industrial center of Taiwan, several important infrastructures were proposed since the 1980's (WRA, 1984). One of these projects was to build a large scale water storage dam to satisfy the demand for water from industries and municipal uses. The dam project was planned both to supply increasing water demands as well as to solve the water shortage problem in the southern region.

As the second largest city in Taiwan, Kaohsiung is not only the center of the oil refinery and shipbuilding industries, but it is also one of the busiest ports in Southeast Asia. Since 1960, the expansion of these industries has led to a gradually increasing population and a higher water demand. According to the water resource management report of southern Taiwan by the Water Resource Agency in 1990, water demands will increase from approximately 613.2 million m^3 per year, in 2001 to 730 million m^3, in 2021. Current water supply systems can only provide 1.66 million tons of water per day[5] that is 605.9 m^3 per year. If the goal has to be met in 2021, either the government has to find a new water source or the rest of the demand will be met by transferring water from agricultural use. However, if water is transferred from the agricultural sector, it will only temporarily fill the gap. Satisfying the future water needs will rely on new water sources and on more effective water conservation policies and regulations.

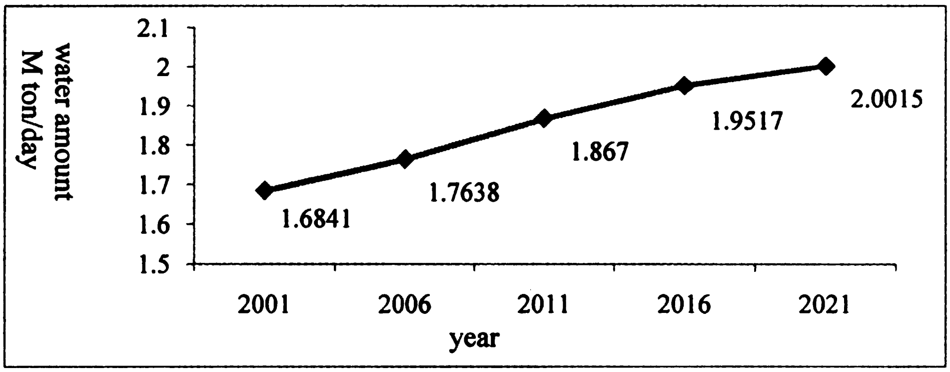

Figure 2 Estimated Increasing Demand in Kaohsiung City. (Source:WRA, 1990)

In response to the loss of water in the agricultural sector, as well as to meet the projection for water demand in 2021, the MND project was proposed by the Taiwanese government in 1984. The dam project was designed to hold 406 million cubic meters of water at its full capacity. It is expected to supply 378 million m3 of water annually to meet the expected water supply goal in 2021 and to satisfy the domestic and industrial

[5] The estimate water increase is calculated by population increase times the daily water use per person. According to the census of Kaohsiung City, the populations will slowly grow from 1.52 million people in 2001 to 1.76 million people in 2021. As for the industrial water increase, the amount consumed by industries is projected by the increased percentage of industries in southern Taiwan.

needs of Kaohsiung City, Tainan and Ping-Dong Counties in the next two decades. The MND project will also be expected to provide power and higher quality water to people and industries in Kaohsiung City (WRA, 1990).

The MND project was expected to begin in 1992 and start to supply water and electricity in 1999 after seven years of construction. However, the project was suspended in 1999, due to strong opposition from the people in Mei-Nong Township, environmental organizations, and political parties. Since the project has been suspended, Taiwan government decides to intake water from the Nan-Hua Dam in Tainan County to satisfy the growth demand of water (WRA, 1984).

3. Potential Impacts of the MND Project

One of the positive impacts of MND project is to provide clean water and to reduce the consumption of packaged water in Kaohsiung City. As many heavy industries, such as oil-refineries and steel mills, are located in this area, the residents in Kaohsiung have complained about the water quality for a long time (Tse, 2004). Almost all the major water sources near Kaohsiung city have been polluted by the wastewater discharged by these factories. After such long-term pollution, the water's odor and color are abnormal and still one of the concerns of the residents even after treatment. As a result, the majority of their daily drinking water is from consumption of bottled water (Wu, 2007).

The MND project is expected to solve this problem by using a water source in a remote area where there is not much pollution. The goal is for people in Kaohsiung to have clean tap water and save money from buying bottled water.

In addition to providing water for municipal use, the other important task of the MND project is to maintain a consistent supply of water for the water consuming industries during the dry season. The drought season adds further strain to the insufficient water supply, and water consuming industries are often forced to shut down factories temporarily. To protect these high technology industries, the government asks some farmers to stop irrigation in order to transfer water to the necessary sectors. In return, these farmers receive compensation from the government. As the water consuming industries continue to expand, more farmers are asked to stop irrigating for one or two seasons a year. This difference in demand left by these farms can be temporarily replaced by cheaper imports such as rice, sugar cane and fruits. However, this strategy can only temporarily solve the problem, and will inevitably cause unforeseeable damage to local agricultural productivity in the long run. If the MND was built, it could meet the increasing demand without interrupting the agricultural sectors (Ke, 2005).

While the construction of MND project might contribute to the improvement of water quality and the growth of industries in Kaohsiung City, there will also be important social and environmental costs. First, if the MND were built, a minimum of five hundred local people upstream will be displaced. Large portions of these people rely heavily on natural resources. They earn their livings planting agricultural products in the proposed flood zone, such as mangoes and papayas. The dam project will take away their source of revenue and limit their rights to access natural resources such as fish or timber. Therefore, in order to proceed with the MND, the project holders will have to compensate these displaced individuals based on the law for the loss of their farms and help them to resettle. This will inevitably increase the cost of the project as well as create unnecessary social problems.

Second, there is fear that potential dam failure will cause huge casualties and destroy the traditional Hakka culture; as a result, the local community has joined forces the opposition party and several environmental groups to resist the execution of the MND project. They believe the dam site is located in the cross area of several faults where several large scale earthquakes have occurred. There are, on average, 214 earthquakes a year in Taiwan (Central Weather Bureau, 2008). The most recent large scale earthquake occurred in September 21st, 2000 claiming more than 2,000 lives. The people of Mei-Nong worry that the 147-meter tall dam, located just 1.5 km away, will bring devastating consequences once it collapse due to earthquakes.

The local people are also worried that the dam will destroy the nearby landscape where much of their traditional cultural customs take place. The balance between Mei-Nong, a small village famous for making umbrellas and tobacco, and the harmony between the people and the environment will be broken by the MND project because of the large mechanical equipment entering, disrupting people's daily lives. Moreover, the dam damages the holy place of the local people. The YBV, known to the Mei-Nong people as Twin Creeks, has strong cultural connections and connotations to Mei-Nong society since its first settlement in 1763. The people of Mei-Nong view the Twin Creeks and the YBV as the origin of their cultural and economic being. The construction of the MND project will flood over the entire YBV, and permanently change the lives of Mei-Nong's people.

In addition to the social impacts, the MND project is expected to have serious impacts on the environment 863 hectares of the land upstream from the dam will be flooded; 725.72 hectare of this flood area is tropical forest, 100.92 hectare is rangeland, 35 hectare is a wild field or grassland, and 3 hectare is residential land. In other words, the reservoir will lead to massive deforestation (WRA, 1984). The forest currently provides food and shelter for a variety of flora and fauna, regulates climate, reduces soil erosion, and provides recreational and aesthetic values.

Consequently, large dam construction projects have continuously led to public controversy in Taiwan. Despite the Taiwanese government's insistence of the projects' economic benefits, more and more people have started to question the efficiency of large dams and wonder if the economic benefits are enough to justify the environmental damage.

CHAPTER IV: ANALYTICAL METHOD

The main goal of CBA is to estimate the net present value (NPV) of this project. The previous chapters have discussed and identified the most significant costs and benefits involved in this study. Therefore, in this chapter, the focal point is how to calculate and estimate the costs and benefits based on available references. As the selection of a discount rate has direct influence on the NPV, an appropriate discount rate for this study will be discussed referring to the common discount rate used in international projects. Finally, this study will apply sensitivity analysis which give us a big picture of the magnitude of the potential uncertainties and offer a reference for decision makers.

1. Valuation of Dam project

In CBA, some effects can be valued through their market prices, such as construction costs. However, the non-market costs such as the environmental impacts of the dam and the tourism losses created by the reservoir cannot be determined simply through a market valuation study; therefore, a non-market valuation study is required to assess these values. While original data is best in a situation like this, when there are time and budget constraints, environmental values may be estimated from existing studies or secondary data (ADB, 2001). When using secondary data, information from relevant studies is used to estimate the costs and benefits of similar projects in a specific area. The transferred values must be used for the same kind of environmental conditions, and the same terms of value must also be used.

2. Measure Benefits and Costs

This section will examine the economic valuations of each impact of the MND project and provide details for the appropriate valuation methods that are practical and consistent with economic appraisal principles. The benefit and costs of MND and their corresponding measurement approaches are shown in Table 2.

Income from Water Supply. The main task of MND is to offer a consistent supply of water. Most of the water from MND will be sold for industrial and municipal uses in Kaohsiung City, and the revenue will be used to cover the water production costs.

The benefit can be calculated by the water price times the quantity of water sold to public and industries.

Income from Power Sale. In addition to supplying water, the MND can also generate power by using the differenrce in height of upstream and downstream. This benefit is estimated through the market price of power times the power amounts actually provided to users.

Savings from Bottled Water. The construction of the MND can provide better-quality water to people who live in the metropolitan area, and therefore save them from purchasing bottled drinking water. According to Tse's survey (2004) of 500 people living in Kaohsiung, 68% of Kaohsiung residents use bottled water as their main source for drinking and 30.2% of these respondents would like to stop buying drinking water as long as they get improved quality of tap water.

Table 2 Appropriate Valuation Methods for the Impacts of Dam Construction.

	Physical impacts	Measurement	Valuation method
Benefits			
Income for water sale	Incremental productivity	water price × quantity sold	Market price
Income from power sale	Electricity generated	Power price × the quantity sold	Market price
Saving from reducing use of packaged water	Saving on buying drinking water	Drinking water price × the quantity of municipal water use × percentage of use in drinking	Market price, Shadow Prices
Tourism gain upstream	Gain of tourism Value		Reveal preference (TCM)
Costs			
Construction cost		Labor, Capital	Market price
Operation and Maintenance cost			
Resettlement cost	Property loss	Physical property	Market price
Land Acquisition	Forest land, commercial products	Product prices × quantity	Market Price
Tourism loss downstream	Loss of tourism Value	Reducing tourists number × the average expenditure per person	Reveal preference (TCM)

Source: ADB, 2001

The total savings can be calculated through the following formula[6]:

$$\text{Annual savings on buying bottled water} = \text{The amount of water each person drinks daily} \times \text{The price of bottled water per million tons} \times \text{Number of people stop using bottled water} \times \text{365 days}$$

Construction Cost. The MND project consists of the dam, the power system, and the spillway. The total construction period is estimated to take seven years, and the year before the project begins, year zero, is used to resettle the local residents and acquire land. The construction cost is estimated based on the 1992 report of Sino-Tech Engineering Consultants, Ltd.

