

## **INFORMATION TO USERS**

**This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.**

**The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.**

**In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.**

**Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.**

**Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.**

**ProQuest Information and Learning  
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA  
800-521-0600**

**UMI<sup>®</sup>**

**DISSERTATION**

**COST-BENEFIT ANALYSIS OF A FLOOD PROTECTION PROJECT  
INCORPORATING POVERTY ALLEVIATION CONCERNS:  
CASE STUDY VIETNAM**

**Submitted by**

**Eric Franklin Biltonen**

**Department of Agricultural & Resource Economics**

**In partial fulfillment of the requirements**

**For the Doctor of Philosophy Degree**

**Colorado State University**

**Fort Collins, Colorado**

**Summer 2001**

UMI Number: 3032667

UMI<sup>®</sup>

---

UMI Microform 3032667

Copyright 2002 by ProQuest Information and Learning Company.  
All rights reserved. This microform edition is protected against  
*unauthorized copying under Title 17, United States Code.*

---

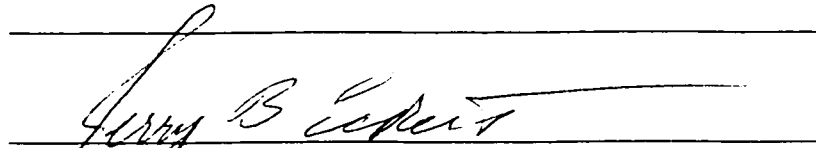

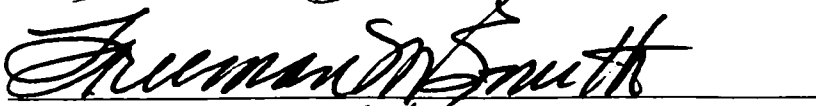
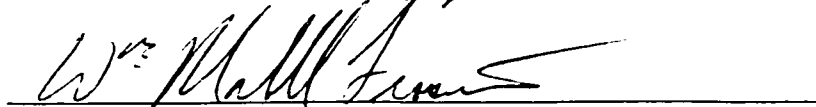

ProQuest Information and Learning Company  
300 North Zeeb Road  
P.O. Box 1346  
Ann Arbor, MI 48106-1346

COLORADO STATE UNIVERSITY

May 22, 2001

WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY ERIC FRANKLIN BILTONEN ENTITLED COST-BENEFIT ANALYSIS OF A FLOOD PROTECTION PROJECT INCORPORATING POVERTY ALLEVIATION CONCERNS: CASE STUDY VIETNAM BE ACCEPTED AS FULFILLING IN PART REQUIRMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE.

Committee on Graduate Work

  
\_\_\_\_\_  
  
\_\_\_\_\_  
  
\_\_\_\_\_  
  
\_\_\_\_\_  
Adviser  
  
\_\_\_\_\_  
Department Head

**ABSTRACT OF DISSERTATION**  
**COST-BENEFIT ANALYSIS**  
**INCORPORATING POVERTY ALLEVIATION CONCERNS:**  
**CASE STUDY A OF FLOOD PROTECTION PROJECT, VIETNAM**

Cost-benefit analysis is the practical application of welfare economics. Cost-benefit analysis uses the potential Pareto criterion to judge alternative resource allocations. The potential Pareto criterion, however, does not allow for consideration of non-efficiency goals such as poverty alleviation. Difficulty in measuring utility has resulted in cost-benefit analysis relying on aggregate valuations of project benefits.

Valuations of project benefits are based on willingness-to-pay measures, which impose equal marginal utility of income weights to beneficiaries. If marginal utility of income is greater for the poor then relatively low estimates of project benefits will result. Benefit weighting is an attempt to overcome this shortcoming. Benefit weighting can be arbitrary and inconsistent, however, making it difficult to compare alternative projects or derive meaning from results. Another method is the poverty impact ratio, which compares unweighted benefits for the poor with unweighted total project benefits.

In this study, a flood protection project with poverty alleviation as a major objective is examined. Flood protection project benefits are estimated using production and asset values. Therefore, projects that provide substantial benefits to the poor will tend to be outranked by projects that benefit the rich making it difficult to realize the

poverty alleviation objective. This method is also inconsistent with the idea of differing marginal utilities of income.

A procedure is proposed based on safety-first valuations. Safety-first valuations incorporate risk in a manner consistent with decision-making behavior of the poor. Safety-first valuations are used to rank alternative projects for their effect poverty alleviation effects. The theory is tested on a flood protection project to show that the safety-first approach is superior to the poverty impact ratio for the identification of flood protection projects that alleviate poverty.

Estimated safety-first valuations yielded much higher incremental increases in the value of a project than the willingness to pay estimates. For the smallest farm model, the willingness to pay estimate of project benefits was VND 176,000 compared to the safety-first estimated increase in benefits of VND 6.4 million. The safety-first estimate is more consistent with utility theory. Safety-first provides a preference ordering that is superior to the poverty impact ratio.

Eric Franklin Biltonen  
Department of Agricultural and  
Resource Economics  
Colorado State University  
Fort Collins, Colorado  
Summer 2001

## ACKNOWLEDGEMENTS

I would like to thank my dissertation committee: Dr. Marshall Frasier, Dr. Andy Seidl, Dr. Jerry Eckert, and Dr. Freeman Smith. Your insightful comments, useful suggestions, and unwavering enthusiasm made the process educational and rewarding. I experienced the above through the conversations we have had, the courses I took, and your written comments on early drafts of my dissertation. I am only now beginning to appreciate the breadth and depth of what I have been taught.

I would like to give a deep thanks to Dr. George Radosevich. George gave me my first professional experiences in Southeast Asia. However, it was the non-working experiences I had with George that brought me to the realization that Southeast Asia is a place I would like to live. The number of friends that he has throughout the region is truly astounding and a reflection of his generosity and kindness. I am fortunate to count myself among his friends.

Next, I would like to express a special debt of gratitude to Dr. Marshall Silver in Hanoi, Vietnam. Dr. Silver offered guidance with my dissertation and an opportunity to work in Vietnam. The work in Vietnam has proved to be an important stepping-stone in the transition from student to professional.

I must also give thanks to Dr. Intizar Hussain at the International Water Management Institute in Sri Lanka. Dr. Hussain offered me the perfect opportunity to

complete my transition from student to professional. Dr. Hussain has allowed me to realize the most satisfying combination of work both topically and geographically.

I would like to express a warm debt of appreciation to Mrs. Monticha (Tanatammatid) Sompolvorachai for her company and friendship. Monticha was responsible for first introducing me to Thailand and Southeast Asia. It is the region of the world I have come to love and call home. I wish Monticha the best of luck with her Ph.D. program and everything in her life.

I would like to thank Pham Hong Lien. Your company, kindness, encouragement, and jokes made my time in Vietnam truly exceptional. I look forward to the next time we are able to sit on the street and eat dried squid.

Finally, I give highest thanks and praise to my parents. Their encouragement and support helped me in ways that I can never repay.

## TABLE OF CONTENTS

<b>CHAPTER 1: INTRODUCTION .....</b>	<b>1</b>
1.1 General Introduction .....	1
1.2 Problem Statement .....	3
1.3 Purpose of Dissertation .....	7
1.4 Objective of Dissertation.....	8
1.5 Definition of Geographical Area for Research .....	8
<b>CHAPTER 2: SOCIAL CHOICE AND WELFARE ECONOMICS.....</b>	<b>14</b>
2.1 Social Choice Theory .....	14
2.1.1 Individual Utility as a Representation of Individual Welfare.....	15
2.1.1.1 Cardinal Utilities.....	18
2.1.1.2 Ordinal Utilities .....	19
2.1.1.3 Interpersonal Comparability of Utility .....	20
2.1.2 Social Welfare as an Aggregate of Individual Utilities .....	21
2.1.3 Bergson-Samuelson Social Welfare Function .....	22
2.1.4 Arrow Impossibility Theorem .....	23
2.1.5 Comparison of Approaches by Bergson and Arrow .....	25
2.1.6 Value Judgments.....	26
2.2 Making Collective Decisions Concerning Different States of Social Welfare .....	27
2.3 Welfare Economics .....	28
2.3.1 The Pareto Criterion.....	29
2.3.2 Strict Pareto Improvements .....	30
2.3.3 Potential Pareto Improvements.....	31
2.3.4 Pareto Optimality .....	32
2.3.5 Mathematical Conditions for Pareto Optimal Allocations .....	34
2.3.6 Compensation Tests for Potential Pareto Improvements.....	37
2.4 Theoretical Calculation of Utility as Consumer Surplus .....	38
2.4.1 Marginal Utility as a Valuation of Welfare .....	39
2.4.2 Divergence of value in use and value in exchange.....	40
2.5 Resource Allocations in a Market Setting.....	41
2.5.1 Scarcity and the Importance of Allocation Decisions .....	42
2.5.2 Efficiency Objectives for Allocation Decisions .....	42
2.5.3 Efficient Outcomes in a Perfectly Competitive Market.....	42
2.5.4 Equity and Distribution.....	43
2.5.5 Market Failure.....	45
2.6 Provision of Public Goods.....	45
2.7 Extensions to Standard Welfare Theory.....	50
2.7.1 Utility and Poverty.....	50
2.7.2 The Utility of Poverty Graphically .....	53