Operation and Maintenance (O&M). O & M covers all services and materials required in MND construction. The maintenance fee refers to the costs of maintaining and replacing the engineering part of the facilities, and is estimated at 10% of the total construction cost[7]. The operation costs are referring to the personnel expenditure and the basic water treatment fee when the water is supplied. O & M costs will emerge in year eight.

Replacement Costs. It is estimated that the MND project will continue to supply water and power for 70 years. During the project analysis period, some parts of this facility need to be replaced in order to keep both water and power system running well. Two most important parts need to be replaced are the pipelines and the water gates. The pipeline will need to be changed every twenty five years and the water gate has to be

---

6 According to the public construction regulation in Taiwan, the operation and maintenance costs are estimated as 10% of total construction costs, total construction costs include the design, investigation, and construction costs which are shown in Table 7 and Table 8.

changed every fifty years. The cost of replacing these two facilities is estimated based on their constructing cost in 1992.

Resettlement Costs and Land Acquisition. Resettlement costs are composed of two parts: compensation and assistance expenses. Compensation can be calculated directly from physical property losses of the people located in the MND area. Analysts may use the market price method to arrive at the value of property losses. The assistance expenses are the costs of the government programs implemented to help the displaced residents, and are determined accordingly. In the MND project, the estimated total cost of resettlement, in 1992, is 1.388 billion NTD, and should be accounted for in year zero of the project (WRA, 1992).

Opportunity Cost of Land. The opportunity cost of land will be estimated through the value of ecosystem services per kilometer times the affected areas. The inundated area includes forest, agricultural, and residential lands.

In fact, Pong (1992) uses CVM to estimate Mei-Nong people's WTA for constructing the MND and the results can be used in the analysis to represent the opportunity cost of land. Consequently, Costanza (1997) use the social surplus to calculate the values of ecosystem services in the world and the results are also used in the calculation. This cost will be further addressed by using the data from Pong (1992) and Costanza (1997) in the analysis section.

Tourism Gain and Loss. The Mei-Nong Township is famous for its good preservation of Hakka culture and beautiful surrounding. Every year the Hakka Festival attracts many tourists into the town for its exhibition of domestic culture and art. Most tourists also come here to enjoy the fresh air and clean water and some parents or teachers bring their children here to introduce them to the plentiful flora and fauna.

However, once the MND begins to provide water, the whole region will be changed and replaced by different ecosystem and the expected reduction of tourists will lead to obvious impacts on the local economy. Therefore, this study estimates the loss of tourism through the reducing number of these tourists and their expenditure.

Although the landscape will be changed when the project starts, the new reservoir also will provide a new feature to attract people. There are famous examples about dams providing tourism value for people including the Bedok reservoir park in Singapore. The new reservoir can provide people with a boating, camping jogging and hiking area. These new benefits could be calculated through its average value per hector multiple the area of reservoir.

Inflation Adjustment. Almost all the costs in MND project are estimated based on 1992 consumer basis and the inflation factor should be taken into account in the analysis. Table 3 shows the Consumer Price Index between 1991 and 2006.

3. Discount Factor

Two major discount rates are used in this study. First, Gittinger (1982) pointed out that the common discount rate used in financial analysis is the rate at which the enterprise is able to borrow money. A thematic review of WCD also suggests that a discount rate of 6% is applied in a developed country, and consequently, a discount rate in public projects ranged anywhere from eight to twelve percent is used in developing countries considering the higher inflation rate (WCD, 2000).

Table 3 Consumer Price Index and Adjustment Factors

Year	Consumer Price Index	Adjustment Factor
1991	77.18	1.29
1992	80.63	1.24
1993	83.0	1.20
1994	86.41	1.15
1995	89.58	1.11
1996	92.33	1.08
1997	93.17	1.07
1998	94.73	1.05
1999	94.90	1.05
2000	96.09	1.04
2001	96.08	1.04
2002	95.89	1.04
2003	95.62	1.04
2004	97.17	1.02
2005	99.41	1.01
2006	100	1

Source: National Statistic, Taiwan, 1991-2006

Second, some scholars suggest future generations should have the same weight to use the resource as current generation and a zero discount rate means that future generations are involved in the decision process, and can prevent future environmental damage. Therefore, this study also applies a zero discount factor as a reference and intends to realize the profitability of MND project after considering the equity issue.

Lastly, in order to estimate the Internal Rate of Return (IRR) the discount rate of 3% is used. The IRR is a rate of return used in capital budgeting to measure and compare the profitability of investments. It is also called the discounted cash flow rate of return or simply the rate of return (ROR).

4. Sensitivity Analysis

In order to better evaluate the potential impacts of uncertainty and risk. Sensitivity analysis refers to an analytical technique used to test the potential earning capacity of a project if actual events differ from the initial estimation made during the planning stage (Gittinger, 1982). This type of analysis is useful as it provides flexibility in results. It can be assumed that an actual event will not materialize exactly as planned because of unexpected changes in factors over time or the use of faulty or limited data in the initial projection. In forecasting any occurrence over time, an analyst may encounter two types of situations: risk and uncertainty. Risk refers to a situation where the probability of an outcome's occurrence is available. In contrast, uncertainty refers to a situation where such information is not available.

According to the cross check of WCD (2000), this study concerns following three factors causing uncertainty: 1) the efficiency of dam, 2) overrun of construction costs, and 3) schedule delays.

The Efficiency of MND. The dam site is located in a relative high area, and the high slope will increase the chance of soil being brought into the reservoir and reducing the capacity of the dam, as well as the amount of water and power available to the public and industries. Therefore scenario one in Chapter V, accounts for the effect of reduced water yield on the NPV due to more serious sedimentation problems.

The Overrun of the Construction Cost. Sedimentation isn't the only factor capable of affecting the NPV, the overrun of construction costs commonly leads to a different result of the NPV. According to the crosscheck by Bacon and Besant-Jones in 1998, over seventy dam projects financed by the World Bank between 1915 and 1986 show average cost overruns of about 30%. Therefore scenario two will simulate the effects of construction cost overruns on the NPV.

Delay of the Construction Period. Another potential source of uncertainty is a delay in the project schedule. The WCD crosscheck shows 40% of projects with one year delays, and 5% with five or more years. The impact of delays is discussed in the scenario three.

5. Data Collection

The study area is located in the southern part of Taiwan. For full details of the study area, please refer to Chapter III. The area of unit of analysis is the hectare. Data related to the study area were aggregated from the environmental impact assessment made by Sino-Tech Incorporated in 1992.

Data used in this study were obtained from both primary and secondary sources. Secondary data reflecting prices were acquired from the Water Resource Agency publication, the Taiwanese government, as well as other government studies on similar topics.

CHAPTER V: RESULTS AND DISCUSSION

The net present value (NPV) of the project is discussed in this chapter. To determine the NPV, the discounted values of benefits and costs are needed. The identified benefits and costs, the NPVs, and the results of the sensitivity analysis are discussed in turn. The analysis period in this study is designed as 70 years because the average life span of dams in Taiwan is 70 years due to the soil deposition problem (Cheng, 2004).

1. Benefits of MND Project

The benefits of the MND project include income from the sale of water and power, savings from reducing consumption of packaged water, and newly created recreation value from the reservoir.

Benefits without MND Project. If this project were not to take place, the would-be inundated area, consisting of tropical forest, cropland, and rangeland, could offer several eco-services including providing food, raw materials, and cultural and recreational value. In this study, two approaches are used to estimate these non-market services. First, CVM is used to estimate the values for environmental goods and services in hypothetical situations. Pong (1992) tried to use the CVM to estimate the opportunity cost of the MND project's selected site. Based on her study, the WTA for constructing the dam project, or opportunity cost, is 899.4 New Taiwan Dollars (NTD) per person every month. The population of Mei-Nong Township is approximately 50,000, and therefore the opportunity cost for the dam project will be 540 million NTD per year by multiplying the WTA to the population of Mei-Nong town.

Second, the benefits created by the submerged land can be also estimated by multiplying the area of flooded land to the averaged price of a serious of benefits. The value of ecosystems services is estimated from the research of Costanza (1997) and the benefits from ecosystem services are shown in Table 4.

Benefits with the MND Project. The MND is expected to satisfy the increasing demand both from municipal and industrial sectors. The power and water supplied by the MND will be the main benefits of the MND. Consequently, through improving the water quality, the city's residents could save money from buying bottled water.

Income from Sale of Water. The MND project was planned to satisfy the increasing water demand in the Kaohsiung area. Once the new water source is established, the annual income from selling water will become an important indicator of the project's benefit. In fact, municipal and industrial water uses in Kaohsiung City are two major water consumers of the MND. Therefore, the benefit of increasing water quantity can be described in following:

$$\text{Income from water sale} = \text{Water price} \times \text{Amount of water sold every year}$$

This study uses the market price of water in 2006 to estimate the benefits of the project. The actual charge for municipal water use is 10.84 NTD per cubic meter and the price for industrial water is 9.74 NTD per cubic meter (WRA, 2006) as the mission of the project is to satisfy the increasing population and the growing industries. All the water supplied by MND will go to these two sectors.

In addition, the MND is expected to generate 406 million cubic meters of water annually, but part of the water will lose during the distribution and, therefore, 378.2 million cubic meters water is the actual amount sold every year.

Table 4 Benefit Provided by Ecosystem Services.

Service Name	Area of land	Unit	Benefit /Unit per year (NTD)	Total Benefit per year (million NTD)
1.Tropical Forest	726 ha			
1.1 Climate Regulation		1 ha	6690	4.85
1.2 Erosion control		1 ha	7380	5.35
1.3 Nutrient cycle		1 ha	27660	20.08
1.4 Waste Treatment		1 ha	2610	1.89
1.5 Food production		1 ha	960	0.69
1.6 Raw material		1 ha	9450	6.86
1.7 Cultural		1 ha	60	0.04
2. Cropland	101 ha			
2.1 Food production		1 ha	54	0.16
3. Grass/Rangeland	35 ha			
3.1 Erosion control		1 ha	29	0.02
3.2 Waste treatment		1 ha	87	0.08
3.3 Food production		1 ha	67	0.07
3.4 Recreation		1 ha	2	0.01
Total Benefits provided by eco services				44.11

Source: Costanza, 1997

Note: ha =Hectare; Exchange Rate: 1 USD for 30 NTD in 1997

Furthermore, the soil deposit rate 0.1% is used in the analysis to simulate real yield of water and power from the MND. The actual water of MND project sold to these two sectors is listed in Table 5.

Income from Sale of Power. Similar to the income from selling water, the market price of power, 2.3 NTD, per KW in 2006 is used to calculate the benefit of power sale. According to WRA's 1992 report, 146 million KW power is expected to be generated in 1999, and, the amount of power provided by the MND also gradually decreases due to the soil deposition problem. Table 6 shows the expected benefits created by power sale.

Table 5 Income from Sold Water

Year	Municipal water consumption (Million m3)	Industrial water consumption (Million m3)	Water supplied by MND (Million m3)	Municipal Water from MND (Million m3)	Industrial Water from MND (Million m3)	Income from sold water (Million NTD)
1992	267.58	173.12				
1993	0	279.72				
1994	292.58	192.39				
1995	302.09	197.70				
1996	304.00	205.58				
1997	324.48	189.32				
1998	326.53	221.06				
1999	341.90	225.93	24.75	14.90	9.85	161.56
2000	372.68	254.17	24.42	14.52	9.90	139.26
2001	369.45	244.46	24.09	14.50	9.59	139.07
2002	374.17	252.94	48.23	28.78	19.45	276.02
2003	367.40	238.22	71.80	43.56	28.24	417.72
2004	347.24	230.28	94.78	56.99	37.79	546.54
2005	353.60	240.61	117.21	69.75	47.46	668.92
2006	364.64	245.48	139.10	83.14	55.97	797.30
2007	361.77	255.23	160.48	94.09	66.39	902.37
2008	395.05	256.08	181.35	110.03	71.32	1055.19
2009	400.53	259.39	201.74	122.44	79.30	1174.26
2010	406.00	262.71	221.66	134.58	87.08	1290.66
2011	411.48	266.03	241.13	146.45	94.68	1404.50
2012	416.95	269.34	260.18	158.07	102.11	1515.91
2013	422.43	272.66	278.80	169.44	109.36	1624.92
2014	427.90	275.97	297.02	180.56	116.46	1731.66
2015	433.38	279.29	314.86	191.47	123.39	1836.23
2016	438.86	282.61	332.35	202.16	130.19	1938.75
2017	444.33	285.92	349.48	212.64	136.84	2039.28
2018	449.81	289.24	366.29	222.93	143.36	2137.98
2019	455.28	292.56	371.16	225.96	145.20	2169.63
2020	460.76	295.87	371.29	226.10	145.19	2168.30
2021	466.23	299.19	370.96	225.96	145.00	2166.95
2022	471.71	302.51	370.63	225.81	144.82	2165.59
2023	477.18	305.82	370.30	225.67	144.63	2164.21
2024	482.66	309.14	369.97	225.52	144.45	2162.82
2025	488.13	312.46	369.65	225.38	144.27	2161.42
2026	493.61	315.77	368.99	225.03	143.96	2160.00
2027	499.08	319.09	368.66	224.88	143.78	2158.58
2028	504.56	322.41	368.34	224.74	143.60	2157.14
2029	510.03	325.72	368.01	224.58	143.43	2155.69
2030	515.51	329.04	367.68	224.43	143.25	2154.24
2031	520.98	332.36	367.35	224.28	143.07	2152.77
2032	526.46	335.67	367.03	224.13	142.90	2151.29
2033	531.93	338.99	366.70	223.97	142.73	2149.80
2034	537.41	342.30	366.37	223.81	142.56	2148.30

Table 5 Continued

2035	542.88	345.62	366.04	223.65	142.39	2146.80
2036	548.36	348.94	365.71	223.50	142.22	2145.28
2037	553.83	352.25	365.39	223.34	142.05	2143.76
2038	559.31	355.57	365.06	223.18	141.88	2142.22
2039	564.78	358.89	364.73	223.02	141.71	2140.68
2040	570.26	362.20	364.08	222.66	141.42	2139.13
2041	575.74	365.52	363.75	222.49	141.26	2137.58
2042	581.21	368.84	363.42	222.33	141.09	2136.02
2043	586.69	372.15	363.09	222.16	140.93	2134.44
2044	592.16	375.47	362.77	222.00	140.77	2132.87
2045	597.64	378.79	362.44	221.84	140.60	2131.28
2046	603.11	382.10	362.11	221.67	140.44	2129.69
2047	608.59	385.42	361.78	221.50	140.28	2128.09
2048	614.06	388.74	361.45	221.33	140.12	2126.49
2049	619.54	392.05	361.13	221.17	139.96	2124.88
2050	625.01	395.37	360.80	221.00	139.80	2123.26
2051	630.49	398.69	360.47	220.83	139.64	2121.64
2052	635.96	402.00	360.14	220.66	139.48	2120.01
2053	641.44	405.32	359.82	220.49	139.33	2118.38
2054	646.91	408.63	359.49	220.32	139.17	2116.74
2055	652.39	411.95	359.16	220.15	139.01	2115.10
2056	657.86	415.27	358.83	219.97	138.86	2113.45
2057	663.34	418.58	358.51	219.81	138.70	2111.79
2058	668.81	421.90	358.18	219.63	138.55	2110.14
2059	674.29	425.22	357.85	219.46	138.39	2108.47
2060	679.76	428.53	357.52	219.28	138.24	2106.80
2061	685.24	431.85	357.19	219.11	138.08	2105.13
2062	690.71	435.17	356.87	218.94	137.93	2103.45
2063	696.19	438.48	356.54	218.76	137.78	2101.77
2064	701.66	441.80	356.21	218.58	137.63	2100.09
2065	707.14	445.12	355.88	218.40	137.48	2098.40
2066	712.62	448.43	355.56	218.23	137.33	2096.70
2067	718.09	451.75	355.18	218.02	137.16	2095.00
2068	723.57	455.07	354.84	217.84	137.00	2093.30

Source: WRA annual report, 1992, to 2007
Note: The trend line for municipal water projection since 2008 is Y=5.4752X+301.98; The trend line for industrial water projection since 2008 is Y=3.3165X+199.7

Saving on Buying Packaged Water. As we mentioned in the previous chapter, water quality is always an important factor affecting the consumers' willingness of using tap water. The bad water quality caused by pollution in the major water source in Kaohsiung City forces almost every household in Kaohsiung to buy packaged water for drinking.

Table 6 Income from Sold Power and Saving From Clean Water.

Year	Power supplied by MND	Income from sold power	Municipal Water Use from MND (million m^3)	Drinking use (million m^3)m^3)	Annual Consumption of packaged water (million m^3)	Reduction of packaged water consumption (million m^3)	Saving from reducing consumption of packaged water (million NTD)
1999	1.44	3.30	14.90	0.30	0.20	0.06	30.88
2000	1.43	3.30	14.52	0.29	0.20	0.06	30.08
2001	1.43	3.30	14.50	0.29	0.20	0.06	30.04
2002	1.43	3.29	28.78	0.58	0.39	0.12	59.63
2003	1.43	3.29	43.56	0.87	0.60	0.18	90.24
2004	1.43	3.29	56.99	1.14	0.78	0.24	118.07
2005	1.43	3.28	69.75	1.40	0.96	0.29	144.51
2006	1.43	3.28	83.14	1.66	1.14	0.34	172.24
2007	1.42	3.28	94.09	1.88	1.29	0.39	194.94
2008	1.42	3.27	110.03	2.20	1.51	0.46	227.95
2009	1.42	3.27	122.45	2.45	1.68	0.51	253.67
2010	1.42	3.27	134.58	2.69	1.85	0.56	278.82
2011	1.42	3.26	146.45	2.93	2.01	0.61	303.41
2012	1.42	3.26	158.07	3.16	2.17	0.65	327.48
2013	1.42	3.26	169.44	3.39	2.32	0.70	351.03
2014	1.41	3.25	180.57	3.61	2.48	0.75	374.09
2015	1.41	3.25	191.47	3.83	2.63	0.79	396.68
2016	1.41	3.25	202.16	4.04	2.77	0.84	418.83
2017	1.41	3.24	212.65	4.25	2.92	0.88	440.54
2018	1.41	3.24	222.94	4.46	3.06	0.92	461.87
2019	1.41	3.24	226.24	4.52	3.10	0.94	468.70
2020	1.41	3.23	226.10	4.52	3.10	0.94	468.42
2021	1.40	3.23	225.96	4.52	3.10	0.94	468.12
2022	1.40	3.23	225.82	4.52	3.10	0.94	467.83
2023	1.40	3.22	225.67	4.51	3.10	0.94	467.53
2024	1.40	3.22	225.53	4.51	3.09	0.93	467.23
2025	1.40	3.22	225.38	4.51	3.09	0.93	466.93
2026	1.40	3.21	225.24	4.50	3.09	0.93	466.62
2027	1.40	3.21	225.09	4.50	3.09	0.93	466.32
2028	1.39	3.21	224.94	4.50	3.09	0.93	466.01
2029	1.39	3.20	224.79	4.50	3.08	0.93	465.69
2030	1.39	3.20	224.63	4.49	3.08	0.93	465.38
2031	1.39	3.19	224.48	4.49	3.08	0.93	465.06
2032	1.39	3.19	224.33	4.49	3.08	0.93	464.74
2033	1.39	3.19	224.17	4.48	3.08	0.93	464.42
2034	1.39	3.19	224.01	4.48	3.07	0.93	464.10
2035	1.38	3.18	223.86	4.48	3.07	0.93	463.77
2036	1.38	3.18	223.70	4.47	3.07	0.93	463.44
2037	1.38	3.18	223.54	4.47	3.07	0.93	463.11
2038	1.38	3.17	223.38	4.47	3.06	0.93	462.78
2039	1.38	3.17	223.22	4.46	3.06	0.92	462.45
2040	1.38	3.17	223.06	4.46	3.06	0.92	462.12

Table 6 Continued

2041	1.38	3.16	222.90	4.46	3.06	0.92	461.78
2042	1.37	3.16	222.73	4.45	3.06	0.92	461.44
2043	1.37	3.16	222.57	4.45	3.05	0.92	461.10
2044	1.37	3.15	222.41	4.45	3.05	0.92	460.76
2045	1.37	3.15	222.24	4.44	3.05	0.92	460.42
2046	1.37	3.15	222.07	4.44	3.05	0.92	460.08
2047	1.37	3.14	221.91	4.44	3.04	0.92	459.73
2048	1.37	3.14	221.74	4.43	3.04	0.92	459.38
2049	1.36	3.14	221.57	4.43	3.04	0.92	459.04
2050	1.36	3.13	221.40	4.43	3.04	0.92	458.69
2051	1.36	3.13	221.23	4.42	3.04	0.92	458.34
2052	1.36	3.13	221.06	4.42	3.03	0.92	457.98
2053	1.36	3.12	220.89	4.42	3.03	0.92	457.63
2054	1.36	3.12	220.72	4.41	3.03	0.91	457.28
2055	1.36	3.12	220.55	4.41	3.03	0.91	456.92
2056	1.35	3.11	220.38	4.41	3.02	0.91	456.57
2057	1.35	3.11	220.21	4.40	3.02	0.91	456.21
2058	1.35	3.11	220.04	4.40	3.02	0.91	455.85
2059	1.35	3.10	219.86	4.40	3.02	0.91	455.49
2060	1.35	3.10	219.69	4.39	3.01	0.91	455.13
2061	1.35	3.10	219.51	4.39	3.01	0.91	454.77
2062	1.35	3.09	219.34	4.39	3.01	0.91	454.41
2063	1.34	3.09	219.16	4.38	3.01	0.91	454.04
2064	1.34	3.09	218.99	4.38	3.00	0.91	453.68
2065	1.34	3.08	218.81	4.38	3.00	0.91	453.31
2066	1.34	3.08	218.63	4.37	3.00	0.91	452.95
2067	1.34	3.08	218.46	4.37	3.00	0.91	452.58
2068	1.34	3.07	218.28	4.37	2.99	0.90	452.21

Note: About 2% of municipal water use is drinking water; 68.6% inhabitant of Kaohsiung use the packaged water as the source of drinking water; 30.2% of the inhabitant would use tap water and stop buying packaged water if a new water source is available.