2.7.3	Implications for Equilibrium Conditions .....	54
2.8	Risk, Utility, and Resource Allocation Decisions for Individuals .....	55
2.8.1	Individual Decision-Making under Risk.....	56
2.8.2	Safety-first Rules for Farmer Decision-Making .....	59
<b>CHAPTER 3:</b>	<b>COST-BENEFIT ANALYSIS .....</b>	<b>63</b>
3.1	Cost-Benefit Analysis: Applied Welfare Economics.....	63
3.1.1	The Basic Concept Behind Cost-Benefit Analysis .....	64
3.1.2	Discounting of Future Net Benefits .....	65
3.1.3	Criteria for Decision-Making among Alternative Projects.....	66
3.1.4	Information Aid or Decision Tool .....	69
3.2	From Theory to Practice.....	70
3.2.1	Moves towards Optimality vs. Optimal Allocations .....	70
3.2.2	Reliance on Compensation Tests.....	70
3.2.3	Willingness to pay as a Measure of Benefits .....	71
3.2.4	Goal of Government Policy and Project Appraisal .....	72
3.3	Impact of Cost-Benefit Analysis on Poverty Alleviation Concerns .....	73
3.3.1	Impact of Flood Risk Reduction on Poverty Alleviation .....	76
3.3.2	Impact of Risk and Uncertainty on Cost-benefit Analysis .....	76
3.3.3	Impact of Poverty on Cost-Benefit Analysis .....	77
3.4	Incorporating Poverty Alleviation Concerns into Cost-benefit Analysis.....	77
3.4.1	Poverty Impact Ratio .....	78
3.4.2	Point-Cost and Cost-Effectiveness Analyses.....	79
3.4.3	Weighting of Benefits across Different Income Groups .....	80
3.4.4	Safety-first Valuation.....	85
<b>CHAPTER 4:</b>	<b>FLOOD PROTECTION BENEFITS: A REVIEW.....</b>	<b>88</b>
4.1	Dykes.....	88
4.2	Estimating Flood Control Benefits in the United States .....	89
4.3	Estimating Flood Control Benefits in Vietnam.....	91
<b>CHAPTER 5:</b>	<b>BACKGROUND OF RELEVANT TOPICS IN VIETNAM.....</b>	<b>95</b>
5.1	Institutional Setting .....	95
5.1.1	National Policies .....	95
5.1.2	Institutions .....	97
5.1.3	Legal Setting .....	99
5.1.4	Development Policies of the Asian Development Bank.....	100
5.2	Water Resources in Vietnam.....	100
5.2.1	Red River Basin in Vietnam .....	101
5.2.2	Red River .....	103
5.2.3	Duong River.....	104
5.2.4	Project Area .....	104
5.3	Flooding in Vietnam.....	105
5.3.1	Flooding in the Red River Delta .....	107
5.4	Poverty in Vietnam.....	108

<b>CHAPTER 6: METHODOLOGY .....</b>	<b>112</b>
6.1 General Introduction .....	112
6.2 Scope of Economic Analysis.....	112
6.3 Financial versus Economic Analysis.....	113
6.4 Cost Analysis of the Flood Control Project .....	114
6.4.1 Construction Activity and Price Information for Cost Analysis.....	114
6.4.2 Project Cost Tables .....	116
6.5 Benefit Analysis of the Flood Protection Project.....	116
6.5.1 Identification of Protected Area.....	117
6.5.1.1 Population Density Calculation .....	118
6.5.1.2 Construction of Typical Commune Profile.....	118
6.5.1.3 Parameters for Estimating Flood Damage and Project Benefits.....	120
6.5.1.4 Flood Frequency and Dyke Failure Probabilities .....	120
6.5.2 Estimating Economic Damage.....	122
6.5.2.1 Expected Flood Damage Estimates .....	122
6.5.3 Estimating Flood Protection Benefits as Property Damage Avoided.....	124
6.5.4 Cost-Benefit Analysis of the Flood Protection Project.....	125
6.5.5 Sensitivity Analysis .....	126
6.6 Poverty Impact Analysis .....	127
6.6.1 Poverty Impact Ratio .....	128
6.6.2 Safety-first Criteria and Poverty Alleviation Impacts .....	130
 <b>CHAPTER 7: RESULTS OF THE RESEARCH.....</b>	 <b>135</b>
7.1 Introduction .....	135
7.2 Basic Information for the Benefit and Cost Analyses.....	135
7.3 Cost Analysis of the Flood Protection Project .....	136
7.3.1 Construction Quantities and Completion Rates.....	136
7.3.2 Results of the Cost Analysis .....	139
7.4 Results of the Benefit Analysis .....	140
7.4.1 Identification of Protected Area and Beneficiaries.....	140
7.4.2 Population Density Calculation .....	144
7.4.3 Construction of Typical Commune Profile.....	144
7.4.4 Parameters for Flood Damage Analysis .....	148
7.4.4.1 Flood Damage Parameters .....	148
7.4.4.2 Crop Storage Parameters .....	150
7.4.4.3 Sectoral Scaling Factors for Aggregation.....	151
7.4.4.4 Poverty Rates in the Project Area .....	152
7.4.5 Typical Farm Profile.....	152
7.4.6 Flood Frequency and Dyke Failure Probabilities .....	153
7.4.6.1 Flood Frequency Estimates.....	154
7.4.6.2 Dyke Failure Probabilities .....	155
7.4.7 Estimating Economic Flood Damage .....	157
7.4.8 Estimation of Project Benefits .....	161
7.4.9 Cost-Benefit Analysis of the Flood Protection Project.....	162
7.4.10 Sensitivity Analysis .....	162
7.5 Sustainability of Project Effects.....	166
7.6 Poverty Impact Analysis .....	166

**CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS..... 180**  
**REFERENCES..... 188**  
**APPENDIX: DETAILED COST TABLES..... 196**

## LIST OF TABLES

Table 5.1 Flood Damage for Vietnam, 1971-1999.....	106
Table 6.1 Calculations of Flood Damage for Different Economic Components.....	124
Table 7.1 Summary of Basic Input into Economic and Financial Analysis.....	136
Table 7.2 Site Locations and Input Quantities for the Project.....	137
Table 7.3 Summary Cost Table for the Duong River Dyke Rehabilitation Project.....	139
Table 7.4 Estimated Typical Commune Profile in the Project Area.....	147
Table 7.5 Parameters of Flood Damage for Flood Height of 1/3 Meter and 1 Meter. ...	148
Table 7.6 Estimated Scaling Factors for Industrial Production and Assets.....	151
Table 7.7 Estimated Profile of a Typical Farm Production in the Project Area and Expected Damage for a Flood 1/3 m Deep and for a Flood 1 m Deep.....	153
Table 7.8 Flood Frequency Estimates for the Duong River at Thoung Cat.....	154
Table 7.9 Flood Frequency and Dyke Failure Joint Probabilities for the Duong River.	157
Table 7.10 Damage Estimates for the Historic Floods of 1945 and 1971 and a Flood Covering the Whole Project Area Based on Year 2000 Prices and a 1 Meter Depth Flood.....	159
Table 7.11 Damage Estimates for the Historic Floods of 1945 and 1971 and a Flood Covering the Whole Project Area Based on Year 2000 Prices and a 1/3 Meter Depth Flood.....	160
Table 7.12 Project Benefits for Different Flood Scenarios (million VND).....	161
Table 7.13 Results of the Cost-benefit Analysis (VND) Using the 1945 Flood with a 1/3 Meter Flood Depth Scenario.....	163
Table 7.14 Sensitivity Analysis of the Economic Analysis for the 1945 Flood Scenario.... .....	165
Table 7.15 Poverty Impact Analysis for the Project Using the 1945 Flood Scenario. ...	168
Table 7.16 Impact of Project on Farm Income for Different Farm Sizes.....	171
Table 7.17 Safety-First Values for Different Farms Sizes With and Without the Project using expected income as the threshold.....	173
Table 7.18 Safety-First Values for Different Farms Sizes With and Without the Project using the poverty line as the threshold.....	174
Table 7.19 Sensitivity of Safety-First Values to the Risk Parameter.....	175
Table 7.20 Sensitivity of Safety-First Values to the Threshold Level.....	176
Table 7.21 Sensitivity Comparison of Poverty Impact Ratio and Safety-First.....	177
Table 7.22 Sensitivity of Net Present Value to the Discount Rate.....	178

## LIST OF FIGURES

Figure 1.1 Duong River: General Location in the Red River Delta of Vietnam. ....	11
Figure 1.2 The Project Area in the Red River Delta of Vietnam.....	12
Figure 1.3 Floods of 1945 and 1971 in the Protected Area in the Red River Delta of Vietnam.....	13
Figure 2.1 Diminishing Marginal Utility from Consumption of a Good.....	16
Figure 2.2 Indifference Curves for Consumption of Goods X and Y.....	17
Figure 2.3 Strict Pareto Improvements of Utility for a Two-Person Situation. ....	31
Figure 2.4 Potential Pareto Improvements of Utility in a Two-Person Situation.....	32
Figure 2.5 Pareto Efficiency in Exchange for two individuals i and j with utility U. ....	33
Figure 2.6 Pareto Efficiency in Production. ....	34
Figure 2.7 Consumer Surplus. ....	38
Figure 2.8 Lindahl Equilibrium with Taxed Public Goods. ....	46
Figure 2.9 Behavior of Indifference Curves Above and Below a Poverty Line.....	54
Figure 2.10 Expected Utility of a Risk Averse Person. ....	57
Figure 3.1 Rotation of Utility Possibilities Frontier caused by Benefit Weighting.....	81
Figure 3.2 Social Demand for Basic Needs Consumption Level. ....	85
Figure 5.1 General Location of Red River Basin. ....	102
Figure 5.2 Flood of 1971 in the Duong River Area. ....	109
Figure 6.1 Flow Chart of Construction Cost Analysis.....	115
Figure 6.2 Flow Chart for Economic Benefit Analysis. ....	117
Figure 7.1 Construction Locations, Activities, and Quantities.....	138
Figure 7.2 Protected Area as Defined by Rivers and Dyke System Locations. ....	142
Figure 7.3 Inundated Areas for the Flood Scenarios Used in the Benefit Analysis. ....	143
Figure 7.4 Cumulative Dyke Failure Probabilities Without-project and With-project. .	156
Figure 7.5 Historic Floods of 1945 and 1971 in the Project Area. ....	158

## **CHAPTER 1: INTRODUCTION**

### **1.1 General Introduction**

Flooding is one of the most significant natural disasters worldwide. Every year flooding causes massive loss of life, property, and production. A flood induced interruption of normal productive and other living activities can have catastrophic impacts on a region's economy and way of life.

In response to the threat of flooding, various measures have been devised to provide protection from the harmful effects caused by flooding. Flood protection measures can reduce the damage caused by flood events either through actions that prevent excess flows from reaching a protected area or through means that give people the opportunity to take defensive measures against an impending flood. Physical forms of flood mitigation measures include dyke systems, reservoirs, or channel improvements. The benefits of flood protection measures include reduced loss of life, property, and production.

The poor are much more vulnerable to flood disasters than the rich are. If the poor are close to a subsistence level of production, then a flood disaster has the potential to reduce their production and assets to levels that put their continued existence into question. Flood protection projects can reduce the probability of adverse income fluctuations by reducing the probability of experiencing a flood-induced loss. Therefore, flood protection projects can hold large benefits for poor people by

minimizing the chance of their income experiencing negative fluctuations due to flooding.

As with any investment decision, however, the decision to invest in a flood protection project must consider whether the benefits arising from the project outweigh the costs of constructing, maintaining, and operating the project. Cost-benefit analysis techniques have been devised specifically for this purpose. Cost-benefit analysis examines the relative states of project costs and benefits to see whether a given investment alternative is desirable. Cost-benefit analysis can also aid in deciding which project among several alternatives is most desirable. From an economic social welfare perspective, cost-benefit analysis aims to ensure that a country's resources are allocated efficiently. In economic, efficiency is normally equated with the idea of maximizing total net benefits.

It is often the case, however, that social goals aim to address more than efficiency. In developing countries, for example, an important issue for public policy is commonly poverty alleviation. Traditional cost-benefit methods, however, implicitly accept the current distribution of income as acceptable. A standard cost-benefit analysis relies on the potential Pareto criteria, which assigns equal weights to all individuals. Therefore, the economic analysis may not capture non-efficiency concerns when analyzing a project. If the decision maker wishes to consider social goals other than efficiency in the use of resources, then the application of traditional cost-benefit methods will need to be adjusted or augmented for them to address the non-efficiency goals. How cost-benefit methods can be applied to address non-efficiency goals, specifically poverty alleviation, is the main issue of this study.

## **1.2 Problem Statement**

The subject of this study is project appraisal, which has been defined as cost-benefit analysis as applied in developing countries (Brent, 1990). This study explores options for incorporating poverty alleviation analysis into the project appraisal process for flood protection projects. It proposes a method to help bridge a gap that currently exists between the theory and application of cost-benefit analysis of flood protection projects when poverty concerns are part of the decision criteria.

Cost-benefit analysis is a tool used in an attempt to quantify and compare the economic costs and benefits of alternative actions. The results of cost-benefit analysis allow decision makers to determine if an alternative action is economically desirable and also to determine which alternative action society ranks most highly by efficiency criteria. In this manner, society can reap the greatest net benefits from its investment decisions.

Unfortunately, neither the application nor the underlying theory is as simple or straightforward as the above description. Problems can potentially arise from the definition of costs and benefits, the valuation of costs and benefits, the aggregation of net benefits, and the distribution of net benefits. How all of these potential problems are addressed ultimately affects the process for judging the alternative actions. Judging outcomes, however, is the last step in cost-benefit analysis. It is important to first understand how these social choices are made.

In regard to social choice, economists are concerned with how collective decisions are made and what will be the resulting allocation of resources (Stevens, 1993). Moreover, economists are interested in how the social choice reflects the

preferences of the individual members of the group. Normally, it is assumed that individual preferences are ordered to correspond with different levels of welfare or utility (Nicholson, 1995). Unfortunately, there are many difficulties involved with the concept of aggregating individual preferences into a social preference (Bonner, 1986). These problems can be categorized as two issues: aggregate measures of utility and aggregate social preferences. The two ideas are closely related; the first deals with the measure of social utility and the second deals with how social decisions are made. Presumably, social preferences will correspond to levels of social utility.

The judgment of alternative actions is made more difficult by consideration of the tradeoffs between efficiency and equity. Efficiency is concerned with whether the net benefits arising from an investment decision are optimal. That is, no alternative investment yields higher total net benefits to society. Equity is concerned with fairness regarding the distribution of the net benefits. Therefore, efficiency is group-focused while equity is individual-focused. The difficulty is that a strict maximization of total net benefits approach may have a negative impact on income distribution causing it to become less equitable (UNIDO, 1978). If equity is a concern, then a compromise between the equity and efficiency objectives will be required in order to judge the alternative actions.

Welfare economics is the branch of economics interested in determining how to judge alternative actions. Welfare economics has as its distinguishing trait the use of value judgments in the formulation of its basic assumptions (Pearce, 1994). The dominant idea in welfare economics is the Pareto Principle. Paretian economics judges a move from one state to another superior if the move to the other state makes at least

one person better off without making anyone else worse off. This idea has been extended through the concept of compensation tests, where one state is judged superior to another if the gainers from the move can compensate the losers and still realize positive net benefits.

Problems with the Paretian theory arise when concerns about the distribution of welfare is introduced. The Pareto approach implies an acceptance of the underlying income distribution. Traditional welfare economics does not distinguish between benefits accruing to the poor and to the rich (Sen, 1982). Therefore, a dollar of benefits going to the poor is given the same value as a dollar of benefits going to the rich. However, it has long been stated that the marginal utility of real income is higher for the poor than for the rich (Marshall, 1948). If the marginal utility of money for poor people is inaccurately reflected in the social value, an alternative action may be undervalued and an inefficient allocation of resources will result. The marginal utility problem can hold serious implications concerning the efficiency conditions if the poor are adequately considered.

Until recently, the economic analysis of a project's potential impact on poverty alleviation was relegated a rather minor role in the project appraisal process, despite poverty alleviation often being stated as a major motivation for international development projects. Relatively recently, poverty alleviation has been given a more prominent status in the project appraisal process. For example, in November of 1999, the Asian Development Bank adopted poverty alleviation as its "overarching goal" (Asian Development Bank, 1999). Project appraisals must now incorporate a much stronger emphasis on poverty alleviation impacts from a project.

In the past, project appraisal guidelines for development agencies addressed poverty concerns by weighting project benefits so that a target group was more heavily favored in the calculation of the project's net benefits (UNIDO, 1978); (Squire and Tak, 1975). The main difficulty with using weights in project benefit calculations is in deciding what the relative weights should be (Brent, 1990). A high degree of arbitrariness can enter the weighting process. As an example, the UNIDIO (1978) guidelines recommend determining the weights through an "iterative process between the analysts...and the politicians or planners." Other methods for calculating weights have been devised, yet all depend on value judgments to be made by the analyst. Even a choice not to use distributional weights involves a value judgment acknowledging acceptance of the existing distribution of income (Brent, 1990).

The potential for arbitrary weighting choices and inefficient outcomes has been pointed out in the literature (Mishan, 1974). The debate over benefit weighting can be characterized as ultimately a debate over the equity-efficiency tradeoff (Schmid, 1989). The debate is an attempt to determine the degree to which existing income conditions should be addressed in the appraisal process. Moreover, if distributional concerns are to be incorporated into the analysis, what is the best method for doing this? Typically, justifying and ranking alternative projects has been largely based on traditional cost-benefit analysis techniques with poverty alleviation impacts analyzed as a separate component and results reported in a short side summary (Asian Development Bank, 1997).

Most poverty impact analysis is usually concerned with numbers of poor people impacted or the proportion of project benefits accruing to a target group (Asian

Development Bank, 1997); (Brent, 1990). Another area of focus for poverty impact analysis is concerned with the development of a better index to measure poverty. However, relatively little attention has been placed on the impact poverty has on benefit calculations and market equilibrium conditions.

If the Pareto principle is an acceptable decision criterion (at least as one of a set of criteria), and the Pareto conditions are derived from economically efficient market solutions, then it is crucial that the impacts of poverty on cost-benefit analysis be examined. This can lead to a better incorporation of concerns for poverty alleviation into the cost-benefit analysis process. It is to this topic that the present study dedicates itself.