Although the government of Kaohsiung has worked hard to improve water quality in the last decade, some problems such as odor and color of the water still exist. The rate of buying among the residents in Kaohsiung remains high.

According to a survey of 500 households in Kaohsiung (Tse, 2004), 68.6 % of people in Kaohsiung city use packaged water as their major source of drinking water. The same survey also indicates that 30.2% of respondents would be likely to reduce packaged water consumption if a new water source were established. The price of packaged water is much higher than tap water, and the cheapest bottled water is around 500 NTD per ton

(Tse, 2004). Therefore, the reduced amount of money spent on buying water due to improved municipal water quality can be seen as one benefit brought by the MND project. The benefit of saving for buy water is shown in Table 6.

New Recreational Value. The newly formed reservoir could create new recreational value. According to Costonza's study (1997), the lake can provide at least 230 USD recreational value per hectare per year. The new reservoir covers 863 hectares and will create 5.9478 million recreational values each year for both local residents and tourist. This benefit is calculated by multiplying the area of reservoir to the recreational value per unit area.

2. Costs of MND Project

The major costs of the MND project are divided into three categories: 1) acquisition of land, 2) construction costs, and 3) replacement, maintenance and operation costs.

Land Right Acquisition and Resettlement Costs. This cost will happen in year zero, which means that the cost happens before the project has begun. According to the WRA's plan, 1.3884 billion NTD will be used to acquire the rights to use the land and resettle the affected people (WRA, 1992).

Construction Costs. The MND project consists of a water supply system and the power system construction. The total construction period for the water supply system is seven years; the construction of generation system begins in year four. The complete list of construction items and the expenditures for these two systems are shown in Table 7 and Table 8.

Table 7 Construction Cost of Dam and Water Supply System

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
1.Land Acquisition and Resettlement costs (Million NTD)	1388.9							
2.Direct Construction Cost of Dam	0							
2.1 Road Construction	0	308	385	77				
2.2 Water Intake Weir						116.9	146.1	29.2
2.3 Sedimentation Pool						47.2	78.6	31.4
2.4 Water Channel					171.6	400.5	400.5	171.6
2.5 Water Split Channel		186.1	206.8	8.3				12.4
2.6 Spill Way					167.1	250.7	292.5	125.4
2.7 Drainage System		66.6	75	8.3		16.7		
2.8 Dam				1913.6	3189.3	3189.3	3189.3	1275.7
2.9 Mechanic Equipment			4.3				17.2	193.1
2.10 Environmental protection		7.5	7.5	15	22.5	22.5	37.5	37.5
2.11 Soil Erosion Protection				45	45	45	90	75
2.12 Others		175	100	75	50	50	25	25
Subtotal	0	743.2	778.6	2142.2	3645.5	4138.8	4276.7	1976.3
3. Design and Investigation fee	0	111.48	116.79	321.33	546.83	620.82	641.51	296.45
4. Preparation Fee	277.78	170.94	179.08	492.71	838.47	951.92	983.64	454.55
Total	1666.7	1025.6	1074.5	2956.2	5030.8	5711.5	5901.8	2727.3

Source: WRA, 1992

Table 8 Construction Cost of Power System

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Note
1.Construction Cost of Power System									
1.1 Water gates						32.2	44.3	4	
1.2 Water ways						44.4	103.6		
1.3 Power transfer towers						54.5		29.4	
1.4 Pipes						59.3	11.9	47.4	
1.5 Power adapters							49.7	5.5	
1.6 Drainage System							5		
1.7 Weir							169.38	254.1	
1.8 Operation field								10	
1.9 Roads Construction					40	10			
1.10 Generation units							256.4	598.3	
1.11 Mechanics							64.1	96.1	
1.12 Pipelines							51.5	77.3	
1.13 Water Gates							8.2	77.3	
1.14 Other Equipments							30.7	30.6	
Subtotal	0	0	0	0	40	200.4	794.78	1230	
2. Indirect Construction Cost	0	0	0	0	6	30.06	119.22	184.5	
3. Power Delivery Cable								38.65	15% of 1
4. Preparation Fee	0	0	0	0	9.2	46.092	182.8	290.63	20% of (1+2)
Total	0	0	0	0	55.2	276.55	1096.8	1743.8	

Source: WRA, 1992

Replacement, Operation and Maintenance Fee. According to the design report of Sino-tech Ltd., two important units of the dam, the water gate and the pipelines, will require replacement at certain intervals in the project analysis period. The pipeline needs to be replaced every twenty five years (i.e., the years of 2023 and 2048). The cost for each pipeline replacement will be 128.70 million NTD. As for the water gate, it only needs to be replaced every 50 years, and it costs 80.50 million NTD and will incur in 2049.

Operation costs include personnel and basic water treatment fees. A total of 60 crew members are needed to operate the water supply and power systems: 45 for the water supply system, and 15 for the power system. The average salary for each crew member is 350,000 NTD each year, and 21 million NTD of personnel costs will be incurred after the project begins running in year eight.

The basic water treatment fee depends on the actual amount of water supplied by the dam. The cost for basic water processing is 0.121 NTD per cubic meter of water. Most of the amount is for purchasing the disinfection dose to treat the water. Once the basic water treatment is done, the water can be sold for industrial use or sent for further treatment before supplying to municipal sectors. The complete costs are shown in Table 9.

3. Discussion of Results

After the benefits and costs of the MND project are determined, the next process is to examine if the project is economically efficient by calculating the NPV of MND project. The discount rate used in this analysis is 6%, which is also the interest rate of the Central Bank in Taiwan in 1992. The NPV is a negative 5.024 billion NTD without considering the loss of ecosystem services.

Table 9 Maintenance, Replacement and Operation Costs

Year	[8] Maintenance Fee for Water Supply System (million NTD)	Maintenance Fee for Power Generation System (million NTD)	Personnel Expenditure for Water Supply System (million NTD)	Personnel Fee for Power Generation System	Basic Treatment Cost of Water (million NTD)	Replacement Costs
1999	260.94	31.72	157.5	52.5	2.298	
2000	260.94	31.72	157.5	52.5	3.035	
2001	260.94	31.72	157.5	52.5	5.996	
2002	260.94	31.72	157.5	52.5	8.886	
2003	260.94	31.72	157.5	52.5	11.707	
2004	260.94	31.72	157.5	52.5	14.461	
2005	260.94	31.72	157.5	52.5	17.149	
2006	260.94	31.72	157.5	52.5	19.775	
2007	260.94	31.72	157.5	52.5	22.34	
2008	260.94	31.72	157.5	52.5	24.847	
2009	260.94	31.72	157.5	52.5	27.298	
2010	260.94	31.72	157.5	52.5	29.693	
2011	260.94	31.72	157.5	52.5	32.037	
2012	260.94	31.72	157.5	52.5	34.33	
2013	260.94	31.72	157.5	52.5	38.575	
2014	260.94	31.72	157.5	52.5	38.773	
2015	260.94	31.72	157.5	52.5	40.928	
2016	260.94	31.72	157.5	52.5	43.041	
2017	260.94	31.72	157.5	52.5	45.115	
2018	260.94	31.72	157.5	52.5	45.799	
2019	260.94	31.72	157.5	52.5	45.799	
2020	260.94	31.72	157.5	52.5	45.799	
2021	260.94	31.72	157.5	52.5	45.799	
2022	260.94	31.72	157.5	52.5	40.928	
2023	260.94	31.72	157.5	52.5	43.041	128.7
2024	260.94	31.72	157.5	52.5	45.115	
2025	260.94	31.72	157.5	52.5	45.799	
2026	260.94	31.72	157.5	52.5	45.799	
2027	260.94	31.72	157.5	52.5	40.928	
2028	260.94	31.72	157.5	52.5	43.041	
2029	260.94	31.72	157.5	52.5	45.115	
2030	260.94	31.72	157.5	52.5	45.799	
2031	260.94	31.72	157.5	52.5	45.799	
2032	260.94	31.72	157.5	52.5	40.928	
2033	260.94	31.72	157.5	52.5	43.041	
2034	260.94	31.72	157.5	52.5	45.115	
2035	260.94	31.72	157.5	52.5	45.799	
2036	260.94	31.72	157.5	52.5	45.799	
2037	260.94	31.72	157.5	52.5	40.928	
2038	260.94	31.72	157.5	52.5	43.041	
2039	260.94	31.72	157.5	52.5	45.115	
2040	260.94	31.72	157.5	52.5	45.799	
2041	260.94	31.72	157.5	52.5	45.799	

[8] Maintenance fee is 10% of total construction cost.

Table 9 Continued

2042	260.94	31.72	157.5	52.5	40.928	
2043	260.94	31.72	157.5	52.5	43.041	
2044	260.94	31.72	157.5	52.5	45.115	
2045	260.94	31.72	157.5	52.5	45.799	
2046	260.94	31.72	157.5	52.5	45.799	
2047	260.94	31.72	157.5	52.5	40.928	
2048	260.94	31.72	157.5	52.5	43.041	128.7
2049	260.94	31.72	157.5	52.5	45.115	80.5
2050	260.94	31.72	157.5	52.5	45.799	
2051	260.94	31.72	157.5	52.5	45.799	
2052	260.94	31.72	157.5	52.5	40.928	
2053	260.94	31.72	157.5	52.5	43.041	
2054	260.94	31.72	157.5	52.5	45.115	
2055	260.94	31.72	157.5	52.5	45.799	
2056-2068	260.94	31.72	157.5	52.5	45.799	

Source: WRA, 1992

If the loss of ecosystem services is calculated by using Mei-Nong people's WTA to accept the MND, the NPV comes to negative 15.773 billion NTD. Even using more conservative estimate of ecosystem loss (Costanza, 1997), the NPV is still negative 8.026 billion NTD. These NPVs show the project.is not economically feasible at 6% discount rate and other potential alternatives should be considered since the MND is not the best way to contribute to economic efficiency.