### **1.3 Purpose of Dissertation**

The purpose of this dissertation is to propose and evaluate an alternative approach for incorporating poverty concerns into the project appraisal process for a flood protection project. The proposed approach will evaluate the economic efficiency of the project as well as evaluate potential impacts of the project on poverty alleviation. However, it will allow a more precise ranking of project alternatives than other methods, such as the poverty impact ratio favored by the Asian Development Bank.

In particular, the proposed method is designed to address issues unique to flood protection projects. Flood protection projects increase expected income by reducing damage to current production and assets. Therefore, a rich person will receive more benefits than a poor person will simply because they possess more assets or produce more than the poor person does. If income inequality is great, the traditional cost-benefit approach will tend to value projects higher that benefit the richer segments of

society rather than a project that benefits the poorer segments of society. This is caused the greater aggregate value of production and assets possessed by the rich and protected by a flood mitigation project. While this may help attain the Paretian goal of efficiency, it will miss the goal of targeting those in poverty. The proposed approach aims to overcome this shortcoming by ranking acceptable projects according to the effect that the project has on those in poverty. The proposed approach will also avoid some of the difficulties involved with determining and using a weighted benefit approach.

An additional complication in the current case is that flood protection projects are usually non-traded public goods. Public goods have the characteristics of non-excludability and non-rivalry. Unlike a private good, a supplier of a public good does not have the ability to capture the benefits and has no incentive to provide the good. As a result, public goods are under-priced and under-provided by a market mechanism from a social welfare perspective. This concern will also be addressed.

#### **1.4 Objective of Dissertation**

The objective of this dissertation is to incorporate a risk-based valuation method into a traditional cost-benefit analysis of a flood protection project in order to evaluate potential impacts on poverty alleviation. The risk-based valuation technique will more accurately reflect the value of the benefits received by people living in poverty. It is believed that this risk-based approach will allow a more precise ranking of alternative projects than other existing methods when poverty alleviation goals are present.

#### **1.5 Definition of Geographical Area for Research**

The proposed approach will be tested on a proposed flood protection project located in the Red River Delta of Vietnam. Vietnam is one of the poorest countries in

the world, with a per capita income of about US\$350 (World Bank, 1999). Most of the Red River Delta population lives within an area protected by a 3000 km long dyke system. The poor population living in the Delta is extremely susceptible to negative income fluctuations. If forced below the poverty line by a flood event, supporting themselves can become essentially impossible. This situation creates an urgent need to rehabilitate the dyke system in order to protect the existing rural infrastructure of transport, energy, and water resources essential for financially sustaining the country's agricultural population.

The flood protection project involves the rehabilitation of the dyke system along the Duong River which connects the Red River at Hanoi with the Thai Binh River further east (See Figure 1.1). The project area includes parts of four provinces, 22 districts, and 484 communes as shown in Figure 1.2. Two dykes have been built over a period of 500 years on the left and right banks of the Duong River. The left bank dyke is 51.9 km long, and the right bank dyke is 60.1 km long. The two dykes have been regularly rehabilitated over hundreds of years; however, they still suffer deficiencies such as permeable and unsafe foundations and voids in the dyke body. During the historical floods of 1945 and 1971, the study area suffered extensive inundation with large loss of life, property, and production shown in Figure 1.3.

The organization of the remainder of the dissertation is as follows. Chapter 2 examines the theory behind social choice and welfare economics, while Chapter 3 examines the theory underlying cost-benefit analysis. Chapter 4 reviews the estimation of flood protection benefits both in the United States and Vietnam. Chapter 5 offers reviews of the setting in Vietnam. Chapter 6 outlines the methodology that will be used

in the case study. Chapter 7 presents the result of the case study with particular emphasis on the poverty impact analysis. Finally, Chapter 8 presents the conclusions and results.

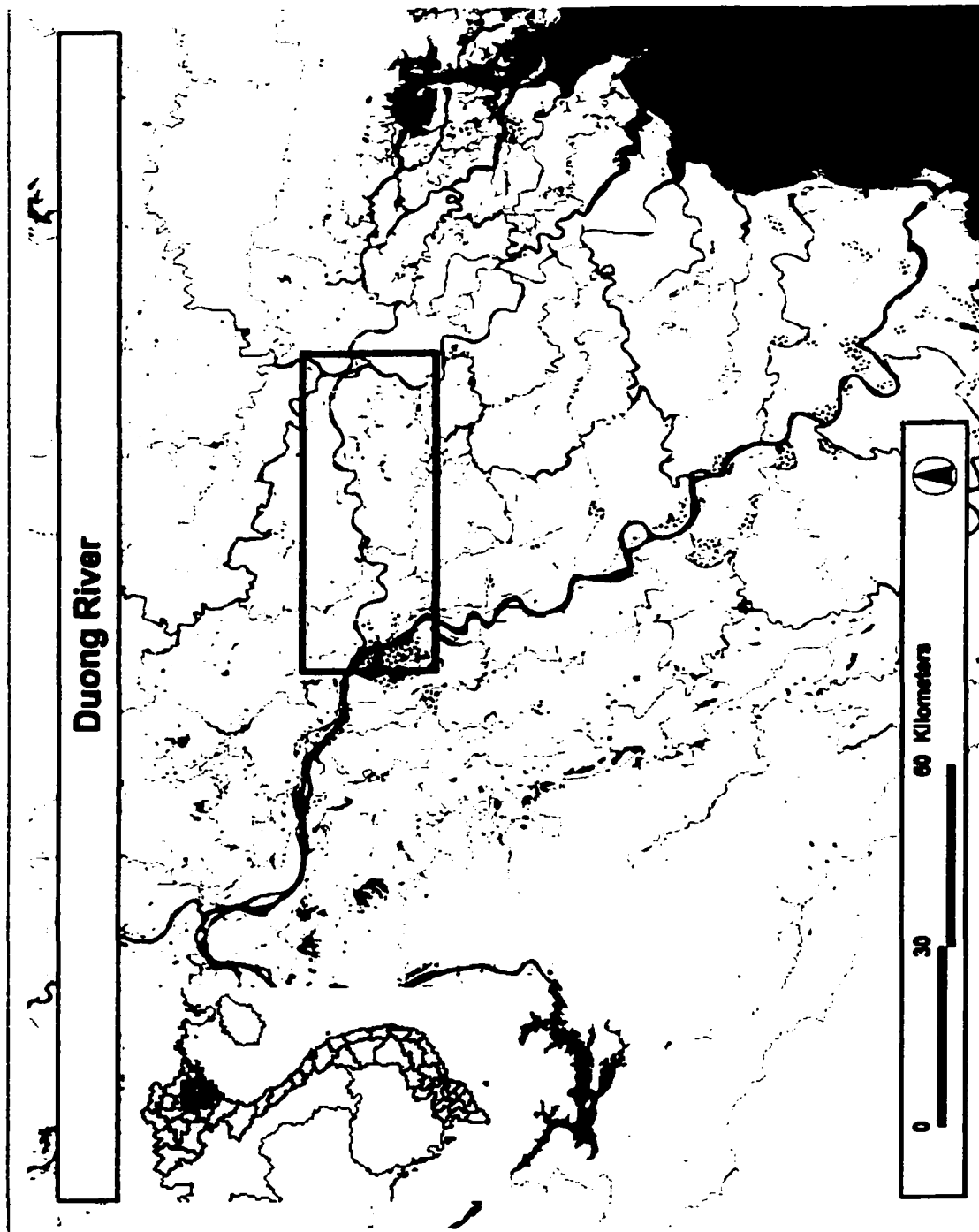


Figure 1.1 Duong River: General Location in the Red River Delta of Vietnam.