Based on the interpolation of discount rate as identified in Table 10, the IRR of the MND project is around 3.49% and it is lower than the prevailing interest rate 6%. The low IRR of the MND suggests the anticipated return is lower than the return of investment on a similar project. Therefore, the MND project is considered infeasible and should not be accepted.

However, when 0% discount rate is applied in the analysis, the NPV of the MND project turns out to be positive (11.584 NTD). The results suggest the execution of the project is feasible and will increase the efficiency of resource distribution when considering the future generation has the same right as current one to decide how to manage environmental resources. The present values of benefits and costs at a zero discount rate are shown in the second column in Table 10.

Table 10 NPV of the MND Project.

Items	PV at 6% Discount Rate (Million NTD)	PV at 0 %Discount Rate (Million NTD)	PV at 3 %Discount Rate (Million NTD)Note
Benefits			
1. Sale of Water	$12919.6	$128443.7	$35583.8
2. Sale of Power	$8478.6	$83294.3	$23216.9
3. Saving from Buying Drinking Water	$ 33.4	$223.1	$74.1
4. Benefits forgone for constructing the new dam	$ 509.4	$ 540.0	$524.3
5. New tourism value created by the reservoir	$ 142.8	$ 151.4	$147.0
Costs			
1. Land acquired and Resettlement costs	($1310.3)	($1388.9)	($1348.4)
2. Direct Construction Cost for Dam	($13502.3)	($ 17701.3)	($15413.6)
3. Indirect Construction Cost	($2025.3)	($2655.2)	($2312.0)
4. Direct Construction Cost for Generation System	($1857.7)	($2265.2)	($2047.9)
5. Indirect Construction Cost	($278.7)	($339.8)	($307.2)
6. Power Delivery Cables	($30.6)	($38.7)	($34.3)
7. Preparation Fee for Dam Construction	($3191.8)	($4349.1)	($3711.6)
8. Preparation Fee for Generation System	($343.3)	($528.7)	($424.6)
9. Maintenance Costs	($4795.1)	($20486.2)	($8523.3)
10. Annual Personnel Expenditure	($3440.8)	($14700.0)	($6115.9)
11. Basic water treatment cost	($488.2)	($2839.5)	($1026.7)
12. Replacement Costs	($303.5)	($337.9)	($319.9)
13. NPV (W/O considering the ecosystem, cultural and tourism loss)	($5024.40)	$169082.8	$26465
14. NPV	($15,773.12)	$115845	$6388.0

4. Sensitivity Analysis

This study applies sensitivity analysis to assess the effects of following uncertain parameter: 1) the efficiency of dam 2) overruns of construction costs and 3) delays of schedule.

Scenario One: Efficiency of the MND. Sedimentation problems exist in almost every dam in Taiwan, and therefore, the first scenario wants to examine the impact of higher sedimentation on the NPV of the MND project. 1% soil deposit rate is used in this scenario.

The higher soil deposited rate directly leads to the reducing yield of water and power and lowers the NPV from - 15.778 billion NTD to -19.307 billion NTD. The decrease rate is about 22% under the 6% discount rate. The effects of sedimentation are shown in Appendix 2.

Scenario Two: Overrun of the Construction Costs. The impact of overruns of construction costs is examined in this scenario using 30% overruns during the construction period. This scenario confirms that overruns do have an obvious effect on the NPV. The NPV decreases about 45%, from -15.778 billion NTD to -22.894 billion NTD. The effect of overruns of construction costs on NPV is presented in Appendix 3.

Scenario Three: Delay of the MND Project. In addition to sedimentation and the overrun of the construction costs, delay of the project schedule is another common problem. In this scenario, a one year delay of the project finish was applied in the calculation and the benefits of water and power sales as well as savings from packaged water consumption begin to happen in the year nine. The results show that the delay also lowers the NPV. The NPV of the project after incorporating the delay factor decreased

6.8%, from -15.778 billion NTD to -16.845 billion NTD. The calculation is presented in Appendix 4.

The results of the Net Present Value of the MND project incorporate all of the above factors and the summary of the simulation analysis based on the above scenarios are presented in Table 11.

Table 11 Sensitivity Analysis of the MND Project.

Types of uncertainties	NPV (Billion NTD)	Economic Feasibility	Change % of NPV	Data shown in appendix
The annual soil deposited rate increase from 0.1% to 1%	($19.307)	Not beneficial	22% decrease of NPV	A.2
The construction costs overrun 30%	($22.894)	Not beneficial	45% decrease of NPV	A.3
The project schedule delay for one year	($16.845)	Not beneficial	6.8% decrease of NPV	A.4

CHAPTER VI: CONCULSIONS AND RECOMMONDATIONS

1. Conclusion

The goal of this study is to use an objective approach to determine if a policy can contribute to the economic efficiency of creating social welfare. To answer these questions, the following analysis has been conducted in this study: 1) identify the benefits and costs incurred in the project and define their values, 2) choose a proper discount rate so that the benefits and costs in the future can be used in comparisons in present value, and 3) conduct sensitivity analysis of commonly occurring problems in dam projects and identify their effects on the dam project.

First, the previous study on the MND project (WRA, 1984) did not consider the opportunity cost of submerged land and making the MND appear overly optimistic. After considering the value of the flooded area, the NPV will lower from -5.024 billion NTD to -15.778 billion NTD. Using a more conservative estimate of the value of ecosystem loss (Costanza, 1997), the NPV is -8.026 billion NTD. Moreover, considering the IRR 3.49% is lower than the interest rate in 1992, the project cannot bring more benefits than interest. These results indicate that the MND, as an approach to providing water to Kaohsiung city, is not feasible.

Second, considering the equity issue of future generations, some scholars suggest that very low or zero discount rate should be applied in economic analysis (Cline, 1999; Weitzeman, 1998). Two discount rates, 6% and 0 %, are used in this study. The MND project is considered unfeasible at 6% rates as the NPV is, -15.778 billion NTD. As for the NPV at 0% discount rate, the NPV become 115.845 billion NTD. While considering the 0% discount rate can make each project more attractive, it also causes the problem of selecting the most appropriate project. Most of the projects will become positive and let the decision makers hard to select the best project. Therefore, the NPV at 6% discount rate is more appropriate in this analysis.

Referring to the WCD's thematic review (WCD, 2000), this study examines scenarios involving three types of common uncertainty for dam projects through sensitivity analysis: unexpected performance, overrun of the construction cost and delay of the project. Of the three scenarios, the overrun of construction costs has the most obvious impact; a 45 % decrease of the NPV. The effects of water yield reduction and delays decreased 22% and 6.8% of the MND project's NPV respectively. Once these factors are taken into account, the MND becomes more and more unfavorable.

2. Restriction, Limitation of the Study

While the goal of this study is to re-examine the MND project's profitability by incorporating several ignored factors, some limitations are still remaining.

First, this study left out some benefits and costs which have not been extensively studied. For example, whether the dam can reduce the emission of greenhouse gas is not clear yet, and further studies are needed to help determine this effect. In addition, this study did not take into account the cost of decommissioning the dam. In Taiwan, no large scale dam is decommissioned due to the lack of law and policy. The lack of this cost in the CBA may cause an overestimate of the NPV.

Second, using the WTA is a possible way to reflect non-market goods and services, but the problem with protesting, strategic over-bidding on WTA may lead the result of CBA to a problematic direction. Most respondents in Mei-Nong strongly oppose the MND project, and they may have higher WTAs in order to boycott the project. In the case, the protesting WTA may lead to overestimate the value of non-market goods.

Third, distortions of market are not taken into account. Due to the limited amount of information and time, the estimates of benefits and costs are directly from their market price instead of the real price which would include taxes as well as subsides on the imported goods.

3. Recommendations

Originally, the purpose of the MND project is to supply the water needed for municipal and industrial use. From the results of CBA, this study suggests that the MND project will result in overall negative impacts on society. Indeed, the MND may be beneficial to most residents and industries in Kaohsiung City, but the people in the watershed may suffer from the project. For the benefit of the entire society, it is necessary for the government to pursue better solutions to create the water resource.

In order to effectively supply and manage water resources, several recommendations could be considered.

Create a Relatively Small Scale or Decentralized Water Storage System. The MND is expected to meet the increasing water use within 20 years; however, considering a large scale project usually take a lot of time and money, and often with delays, a small scale projects might be a better option since it is easier to carry out, causes fewer undesirable impacts to the neighboring area, and is easier to maintain.

Use Alternatives to Supply Water. It is becoming more difficult to build new dams in Taiwan as desirable dam sites are hard to find. Additionally, opposition from the locals leads to more difficulties. Instead of constructing the new dams, the government should seek other potential solutions. Surrounded by ocean, Taiwan has the potential to use desalination to acquire more water. Other alternatives could be taken into account, such as decentralized underground reservoirs, which have a less impact on surface activity, and the installation of advanced water treatment equipment to reuse water.

Set up a Water Market. Unlike many developed countries, water in Taiwan is provided directly by the government. In order to maintain a basic standard of living and competition in industry and agriculture, water is provided to these sectors consistently at a consistently (subsidized) low price. This low water price often leads to waste or overuse.

When comparing the actual water price (10.84 NTD/ ton), paid by consumer in 2005 in this study to the water price (22.54 NTD/ ton) which would make the project economically feasible, it is apparent that the curent income from water sales cannot cover the cost of production. Consequently, with insufficient funds to help maintain the equipment and pipelines, even more water may be wasted during transmission.

Taiwan's rapid economic expansion and climate restrictions have provided a strong incentive to the proponents of the dam project. The MND project is seen as a positive step toward the social growth. Yet, the impacts of MND make opponents question the true costs. The debate has lasted for almost two decades and still no compromise has been reached. The dam is still seen as the only way to solve the water scarcity problem for government even though other alternatives are available such as desalination, water reuse, improved storage and recharge of ground water aquifers.

The application of CBA is a very useful tool to evaluate the project efficiency from an economic perspective. By incorporating the loss of the ecosystems, the effect of different discount rates and the potential impacts of uncertainty in the CBA, this study tries to provide a relatively objective reference for both proponents and opponents.

However, in order to provide a more comprehensive view for the decision makers, social, cultural and political factors should be included in the future. A more restricted interdisciplinary perspective will be needed to further illuminate all possible impacts of the dam on society and the environment.

APPENDICES

Appendix 1 Economic Analysis

Economic Analysis	Without	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Benefits (Million NTD)											
Municipal Water Use		0	0	0	0	0	0	0	0	162	139
Industrial Water Use		0	0	0	0	0	0	0	0	96	97
Sale Power		0	0	0	0	0	0	0	0	3	3
Saving form Buying Drinking water		0	0	0	0	0	0	0	0	31	30
Increasing recreation Value		0	0	0	0	0	0	0	0	6	6
Benefits created by the inundated land	540	540									
Tourism value	151	151									
Total Benefits	691	691	0	0	0	0	0	0	0	298	275
Incremental Benefits		0	-691	-691	-691	-691	-691	-691	-691	-394	-416
Costs (million NTD)											
Land acquircition and Resettlement costs		1389									
Direct Construction Cost for Dam			743	779	2142	3646	4139	4277	1976		
Indirect Construction Cost			111	117	321	547	621	642	296		
Direct Construction Cost for Generation System						40	200	795	1230		
Indirect Construction Cost						6	30	119	185		
Power Delivery Cables						0	0	0	39		
Preparation Fee for Dam Construction		278	171	179	493	838	952	984	455		
Preparation Fee for Generation System		0	0	0	0	9	46	183	291		
Maintenance Costs										293	293
Annual Personnel Expenditure										210	210
Basic water treatment cost										3	6
Replacement Costs											
Total Costs	0	1667	1026	1074	2956	5086	5988	6999	4471	506	509
Inflation Adjustment factor		1	1	1	1	1	1	1	1	1	1
After inflation Adjustment		2159	1272	1295	3421	5678	6486	7512	4720	533	529
Incremental costs(With -Without)		2159	1272	1295	3421	5678	6486	7512	4720	533	529
Net Benefit	691	-975	-1026	-1074	-2956	-5086	-5988	-6999	-4471	-208	-233
Incremental Net Benefits	0	-2159	-1963	-1986	-4113	-6369	-7177	-8203	-5411	-927	-946

NPV at 6% -15773

NPV at 0% 115845

Appendix 1 Economic Analysis (Cont'd)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
139	276	418	547	669	797	902	1055	1174	1291	1405	1516	1625	1732	1836	1939	2039	2138	2170	2168	2167
94	190	276	369	463	546	648	696	774	850	924	996	1067	1136	1204	1270	1335	1399	1418	1416	1415
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	60	90	118	145	172	195	228	254	279	303	327	351	374	397	419	441	462	469	468	468
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
272	535	793	1043	1286	1525	1754	1988	2211	2428	2641	2849	3052	3251	3446	3637	3824	4008	4066	4062	4059
-419	-157	101	351	594	833	1063	1297	1519	1737	1949	2157	2361	2560	2755	2945	3133	3316	3374	3371	3368
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
9	12	14	17	20	22	25	27	30	32	34	39	39	41	43	45	46	46	46	46	46
512	514	517	520	522	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
532	536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548
532	536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548
-240	20	276	523	763	1000	1227	1458	1678	1894	2104	2308	2511	2708	2900	3089	3276	3459	3517	3514	3510
-952	-693	-439	-184	69	308	535	767	987	1202	1412	1616	1819	2016	2209	2398	2584	2768	2826	2823	2819

Appendix 1 Economic Analysis (Cont'd)

2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
2166	2164	2163	2161	2160	2159	2157	2156	2154	2153	2151	2150	2148	2147	2145	2144	2142	2141	2139	2138	2136
1413	1411	1409	1407	1406	1404	1402	1401	1399	1397	1395	1394	1392	1390	1389	1387	1385	1384	1382	1381	1379
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
468	468	467	467	467	466	466	466	465	465	465	464	464	464	463	463	463	462	462	462	461
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4055	4052	4048	4045	4042	4038	4035	4031	4028	4024	4021	4017	4014	4010	4007	4003	4000	3996	3993	3989	3986
3364	3361	3357	3354	3350	3347	3343	3340	3336	3333	3329	3326	3322	3319	3315	3312	3308	3305	3301	3298	3294
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
	129																			
548	677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
548	677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
548	677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
3507	3375	3500	3497	3493	3490	3486	3483	3479	3476	3472	3469	3465	3462	3458	3455	3451	3448	3444	3441	3437
2816	2683	2809	2805	2802	2798	2795	2791	2788	2784	2781	2777	2774	2770	2767	2763	2760	2756	2753	2749	2746

Appendix 1 Economic Analysis (Cont'd)

2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
2134	2133	2131	2130	2128	2126	2125	2123	2122	2120	2118	2117	2115	2113	2112	2110	2108	2107	2105	2103	2102
1377	1376	1374	1373	1371	1369	1368	1366	1365	1363	1362	1360	1359	1357	1356	1354	1353	1351	1350	1348	1347
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
461	461	460	460	460	459	459	459	458	458	458	457	457	457	456	456	455	455	455	454	454
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3982	3979	3975	3971	3968	3964	3961	3957	3954	3950	3947	3943	3940	3936	3933	3929	3926	3922	3919	3915	3912
3291	3287	3284	3280	3277	3273	3270	3266	3262	3259	3255	3252	3248	3245	3241	3238	3234	3231	3227	3224	3220
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
					129	81														
548	548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
548	548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548
548	548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548
3434	3430	3427	3423	3420	3287	3332	3409	3405	3402	3398	3395	3391	3388	3384	3381	3377	3374	3370	3367	3363
2742	2739	2735	2732	2728	2596	2641	2718	2714	2711	2707	2703	2700	2696	2693	2689	2686	2682	2679	2675	2672

Appendix 1 Economic Analysis (Cont'd)

2064	2065	2066	2067	2068
73	74	75	76	77
2100	2098	2097	2095	2093
1345	1344	1342	1341	1339
3	3	3	3	3
454	453	453	453	452
6	6	6	6	6
3908	3904	3901	3897	3894
3217	3213	3210	3206	3202
293	293	293	293	293
210	210	210	210	210
46	46	46	46	46
548	548	548	548	548
1	1	1	1	1
548	548	548	548	548
548	548	548	548	548
3360	3356	3352	3349	3345
2668	2665	2661	2658	2654

Appendix 2 Efficiency of the Dam at 1% Soil Deposit Rate.

Economic analysis	Without Project	1991 0	1992 1	1993 2	1994 3	1995 4	1996 5	1997 6	1998 7	1999 8	2000 9	2001 10
Municipal Water Use		0	0	0	0	0	0	0	0	142	119	99
Industrial Water Use		0	0	0	0	0	0	0	0	85	73	59
Sale Power		0	0	0	0	0	0	0	0	3	3	3
Saving form Buying Drinking water		0	0	0	0	0	0	0	0	31	30	30
Increasing recreation Value		0	0	0	0	0	0	0	0	6	6	6
Loss of Tourism	151.4	151										
Benefits created by the inundated land	540.0	540										
Total Benefits	691.4	691	0	0	0	0	0	0	0	267	232	198
Incremental Benefits		0	-691	-691	-691	-691	-691	-691	-691	-424	-459	-493
Costs (million NTD)												
Land acquircition and Resettlement costs		1389										
Direct Construction Cost for Dam			743	779	2142	3646	4139	4277	1976			
Indirect Construction Cost For Dam			111	117	321	547	621	642	296			
Direct Construction Cost for Generation System						40	200	795	1230			
Indirect Construction Cost For Power System						6	30	119	185			
Power Delivery Cables						0	0	0	39			
Preparation Fee for Dam Construction		278	171	179	493	838	952	984	455			
Preparation Fee for Generation System		0	0	0	0	9	46	183	291			
Maintenance Costs										293	293	293
Annual Personnel Expenditure										210	210	210
Basic water treatment cost										3	6	9
Replacement Costs												
Total Costs	0.0	1667	1026	1074	2956	5086	5988	6999	4471	506	509	512
inflation Adjustment factor		1	1	1	1	1	1	1	1	1	1	1
after inflation adjustment		2159	1272	1295	3421	5678	6486	7512	4720	533	529	532
Incremental costs(With -Without)		2159	1272	1295	3421	5678	6486	7512	4720	533	529	532
			-	-	-	-	-	-	-			
Net Benefit	691.4	-975	1026	1074	2956	5086	5988	6999	4471	-239	-277	-314
		-	-	-	-	-	-	-	-			-
Incremental Net Benefits	0.0	2159	1963	1986	4113	6369	7177	8203	5411	-957	-989	1026
NPV at 6%	-19307	0.22		water price is 10.84/ton(cubic meter)								

Appendix 2 Efficiency of the Dam at 1% Soil Deposit Rate (Cont'd).

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
236	375	502	623	748	851	999	1114	1226	1335	1442	1545	1646	1745	1841	1935	2027	2044	2023	2002	1980	1959
143	219	300	382	453	541	583	649	714	777	838	898	956	1012	1067	1121	1173	1182	1169	1156	1143	1130
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
60	90	118	145	172	195	228	254	279	303	327	351	374	397	419	441	462	469	468	468	468	468
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
448	694	930	1158	1383	1596	1819	2026	2228	2425	2616	2803	2985	3163	3337	3506	3672	3704	3669	3635	3600	3566
-243	2	238	467	692	905	1127	1335	1537	1733	1925	2112	2294	2472	2645	2815	2981	3012	2978	2943	2909	2875
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
12	14	17	20	22	25	27	30	32	34	39	39	41	43	45	46	46	46	46	46	46	46
																					167
514	517	520	522	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548	715
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548	715
536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548	715
-66	177	410	636	858	1068	1289	1494	1693	1888	2075	2262	2442	2617	2789	2958	3123	3155	3121	3086	3052	2851
-780	-539	-297	-59	167	377	597	802	1002	1196	1384	1570	1750	1926	2097	2266	2432	2464	2429	2395	2361	2159

Appendix 2 Efficiency of the Dam at 1% Soil Deposit Rate (Cont'd).

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
1938	1917	1896	1874	1853	1832	1811	1789	1768	1747	1725	1704	1682	1661	1640	1618	1597	1575	1554	1532	1511	1489
1117	1104	1091	1079	1066	1053	1040	1027	1015	1002	989	976	964	951	938	925	913	900	887	875	862	850
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
467	467	467	466	466	466	465	465	465	464	464	464	463	463	463	462	462	462	461	461	461	460
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3532	3497	3463	3428	3394	3360	3325	3291	3256	3222	3187	3153	3119	3084	3050	3015	2981	2946	2912	2877	2843	2808
2840	2806	2771	2737	2703	2668	2634	2599	2565	2530	2496	2462	2427	2393	2358	2324	2289	2255	2220	2186	2152	2117
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
2983	2949	2914	2880	2846	2811	2777	2742	2708	2673	2639	2605	2570	2536	2501	2467	2432	2398	2363	2329	2294	2260
2292	2257	2223	2189	2154	2120	2085	2051	2016	1982	1948	1913	1879	1844	1810	1775	1741	1706	1672	1638	1603	1569

Appendix 2 Efficiency of the Dam at 1% Soil Deposit Rate (Cont'd).