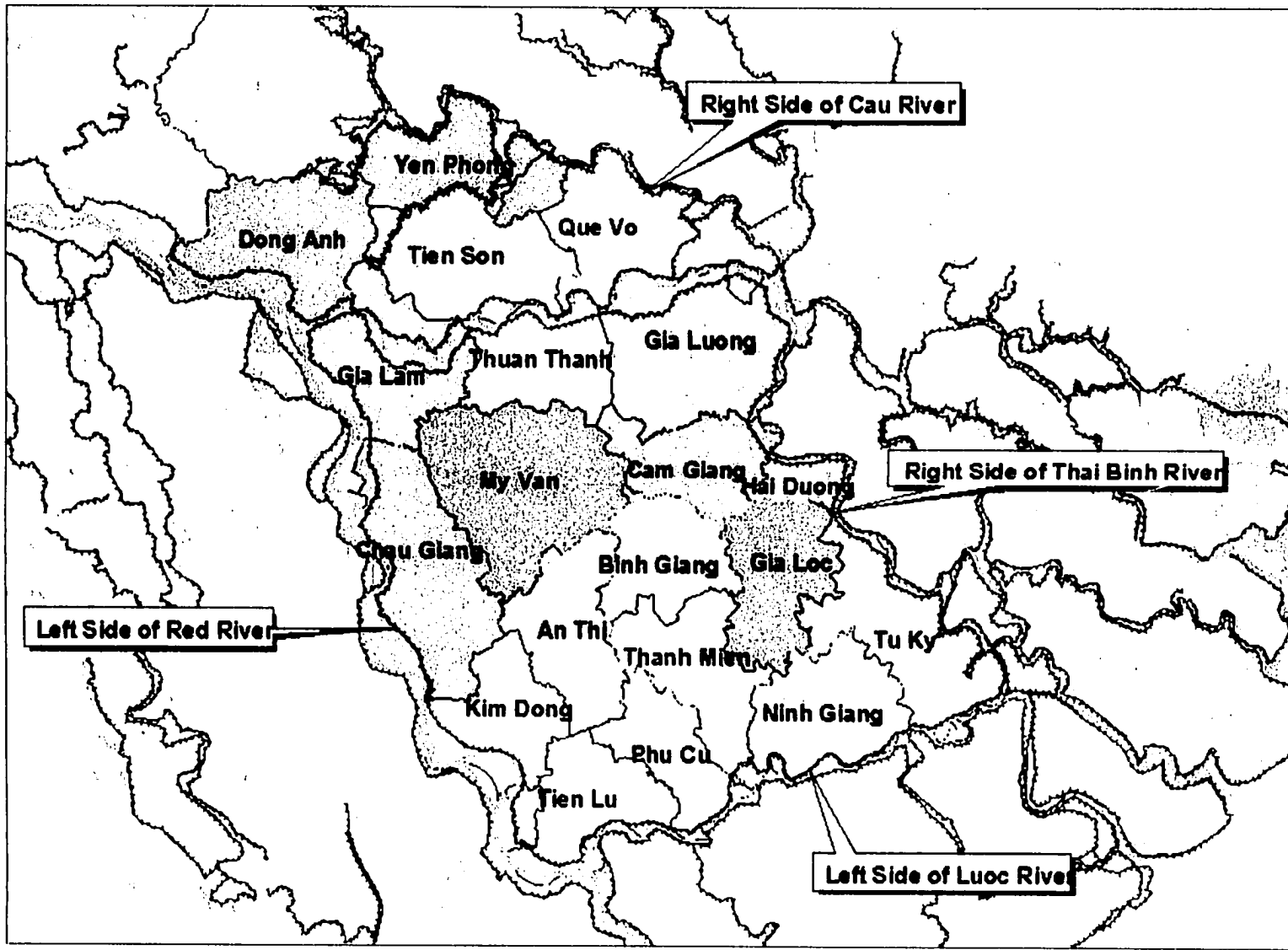


Figure 1.2 The Project Area in the Red River Delta of Vietnam.

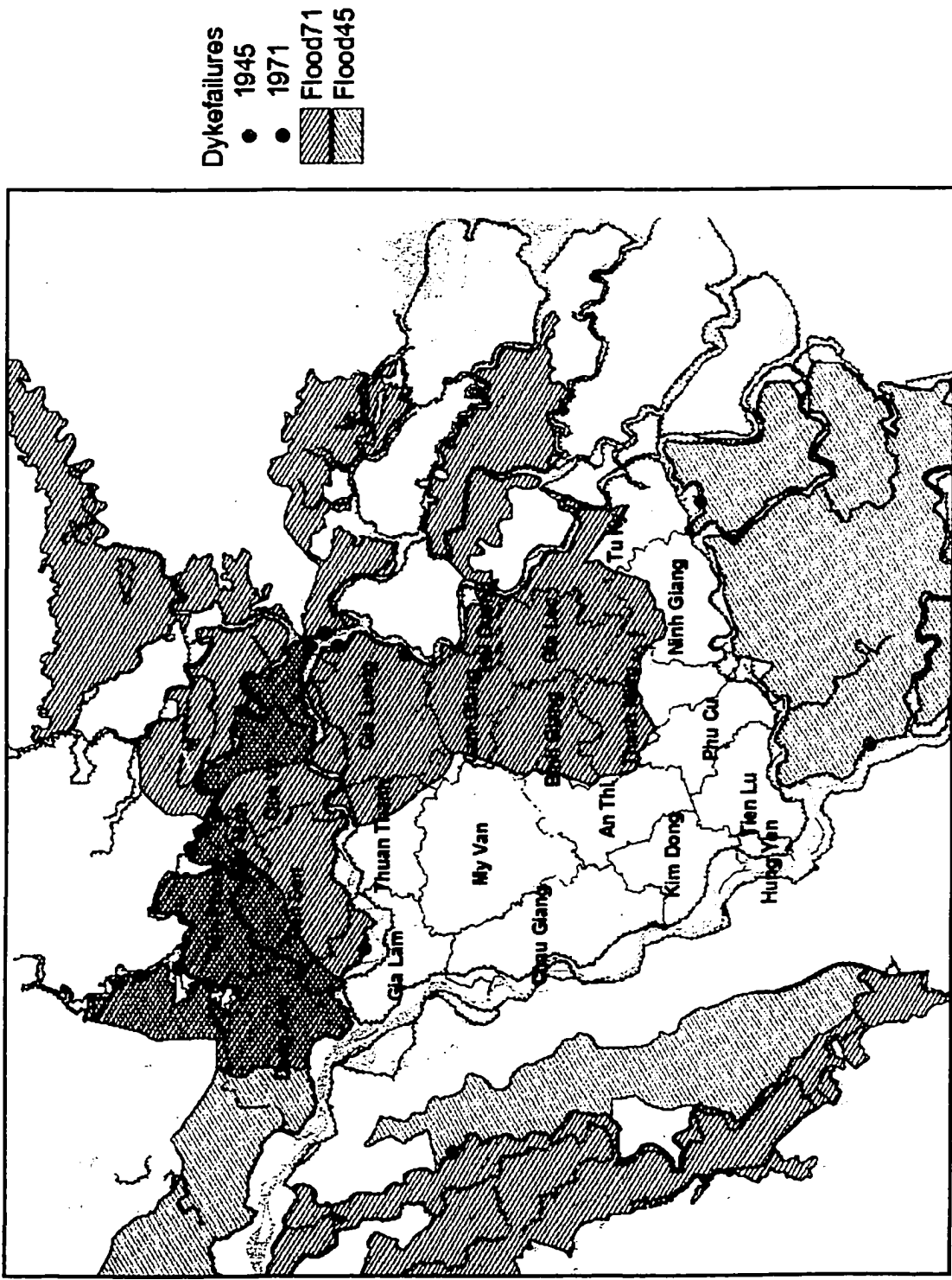


Figure 1.3 Floods of 1945 and 1971 in the Protected Area in the Red River Delta of Vietnam.

## **CHAPTER 2: SOCIAL CHOICE AND WELFARE ECONOMICS**

### **2.1 Social Choice Theory**

Social choice has been defined as any decision made “by or on behalf of a group” (Pearce, 1994). The theory of social choice examines the connections between individual preferences and collective choices (Sen, 1982). In the study of social choice, economists are primarily concerned with how collective decisions are made, how these decisions reflect individual preferences, and what is the meaning and measure of the resulting social welfare (Bonner, 1986); (Pearce, 1994). Because, ultimately, a ranking of all alternatives is desired, it is necessary to examine the conditions which guarantee this result.

Social orderings are generally assumed to be guided by certain necessary conditions. Ideally, the ranking of alternative economic states would be both complete and consistent (Boadway and Bruce, 1984). Completeness ensures that the ordering includes all possible social states. The condition of consistency ensures that the choices are transitive and reflexive. Transitivity can be stated as the condition where if  $x$  is preferred to  $y$  and  $y$  is preferred to  $z$ , then  $x$  must be preferred to  $z$ . Transitivity is important for maximization problems. Reflexivity is a trivial condition that states that for all  $x$  in a consumer’s consumption set,  $x$  is at least as good as itself (Varian, 1992). A final condition usually assumed for mathematical convenience is that of continuity in both individual preferences and in social welfare orderings.

The welfare of an individual has been defined as “the goodness in a man’s state of mind or...the satisfactions embodied in it” (Pigou, 1951). A widely accepted assumption is that people’s preferences are based on a desire to achieve higher levels of personal welfare. That is, for any ordering of a pair of alternatives, the alternative yielding the higher level of welfare will be the preferred alternative. Therefore, it is often given as a reasonable assumption that social choices are made in response to the same type of rationality (Bonner, 1986). Choices are then assumed to be made in a manner such that welfare will increase. In order to analyze the effects of these choices, it would be helpful if different welfare levels could be measured and compared. Measurement is an assignment of numbers that preserves relations such as “better than” (Roberts, 1979). If one were able to measure welfare and if it were correct that more welfare was always preferred to less welfare, then it would seem to be a relatively straightforward process to rank various alternatives on an individual basis. The most explored possibility for discovering a measure or index of welfare is found in the concept of utility.

### ***2.1.1 Individual Utility as a Representation of Individual Welfare***

Utility, in its most general current form, represents the good that a person derives from the consumption of some good. Welfare is how “well off” a person is and differs from utility, which is a measure of welfare. These two terms, however, are often used interchangeably. Economics generally assumes that an individual is aware of the relative good they derive from any alternative action (Nicholson, 1995). Based on the axioms of rational choice, an individual is able to rank all alternative actions according to preference and then to make choices in a consistent fashion. Further, it is the utility

that a person derives from a good that provides the incentive to consume a good (Samuelson, 1973).

Another important concept of utility theory is that of diminishing marginal utility. Diminishing marginal utility is the condition where as a person consumes more and more of a good, the additional satisfaction that the person gets is smaller with each additional unit. The idea of diminishing marginal utility is illustrated in Figure 2.1. The figure illustrates that for each identical increase in the quantity consumed of good X, the increase in utility comes in diminishing amounts, that is,  $A > B > C$ . While, strictly speaking Figure 2.1 shows diminishing incremental utility, the idea is the same for marginality.