2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
1468	1446	1425	1403	1382	1360	1339	1317	1295	1274	1252	1231	1209	1187	1166	1144	1122	1101	1079	1057
837	824	812	799	787	774	762	749	736	724	711	699	686	674	661	649	636	624	611	599
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
460	460	459	459	459	458	458	458	457	457	457	456	456	455	455	455	454	454	454	453
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
2774	2740	2705	2671	2636	2602	2567	2533	2498	2464	2429	2395	2360	2326	2291	2257	2222	2188	2153	2119
2083	2048	2014	1979	1945	1910	1876	1841	1807	1772	1738	1703	1669	1634	1600	1565	1531	1496	1462	1427
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
		167	104																
548	548	715	653	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
548	548	715	653	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
548	548	715	653	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
2226	2191	1990	2018	2088	2053	2019	1984	1950	1915	1881	1846	1812	1777	1743	1708	1674	1639	1605	1570
1534	1500	1298	1326	1396	1362	1327	1293	1258	1224	1189	1155	1120	1086	1051	1017	982	948	913	879

Appendix 2 Efficiency of the Dam at 1% Soil Deposit Rate (Cont'd).

2066	2067	2068
75	76	77
1036	1014	992
587	574	562
3	3	3
453	453	452
6	6	6
2084	2050	2015
1393	1358	1324
293	293	293
210	210	210
46	46	46
548	548	548
1	1	1
548	548	548
548	548	548
1536	1501	1467
844	810	775

Appendix 3 Overrun of the Construction Costs.

Economic Analysis	Without	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Municipal Water Use		0	0	0	0	0	0	0	0	162	139	139
Industrial Water Use		0	0	0	0	0	0	0	0	96	97	94
Sale Power		0	0	0	0	0	0	0	0	3	3	3
Saving form Buying Drinking water		0	0	0	0	0	0	0	0	31	30	30
Increasing recreation Value		0	0	0	0	0	0	0	0	6	6	6
Tourism value	151	151										
Benefits created by the inundated land	540	540										
Total Benefits	691	691	0	0	0	0	0	0	0	298	275	272
Incremental Benefits		0	-691	-691	-691	-691	-691	-691	-691	-394	-416	-419
Costs (million NTD)												
Land acquircition and Resettlement costs		1389										
Direct Construction Cost for Dam			743	779	2142	3646	4139	4277	1976			
Indirect Construction Cost For Dam			111	117	321	547	621	642	296			
Direct Construction Cost for Generation System						40	200	795	1230			
Indirect Construction Cost For Power System						6	30	119	185			
Power Delivery Cables						0	0	0	39			
Preparation Fee for Dam Construction		278	171	179	493	838	952	984	455			
Preparation Fee for Generation System		0	0	0	0	9	46	183	291			
Maintenance Costs										293	293	293
Annual Personnel Expenditure										210	210	210
Basic water treatment cost										3	6	9
Replacement Costs												
Overrun of construction cost		500	308	322	887	1526	1796	2100	1341			
Total Costs	0	2167	1333	1397	3843	6612	7785	9098	5812	506	509	512
Inflation Adjustment factor		1	1	1	1	1	1	1	1	1	1	1
After inflation adjustment		2807	1654	1683	4448	7381	8431	9765	6136	533	529	532
Incremental costs(With -Without)		2807	1654	1683	4448	7381	8431	9765	6136	533	529	532
Net Benefit	691	-1475	-1333	-1397	-3843	-6612	-7785	-9098	-5812	-208	-233	-240
Incremental Net Benefits	0	-2807	-2345	-2374	-5139	-8072	-9123	-10457	-6827	-927	-946	-952
NPV at 6%	-22894	0.45		water price is 10.84/ton(cubic meter)								

Appendix 3 Overrun of the Construction Costs (Cont'd).

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
276	418	547	669	797	902	1055	1174	1291	1405	1516	1625	1732	1836	1939	2039	2138	2170	2168	2167	2166
190	276	369	463	546	648	696	774	850	924	996	1067	1136	1204	1270	1335	1399	1418	1416	1415	1413
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
60	90	118	145	172	195	228	254	279	303	327	351	374	397	419	441	462	469	468	468	468
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
535	793	1043	1286	1525	1754	1988	2211	2428	2641	2849	3052	3251	3446	3637	3824	4008	4066	4062	4059	4055
-157	101	351	594	833	1063	1297	1519	1737	1949	2157	2361	2560	2755	2945	3133	3316	3374	3371	3368	3364
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
12	14	17	20	22	25	27	30	32	34	39	39	41	43	45	46	46	46	46	46	46
514	517	520	522	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548
536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548
20	276	523	763	1000	1227	1458	1678	1894	2104	2308	2511	2708	2900	3089	3276	3459	3517	3514	3510	3507
-693	-439	-184	69	308	535	767	987	1202	1412	1616	1819	2016	2209	2398	2584	2768	2826	2823	2819	2816

Appendix 3 Overrun of the Construction Costs (Cont'd).

2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
2164	2163	2161	2160	2159	2157	2156	2154	2153	2151	2150	2148	2147	2145	2144	2142	2141	2139	2138	2136	2134
1411	1409	1407	1406	1404	1402	1401	1399	1397	1395	1394	1392	1390	1389	1387	1385	1384	1382	1381	1379	1377
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
468	467	467	467	466	466	466	465	465	465	464	464	464	463	463	463	462	462	462	461	461
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4052	4048	4045	4042	4038	4035	4031	4028	4024	4021	4017	4014	4010	4007	4003	4000	3996	3993	3989	3986	3982
3361	3357	3354	3350	3347	3343	3340	3336	3333	3329	3326	3322	3319	3315	3312	3308	3305	3301	3298	3294	3291
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
129																				
677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
3375	3500	3497	3493	3490	3486	3483	3479	3476	3472	3469	3465	3462	3458	3455	3451	3448	3444	3441	3437	3434
2683	2809	2805	2802	2798	2795	2791	2788	2784	2781	2777	2774	2770	2767	2763	2760	2756	2753	2749	2746	2742

Appendix 3 Overrun of the Construction Costs (Cont'd).

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064
2133	2131	2130	2128	2126	2125	2123	2122	2120	2118	2117	2115	2113	2112	2110	2108	2107	2105	2103	2102	2100
1376	1374	1373	1371	1369	1368	1366	1365	1363	1362	1360	1359	1357	1356	1354	1353	1351	1350	1348	1347	1345
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
461	460	460	460	459	459	459	458	458	458	457	457	457	456	456	455	455	455	454	454	454
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3979	3975	3971	3968	3964	3961	3957	3954	3950	3947	3943	3940	3936	3933	3929	3926	3922	3919	3915	3912	3908
3287	3284	3280	3277	3273	3270	3266	3262	3259	3255	3252	3248	3245	3241	3238	3234	3231	3227	3224	3220	3217
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
				129	81															
548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
3430	3427	3423	3420	3287	3332	3409	3405	3402	3398	3395	3391	3388	3384	3381	3377	3374	3370	3367	3363	3360
2739	2735	2732	2728	2596	2641	2718	2714	2711	2707	2703	2700	2696	2693	2689	2686	2682	2679	2675	2672	2668

Appendix 3 Overrun of the Construction Costs (Cont'd).

2065	2066	2067	2068
2098	2097	2095	2093
1344	1342	1341	1339
3	3	3	3
453	453	453	452
6	6	6	6
3904	3901	3897	3894
3213	3210	3206	3202
293	293	293	293
210	210	210	210
46	46	46	46
548	548	548	548
1	1	1	1
548	548	548	548
548	548	548	548
3356	3352	3349	3345
2665	2661	2658	2654

Appendix 4 One Year Delay of the Project.

Economic Analysis	Without	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Benefits (Million NTD)												
Municipal Water Use		0	0	0	0	0	0	0	0	0	162	139
Industrial Water Use		0	0	0	0	0	0	0	0	0	96	97
Sale Power		0	0	0	0	0	0	0	0	0	3	3
Saving form Buying Drinking water		0	0	0	0	0	0	0	0	0	31	30
Increasing recreation Value		0	0	0	0	0	0	0	0	0	6	6
Tourism Value	151.4	151										
Benefits created by the Inundated land	540.0	540										
Total Benefits	691.4	691	0	0	0	0	0	0	0	0	298	275
Incremental Benefits		0	-691	-691	-691	-691	-691	-691	-691	-691	-394	-416
Costs (million NTD)												
Land Acquircition and Resettlement costs		1389										
Direct Construction Cost for Dam			743	779	2142	3646	4139	4277	1976			
Indirect Construction Cost			111	117	321	547	621	642	296			
Direct Construction Cost for Generation System						40	200	795	1230			
Indirect Construction Cost						6	30	119	185			
Power Delivery Cables						0	0	0	39			
Preparation Fee for Dam Construction		278	171	179	493	838	952	984	455			
Preparation Fee for Generation System		0	0	0	0	9	46	183	291			
Maintenance Costs											293	293
Annual Personnel Expenditure											210	210
Basic water treatment cost											6	9
Replacement Costs												
Total Costs	0.0	1667	1026	1074	2956	5086	5988	6999	4471	0	509	512
Inflation Adjustment factor		1	1	1	1	1	1	1	1	1	1	1
After inflation adjustment		2159	1272	1295	3421	5678	6486	7512	4720	0	529	532
Incremental costs(With -Without)		2159	1272	1295	3421	5678	6486	7512	4720	0	529	532
Net Benefit	691.4	-975	-1026	-1074	-2956	-5086	-5988	-6999	-4471	0	-211	-236
Incremental Net Benefits	0.0	-2159	-1963	-1986	-4113	-6369	-7177	-8203	-5411	-691	-923	-949
NPV at 6%	-16845	0.07		water price is 10.84/ton(cubic meter)								

Appendix 4 One Year Delay of the Project (Cont'd).

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
139	276	418	547	669	797	902	1055	1174	1291	1405	1516	1625	1732	1836	1939	2039	2138	2170	2168	2167
94	190	276	369	463	546	648	696	774	850	924	996	1067	1136	1204	1270	1335	1399	1418	1416	1415
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	60	90	118	145	172	195	228	254	279	303	327	351	374	397	419	441	462	469	468	468
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
272	535	793	1043	1286	1525	1754	1988	2211	2428	2641	2849	3052	3251	3446	3637	3824	4008	4066	4062	4059
-419	-157	101	351	594	833	1063	1297	1519	1737	1949	2157	2361	2560	2755	2945	3133	3316	3374	3371	3368
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
12	14	17	20	22	25	27	30	32	34	39	39	41	43	45	46	46	46	46	46	46
514	517	520	522	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548
536	541	535	526	525	528	530	532	535	537	541	541	544	546	548	548	548	548	548	548	548
-242	18	273	520	761	997	1224	1456	1676	1891	2100	2307	2509	2705	2898	3088	3276	3459	3517	3514	3510
-956	-697	-434	-174	69	306	533	764	985	1200	1408	1616	1817	2014	2207	2397	2584	2768	2826	2823	2819

Appendix 4 One Year Delay of the Project (Cont'd).