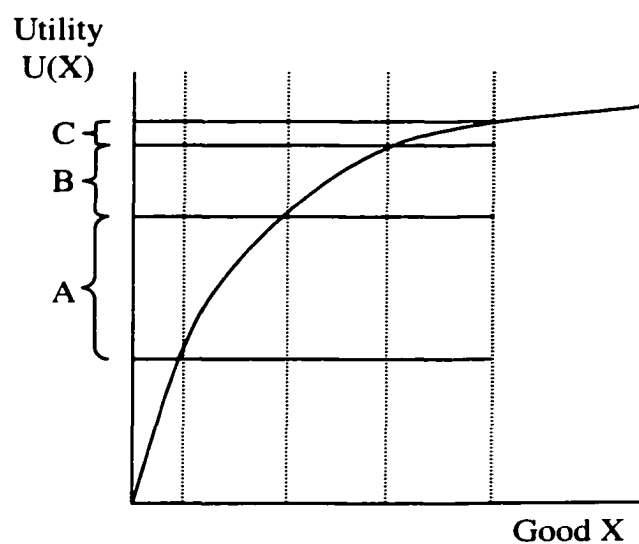


Figure 2.1 Diminishing Marginal Utility from Consumption of a Good. For each identical incremental increase in good X, the incremental increase in utility is decreasing.

When two or more goods are consumed and resources are limited, there will be a tradeoff in the consumption of the two goods. The tradeoff is termed the rate of marginal substitution and is given as the ratio of the marginal utilities of the two goods. The graph of these two goods is represented by indifference curves and is shown in Figure 2.2. Each curve, U, represents the locus of all combinations of goods X and Y where the consumer will experience identical levels of utility. That is, the curves illustrate how much of one good a consumer must give up for consumption of the other so that their utility level stays the same. The slope of an indifference curve is the ratio of the marginal utilities of the two goods. The utility levels radiate out so that the utility level of U1 is higher than the utility level of U2.

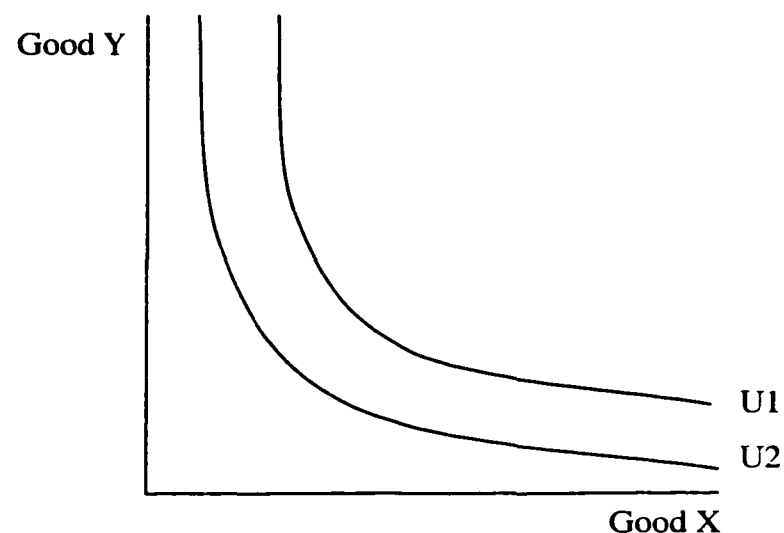


Figure 2.2 Indifference Curves for Consumption of Goods X and Y.

The convexity of curves U1 and U2 is caused by the two goods having diminishing marginal utilities (Pearce, 1994). This convexity reflects the tradeoffs that a person

must make in choosing different consumption levels for the goods. In this case, the tradeoffs are called the diminishing rate of marginal substitution.

If the social welfare ordering is to be based upon individual preferences, then the individual utilities must be measurable and comparable (Boadway and Bruce, 1984). Measurable and comparable utilities can provide insights about welfare changes resulting from changes in consumption (Bonner, 1986). If utility is not measurable and comparable, then tradeoffs in consumption bundles for society cannot be judged and social welfare can only be assumed to improve for non-losing changes in consumption. It is important to examine the properties that would make utilities a useful measure of welfare.

#### *2.1.1.1 Cardinal Utilities*

To judge alternative social actions, it is necessary to be able to know more than just the ranking, but also the magnitude of the changes. In order for magnitudes to be measurable, it must be possible to establish a “unique and reciprocal correspondence” between the magnitudes and cardinal numbers (Pigou, 1951). This requires that the measurement of the effects of alternative actions have both origin and scale (Bonner, 1986). Utility that possesses these qualities is called cardinal utility. A common interpretation of cardinality is that which allows the intervals between alternative states to be compared in terms of multiples or fractions (Pearce, 1994).

Cardinal utility received the majority of attention in the early explorations of utility by economists such as Walras and Jevons (Roberts, 1979). These early explorations of utility were framed within the idea that the primacy of economics was material welfare, which focused on “problems of producing and distributing necessities

to alleviate want,” especially poverty (Cooter and Rappoport, 1984). These problems required a definition of utility that could be compared among people. Moreover, in order to make comparisons between different states, the initial theories of utility held that individual utilities could be summed together for an accurate measure of their combined utility.

#### *2.1.1.2 Ordinal Utilities*

The cardinal measurability of utility was originally questioned by Edgeworth (Edgeworth, 1881). Edgeworth proposed a marginal approach to measuring utility to discover an equilibrium point. Edgeworth’s idea was mathematically derived by Jevons, who discovered that the utilities of different people did not need to be added because the solution depended only upon the ratio of marginal utilities compared to the ratio of prices. Pareto and Fisher (1892) extended the work by analyzing what needed to be known about a utility function to calculate an equilibrium point (Cooter and Rappoport, 1984). Pareto and Fisher discovered that it was unnecessary for individual utilities to be either intra- or interpersonally comparable. Pareto created a major change in economic thought by showing that most economic theory depended only on ordinal utility functions and that the idea of additivity was not necessarily realistic (Roberts, 1979).

The change culminated in the 1930s with the “ordinalist revolution” (Cooter and Rappoport, 1984). The ordinalist revolution rejected cardinal utility resulting in a concentration in most future economic studies on ordinal utility. Ordinal utility differs from cardinal utility in that in terms of utility it cannot be said by how much one state is better than another. That is, there is no available measure of the magnitude of utility.

In this sense, ordinal utility does not convey as much information as cardinal utility (Boadway and Bruce, 1984). However, ordinal utility requires less information in order to estimate utility functions.

The lack of measurable utility does not completely prevent the analysis of utility. Pigou (1951) pointed out that even though utility may lack measurability, one could still conceptualize a marginal utility curve. Based on certain qualities of the conceptualization, assumptions can be made that make it possible to avoid an empirical analysis in order to evaluate a consumer's actions.

Another important change resulting from the ordinalist revolution was the change in the definition of utility. The new definition of utility differed from that of the material welfare economists who defined utility in terms of the satiation of observable material wants. The ordinalists adopted a subjective definition of utility usually used today based on the pleasure people derived from the consumption of certain goods.

#### *2.1.1.3 Interpersonal Comparability of Utility*

Another important consideration of utility is whether it is comparable between people. If individual preference rankings are comparable interpersonally, then social choices can be made that are consistent with individual preferences. The interpersonal comparability characteristic is required if a social welfare ordering is to reflect the utilities of all individuals (Boadway and Bruce, 1984). Comparability of utility requires that utilities can be measured for different people by a common measure.

As with measurability, if utilities are not interpersonally comparable, then decisions for welfare improvement must be confined to strict direction changes. Particularly relevant to this study, a lack of interpersonally comparable utilities

precludes an evaluation of the implications of the transfers from rich to poor persons (Pigou, 1951). This is because it then becomes impossible to know the economic impacts a reallocation has on different segments of society.

Part of the problem in finding a common yardstick allowing interpersonal comparability is two fold: part metaphysical and part psychological (Harsanyi, 1969). The metaphysical component can be described as a likely difference in people's "susceptibility" to satisfaction. That is, one person may have the ability to derive greater satisfaction than another person from the consumption of some good, even though both people are in all other aspects identical. The psychological component is one of perception or motivation. As Harsanyi discovered, the problem facing economists is that any attempts to overcome these obstacles are subject to "large margins of errors" (Harsanyi, 1969). Since Pareto undermined the idea of interpersonally comparable utilities, the problem has become one of how social welfare can be expressed as a function of individual utilities.

### ***2.1.2 Social Welfare as an Aggregate of Individual Utilities***

It is generally accepted that social welfare measures should represent the welfare of every individual in society (Bonner, 1986). If the concept of individual utility is accepted, the problem then becomes one of how to aggregate the individual utilities into a measure of social welfare. If individual utilities are ordinal and not interpersonally comparable, then they cannot be added. The issue of aggregating utilities to form a social welfare ordering is the main issue in theoretical social choice (Boadway and Bruce, 1984).

The search for an aggregate measure of social welfare took a drastic change of direction when economists began to reject the idea of cardinal and interpersonally comparable utility. This shift in the theoretical basis resulted in the rise of what is now called New Welfare Economics lead by the ideas of Pareto, which asserts that ordinal utilities are sufficient for most economic theory (Roberts, 1979). Since Pareto, the idea of a social welfare function composed of additive, interpersonally comparable utilities has been severely criticized (Harsanyi, 1969). The key change led to a focus away from aggregate utilities and towards aggregate individual valuations of benefits for resource allocations (Mishan, 1980). However, the difficulty in aggregating individual values to arrive at a social value persisted. Two approaches to aggregation individual preferences are given by the Bergson-Samuelson Social Welfare Function and by Arrow's Social Welfare Function.

### ***2.1.3 Bergson-Samuelson Social Welfare Function***

One of the most familiar social welfare functions is the Bergson-Samuelson social welfare function (Boadway and Bruce, 1984). This function is a general relation that is a function of individual utilities. In Bergson's work, a social welfare function was formulated based on the prevailing value judgments found in welfare economics at the time (Bergson, 1938). The purpose of Bergson's work was to state explicitly what the functional formulation would be if these value judgments were accepted. Bergson was able to determine that for any specification of a social welfare function there would be a maximum point, however, the set of value propositions on which the formulation may be based is infinite. That is, as society's tastes change, then it would be necessary to formulate a new social welfare function.

A major difficulty with aggregation by a general welfare function, such as Bergson's, is that by allowing each individual to order all states strictly on a self-gain basis an infinite set of optimal points will be created (Bergson, 1938). Here, an optimal point is defined as a state where no reallocation exists that can make someone better off without making some else worse off. The infinite set of optimal points is caused by the infinite set of value propositions imposed on the welfare function in order to evaluate economic alternatives. If the welfare function is to offer relevant results for society, then it is necessary for the economic analyst to know the individual values and preference at the time of analysis. In practical terms it can be seen that the Bergson-Samuelson social welfare function is data intensive and, therefore, not suitable for applied work (Boadway and Bruce, 1984).

#### ***2.1.4 Arrow Impossibility Theorem***

An alternative approach to aggregating individual preferences was explored by Arrow in his Theory of General Possibility (Arrow, 1951). Arrow was concerned with the problem of whether it was possible for a consistent collective ranking of possible actions to result from individual preferences when a set of conditions was imposed that Arrow considered reasonable assumptions regarding the social decision making process underlying a social democracy (Bonner, 1986). The five conditions included collective rationality, unrestricted domain, the Pareto principle, independence of irrelevant alternatives, and non-dictatorship. Collective rationality is the extension of individual axioms of rational choice to social choices. Unrestricted domain is that the social choice can be drawn from any set of individual orderings (Bonner, 1986). The Pareto principle, briefly discussed previously, will be discussed in depth in section 2.3.

Independence of irrelevant alternatives is that the social choice is only affected by the individual preferences regarding relevant alternatives. Non-dictatorship requires that no single individual's preference ordering is imposed on the social choice.

Arrow's conclusion was that anytime that there are three or more alternatives any procedure for social choice will violate one of Arrow's conditions. The implication of Arrow's result is that the construction of a social welfare function that satisfies his five conditions is impossible. That is, it would be impossible to construct a social welfare function that aggregated individual preferences in such a way that collective rationality would guide social decisions.

One claim countering Arrow's argument states that certain decision-making mechanisms, such as a market, do not require collective decision-making and, therefore, do provide consistent choices (Buchanan, 1954). Buchanan felt that the assumption of collective rationality imputed an organic relationship to a group that may not exist. Buchanan further argued that a social welfare function must be approached from the philosophical standpoint that a social welfare function is a product of social origins, distinctly different from a product of individual origins. Therefore, Buchanan believed that attempts to construct a social welfare function as a product of individual preferences should be abandoned. Sugden answered that Buchanan was mistaken in his conclusions because of his attempt to "impose the logic of welfare maximization on the procedures of collective choice" (Sugden, 1993).

Sen (1995) later showed that even if the idea of social preference and the condition of consistency are dropped, Arrow's impossibility result will still hold. Sen had previously extended Arrow's results with his proof of the incompatibility of Pareto

Optimality with certain liberal values (Sen, 1970). Sen concluded that, “in the context of social welfare judgments, the natural resolution of these problems lies in enriching the information base” (Sen, 1995). That is, in order to by pass the impossibility problem, social judgments will require the admission of non-utility information and interpersonal utility comparison.

### ***2.1.5 Comparison of Approaches by Bergson and Arrow***

A Bergsonian Social Welfare Function deviates from Arrow’s conditions by taking individual tastes as given, and making social orderings of alternatives based on a changing environment (Little, 1952). Whereas, Arrow allowed for individual preferences to change and social choices were made as a function of individual tastes. By taking individual preferences as given, for a change in individual preferences, a new ordering may result and no reason exists that the two orderings should have anything to do with each other. A second difference is that the social ordering resulting from a Bergsonian Social Welfare function does not require that it represent social choices (Little, 1952). Little concluded that Arrow’s Impossibility Theorem had no bearing whatsoever on the possibility of a Bergsonian Welfare Function.

Little extended his argument by restricting the interpretation of Arrow’s conditions to a decision process instead of a social welfare function. The difference is that a social welfare function is a value judgment, while a decision process rules between value judgments given to it. Therefore, according to Little (1952), Arrow had proved that consistent decision-making and, therefore, the discovery of a social welfare function, is impossible if one adheres to his conditions. A second point of contention is that Arrow’s conditions cannot be justified (Rothenberg, 1953).

Rothenberg (1953) contrasted Little's claim by showing that a transformed welfare function is dependent on changes in the individual preference rankings. He did this by deriving an Arrow Social Welfare Function from the Bergson social welfare function. Rothenberg criticized Little's interpretation of Bergson's Social Welfare Function as too narrow, since Little specified a Social Welfare Function as a rule which is a function of individual tastes (Rothenberg, 1953). The implication of Little's specification was that if tastes change then a new rule is needed, whereas Arrow's social welfare function is specified for every ordering of individual preferences. Rothenberg devised a compromise solution, declaring that a social welfare function is "a descriptive generalization about the valuation rule of the population at large" (Rothenberg, 1953).

The above discussion does not make any statement as to the usefulness of a social welfare function to welfare economics. Rather, Rothenberg states that "a social welfare function is acceptable only when it adequately describes a social decision-making process for which there exists in the observable real world a significant valuation consensus supporting it" (Rothenberg, 1953). This condition is likely to exist during the relatively short time spans normally examined in welfare economics. The next step is to decide what the value judgments shall be.

### ***2.1.6 Value Judgments***

One aspect of welfare economics is that it is normative and therefore requires the use of value judgments (Boadway and Bruce, 1984). Value judgments hold the special characteristic in that they can be individually unique and it is impossible to substantiate their truth (Pearce, 1994). Some felt that utility theory could never become

independent of the value judgments necessary to give utility measures a common dimension (Bergson, 1938). Bergson (1938) was one of the economists supporting the involvement of economists in the determination of prevailing values in a community.

There are several approaches to guide allocation decisions. Each of the following approaches requires a different set of values judgments to be made regarding what society should try to achieve through resource allocations. One of the earliest of these was put forth by Jeremy Bentham, who called for allocations to be guided by the utilitarian approach (Bentham, 1791). The utilitarian approach holds that it is desirable that allocations should be made that provide the greatest happiness for the greatest number. Another approach that was put forth by Rawls is a maxi-min approach (Rawls, 1971). In this approach, the welfare of the state is determined by the welfare of the worst off member. Finally, an egalitarian approach is primarily concerned with adhering to some sort of equality among members of society.

## **2.2 Making Collective Decisions Concerning Different States of Social Welfare**

There are numerous processes for making social decisions, such as voting and central planning. In voting, each individual has a say in the decision process and his or her input is counted in the final decision. In political voting, each individual has an equal vote. However, the market represents another sort of voting process where each member of society casts votes on resource allocations using money (Pearce and Nash, 1981). Through this collective process, society determines what it wishes to produce and consume thereby theoretically maximizing its welfare. The main difference between economic and political voting is that different individuals have different voting powers. If every individual has roughly the same income, then dollar voting can

embody some expression of intensity of preference among individuals (Pearce and Nash, 1981). However, if there are income disparities then market voting favors those who can vote more, such as the rich. The rich can simply vote more than the poor for higher absolute values, however, the poor may have higher valued marginal voting power.

Opposite to a market process, is a central planning decision process. In this process, social decisions are made by an individual or small group on behalf of society, usually identified as a country's government (Tinbergen, 1964). Central planners may or may not work in accordance with society's best interests in mind. If we assume that society's objectives can be represented by a social choice rule, and the rule is based on the welfare or preferences of the individual members, then the primary problem for the planner is to discover what are the individual preferences (Dasgupta, Hammond et al., 1979). Alternatively, central planners may choose to act as if they knew the preferences of the individual members and makes decisions based on these assumptions. This can be especially useful when consensus decisions are difficult to arrive at.

### **2.3 Welfare Economics**

Welfare economics is the normative branch of economics concerned with the conditions that determine whether one social state is better than another state. It has been defined as the branch of economics that "seeks to formulate and justify propositions by which economists may rank, on the scale of better or worse, alternative economic situations" (Mishan, 1980). In a practical sense, it attempts to prescribe policies that deal with resource allocations. The conditions that are used to judge alternative states are based upon value judgments in welfare economics. It has been

demonstrated that welfare economics requires the use of value judgments (Fisher, 1956).