2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
2166	2164	2163	2161	2160	2159	2157	2156	2154	2153	2151	2150	2148	2147	2145	2144	2142	2141	2139	2138	2136
1413	1411	1409	1407	1406	1404	1402	1401	1399	1397	1395	1394	1392	1390	1389	1387	1385	1384	1382	1381	1379
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
468	468	467	467	467	466	466	466	465	465	465	464	464	464	463	463	463	462	462	462	461
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4055	4052	4048	4045	4042	4038	4035	4031	4028	4024	4021	4017	4014	4010	4007	4003	4000	3996	3993	3989	3986
3364	3361	3357	3354	3350	3347	3343	3340	3336	3333	3329	3326	3322	3319	3315	3312	3308	3305	3301	3298	3294
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
129																				
677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
677	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
3378	3504	3500	3497	3493	3490	3486	3483	3479	3476	3472	3469	3465	3462	3458	3455	3451	3448	3444	3441	3437
2687	2812	2809	2805	2802	2798	2795	2791	2788	2784	2781	2777	2774	2770	2767	2763	2760	2756	2753	2749	2746

Appendix 4 One Year Delay of the Project (Cont'd).

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064
2134	2133	2131	2130	2128	2126	2125	2123	2122	2120	2118	2117	2115	2113	2112	2110	2108	2107	2105	2103	2102
1377	1376	1374	1373	1371	1369	1368	1366	1365	1363	1362	1360	1359	1357	1356	1354	1353	1351	1350	1348	1347
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
461	461	460	460	460	459	459	459	458	458	458	457	457	457	456	456	455	455	455	454	454
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3982	3979	3975	3971	3968	3964	3961	3957	3954	3950	3947	3943	3940	3936	3933	3929	3926	3922	3919	3915	3912
3291	3287	3284	3280	3277	3273	3270	3266	3262	3259	3255	3252	3248	3245	3241	3238	3234	3231	3227	3224	3220
293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293	293
210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
				129	81															
548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
548	548	548	548	677	629	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548
3434	3430	3427	3423	3291	3335	3412	3409	3405	3402	3398	3395	3391	3388	3384	3381	3377	3374	3370	3367	3363
2742	2739	2735	2732	2599	2644	2721	2718	2714	2711	2707	2703	2700	2696	2693	2689	2686	2682	2679	2675	2672

Appendix 4 One Year Delay of the Project (Cont'd).

2065	2066	2067	2068	2069
2100	2098	2097	2095	2093
1345	1344	1342	1341	1339
3	3	3	3	3
454	453	453	453	452
6	6	6	6	6
3908	3904	3901	3897	3894
3217	3213	3210	3206	3202
293	293	293	293	293
210	210	210	210	210
46	46	46	46	46
548	548	548	548	548
1	1	1	1	1
548	548	548	548	548
548	548	548	548	548
3360	3356	3352	3349	3345
2668	2665	2661	2658	2654

REFERENCES

Adams, W. (2000). The *social impact of large dams: Equity and distribution issues*.Cape Town: The World Commissions on Dams.

Adler, M. (2006). *New foundation of cost-benefit analysis.* Cambridge, MA: Harvard University Press.

Asian Development Bank (2002). *Study of large dam and recommendation practice.* Philippine: Asian Development Bank.

Aylward, B., Berkhoff, J., Green, C., Gutman, P., Lagman, A., Manion, M., Markandya, A., McKenney, B., Naudascher- Jankowski, K., Oud, B., Penman, A., Porter, S., Rajapakse, C., Southgate, D., & Unsworth. R., (2000). *Financial, economic and distributional analysis.* Cape Town: The World Commissions on Dams.

Bartolome, L. J., de Wet, C., Mander, H., & Nagraj, V. K. (2000). *Displacement, resettlement, rehabilitation, reparation, and development.* Cape Town: The World Commissions on Dams.

Barbier, E. B. (2000). Valuing the environment as input: Review of applications to mangrove fishery linkages. *Ecological Economics, 35*, 47–61.

Bacon, R. W., & Besant-Jones, J. E. (1998). Estimating construction costs and schedules: Experiences with power generation project in developing countries. *Energy Policy, 26*, 317-333.

Belli, P. (2001). *Economic analysis of investment operation-analytical tools and application.* Washington DC: The World Bank.

Berkamp, G., McCartney, M., Dugan, P., McNeely, J., & Acreman, M. (2000). *Dams, ecosystem functions and environmental restoration.* Cape Town: The World Commissions on Dams.

Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2001). *Cost-benefit analysis: Concepts and practice.* Upper Saddle River, NJ: Prentice Hall.

Central Weather Bureau (2008). *Knowing the earthquake in Taiwan.* Taipei, Taiwan: CWB.

Cheng. T. (2004). *The life cycle assessment of dams in Taiwan.* Taipei, Taiwan: National Taiwan University.

Chutubtim, P. (2001). *Guidelines for conducting extended cost-benefit analysis of dam projects in Thailand.* Singapore: EEPSEA.

Cline, W. R. (1999). *Discounting for the very long term: In discounting and intergenerational equity*. Washington DC: Resources for the Future.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387, 253-260.*

Crawford, E. (2006). *Note on benefit cost analysis*. Class handout.

Economic Co-Operation and Development (2004). *Regulatory Impact Analysis (RIA) inventory, internal document*. Paris: OECD.

Farber, S. C., Costanza, R., & Wilson, M. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological Economic, 41*, 375-392.

Gittinger, J. P. (1982). *Economic analysis of agricultural projects*. Washington DC: John Hopkins University Press.

Hanley, N., & Spash, C. (1993). *Cost-benefit analysis and the environment*. Northampton, MA: Edward Elgar Publishing, Inc.

Huang (2004). *The research of water resource cost in Taiwan: From a viewpoint of green accounting.* Taichung, Taiwan: Feng Chia University.

International Commission on Large Dam (1999). *Benefit and concerns about dams*. Paris: ICOLD.

Jager, H. I., & Smith, B. T., (2008). Sustainable reservoir operation: Can we generate hydropower and preserve ecosystem values? *River Research and Application, 24,* 340-352.

Kaohsiung City Government (2009). *Discover Kaohsiung City*. Kaohsiung, Taiwan: KCG.

Ke, A. (2005). *The necessity of water market in Taiwan*. Kaohsiung, Taiwan: National Sun-Ye Shih University.

Liu, K. (2003). *Estimate recreation benefit of A-Li mountain forest recreation area by contingent valuation method and travel cost method.* Chiayi, Taiwan: National Chiayi University.

Markandya, A., & Pearce, D. (1988). Environmental considerations and the choice of the discount rate in developing countries. *Environment Department Working Paper No. 3.* Washington DC: The World Bank Policy Planning and Research Staff.

Mei-Nong People Assosiation (1999). *The reason to oppose Mei-Nong Dam Project.* Kaohsiung, Taiwan: MPA.

Mei-Nong Township Administration (2004*). The beauty of Mei-Nong*. Kaohsiung, Taiwan: MPA.

Mikesell, R. F. (1977). *Rate of discount for evaluating public projects*. Washington DC: American Enterprise Institute for Public Policy Research.

Mitchell, R., & Carson, R. (1989). *Using surveys to value public goods: The contingent valuation method.* Washington DC: Johns Hopkins University Press for Resources for the Future.

Morimoto, R., & Hope, C. (2004). A CBA model of a hydro project in Sri Lanka. *International Journal of Global Energy Issues*, *21*, 47-68.

Pearce, D., Atkinson, G., & Mourato, S. (2006). *Cost-benefit analysis and the environment: Recent development*. Paris: OECD.

Pong, T. (1994). *Use of contingent value method on dam project*. Kaohsiung, Taiwan: National Sun-Ye Shih University.

Rosa, L. P., & dos Santos, M. A. (2000). *Certainty and uncertainty in the science of greenhouse gas emissions from hydroelectric reservoirs.* Cape Town: The World Commissions on Dams.

Rosenberg, D. M., Bodaly, R. A., & Usher, P. J. (1995). Environmental and social impact of large scale hydro-electric development: Who is listening? *Global Environmental Change*, *5*, 127-148.

Schmid, A. (1989). *Benefit-cost analysis: A political economy approach*. Boulder, CO. West View Press.

Shah, Z., & Kumar, M. D. (2008). In the midst of the large dam controversy: Objectives, criteria for assessing large water storages in the developing world. *Water Resource Management, 22*, 1799-1824.

Sino-Tech Engineering Consultants, Ltd. (1992). *Mei-Nong dam projects design and execute report*. Taipei, Taiwan: Sino-Tech Ltd.

Sullivan, M. E. (1995). The Three Gorges Dam project: The need for a comprehensive assessment. *The Georgetown International Environmental Law Review, 8*, 109-140.

Tse, H (2004). *Economic valuation of water improvement in Kaohsiung City*. Kaohsiung, Taiwan: National Sun-Ye Shih Unversity.

Turner, R. K., van den Bergh, J. C. J. M., Soderqvist, T., Barendregt, A., van der Straaten, J., Maltby, E., & van Ierland, E. C. (2000). Ecological-economic analysis of wetlands: Scientific integration for management and policy. *Ecological Economics, 35*, 7–23.

United Nation Environment Programme (2007). *Guidelines for conducting economic valuation of coastal ecosystem goods and services*. New York: UNEP.

Wang, T. (2003). *The study of anti-dam movement in Mei-Nong*. Hsinchu, Taiwan: National Tsing Hua University.

Water Resource Agency (1984). *The construction of Mei-Nong dam project report.* Taipei, Taiwan: WRA.

Water Resource Agency (1990). *The projection of water use in southern Taiwan.* Taipei, Taiwan: WRA.

Water Resource Agency (1992). *Water resource development and management report in southern Taiwan*. Taipei, Taiwan: WRA.

Water Resource Agency (2004). *Adjust the reasonable water price in Taiwan*. Taipei, Taiwan: WRA.

World Commissions on Dams (2000). *Dams and Development: A new framework for decision-making.* London: Earthscan.

Wu, C. Y. (2007). *A study of the drinking water of Kaohsiung region*. Taipei, Taiwan: National Taiwan Normal University.

Wu, Y., Chang, J., Xu, B., Peng, C., & Ge, Y. (2008). Ecosystem services value assessment for constructed wetlands: A case study in Hangzhou, China. *Ecological Economics, 68*, 116-125.

The World Bank (1999). *World development report in 1999*. Washington DC: The World Bank.

MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03063 3154