Mishan (1980) stated that New Welfare Economics is based on two fundamental maxims. The first is what Mishan calls the individualist maxim, which is that the economist's objective data is the set of individual's subjective valuations. The second maxim is the Pareto criterion which states that a state B is preferred to a state A if the aggregate net benefits are higher in state B. Some economists believe that if the ethics of society do not match these maxims, then the allocative economist loses all basis for pronouncing a given allocation suboptimal (Mishan, 1980).

### ***2.3.1 The Pareto Criterion***

The Pareto criterion is a rule used to judge alternative states. The Pareto criterion defines an optimal state as one in which no reallocation can be made that improves at least one person without harming another. By itself, the criterion does not allow a complete ordering of social states. The Pareto criterion arose out of the rejection of cardinal and interpersonally comparable utilities. Pareto's work replaced the idea of measurable utility with the idea of a scale of preferences (Hicks and Allen, 1934). Ordinal utilities confined reallocation options to those where at least one person is made better off without any other person being made worse off. Pareto demonstrated that the derivation of a utility function from a scale of preferences is not possible. That is, that utility is ordinal.

Hicks and Allen (1934) evaluated the adjustments to the theory of value made necessary because of Pareto's theories. There were two issues confronting them, the first reason being rather practical. They felt that the marginal utility for any good tends

to want to stay in isolation as any two marginal utilities have an almost irresistible tendency to “wander” apart (Hicks and Allen, 1934). The second reason is that in equilibrium, the marginal rate of substitution must equal the ratio of prices. Their analysis concluded that the theory of value did not require a measure of utility. For these reasons, the idea of marginal utility was supplanted with the idea of marginal rate of substitution.

A second adjustment is the replacement of diminishing marginal utility with decreasing rate of marginal of substitution. This adjustment creates a mapping of convex indifference curves, which is mathematically desirable for maximization problems. Other assumptions made concerning the indifference curves are that they are continuous for all goods, that they are positive in quantity, and that the marginal rate of substitution is always decreasing (Hicks and Allen, 1934). These conditions are standard conditions of calculus normally given as necessary for well-behaved mathematical optimization solutions. The non-negativity condition is meant to constrain solutions to economic reality.

### **2.3.2 *Strict Pareto Improvements***

Strict Pareto improvements are resource allocations where at least one person is made better off, but no one is made worse off (Londero, 1996). The implications of these kinds of improvements can be show graphically. The following assumes that there are two individuals, X and Y, with utility functions U as shown in Figure 2.3. If they initially start at point A, then a strict Pareto improvement would restrict reallocations to within the dot shaded area, such as point C. Points B and D, would not be allowed since X would lose utility in the move.

The implication is that judgments regarding alternative allocations are limited to those within the shaded areas. Points such as B and D have ambiguous welfare changes. In this sense, the strict Pareto improvement approach offers an incomplete ordering. Another implication is that reallocation will result in distributions that are similar to those existing in the initial state. This is because no one can be made worse off than the initial allocation. Unless society judges that the existing distribution is acceptable, then a strict Pareto improvement is not a suitable criteria for project evaluation. Another practical limitation is that most policy decisions usually help some people, while hurting others.

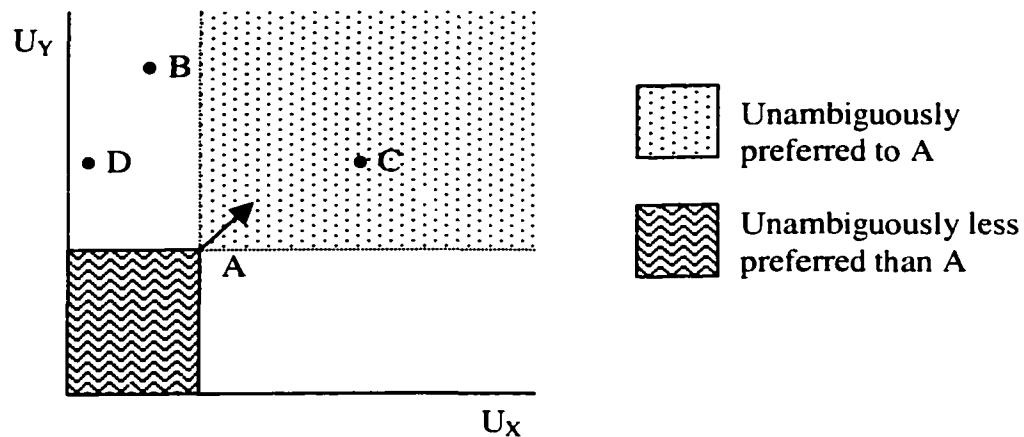


Figure 2.3 Strict Pareto Improvements of Utility for a Two-Person Situation. If A is the initial allocation, then C is an unambiguous Pareto improvement, but no judgment can be made about allocations B and D.

### 2.3.3 Potential Pareto Improvements

If a reallocation can be made where at least one person is made better off and the gainers could compensate the losers, then this is known as a potential Pareto improvement. The compensation, however, does not actually need to be paid. The

difference between strict and potential Pareto improvements is shown in Figure 2.4. A potential Pareto improvement allows consideration of all resource allocations to the right of the line PP, so now point B is an acceptable allocation. Potential Pareto improvements allow for a complete ordering of states. Another advantage is that the potential for a redistribution of net benefits to occur is now allowed, however, in the absence of interpersonal utility comparisons it is not possible to pick a single solution.

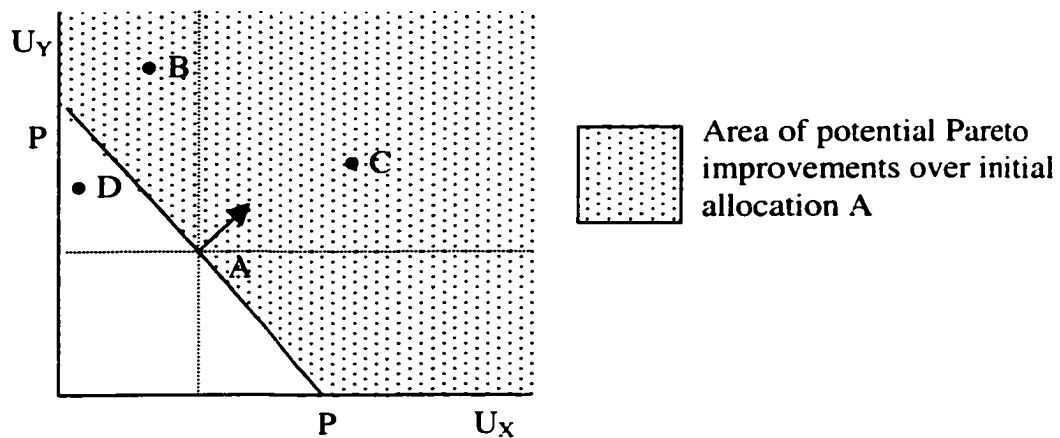


Figure 2.4 Potential Pareto Improvements of Utility in a Two-Person Situation.

### 2.3.4 Pareto Optimality

A Pareto optimal allocation of a resource occurs when no reallocation exists where one party can be made better off without another party being made worse off (Pearce, 1994). Another way of thinking about it is that all mutually beneficial trades have been exhausted. The idea of Pareto optimality can be demonstrated graphically with an Edgeworth box diagram. In the diagram, there are two people,  $i$  and  $j$ , exchanging two goods  $X$  and  $Y$  as shown in Figure 2.5. They are each characterized by

the utility curves  $U$ , where  $U^1 > U^2 > U^3$ . Point C in the diagram represents an inefficient allocation in that by moving to point A, j's utility can be increased without hurting i. Likewise, a move from point C to B increases i's utility without hurting j. Points A and B, however, are both Pareto optimal in that no move exists that will not hurt at least one of them. It can be seen that at the Pareto optimal points, A and B, the marginal rates of substitution for both i and j are equal. All points where the marginal rates of substitution are equal for both i and j form a contract curve shown as curve  $O_i O_j$ . The contract curve is the locus of all the Pareto efficient allocations of good X and Y.

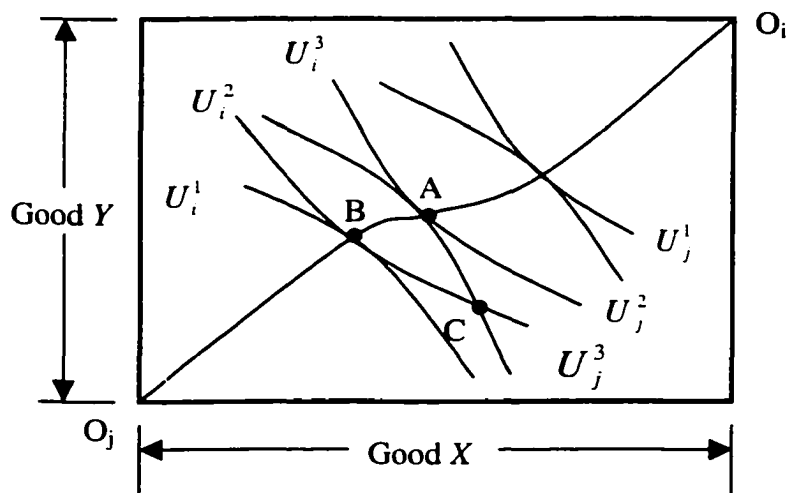


Figure 2.5 Pareto Efficiency in Exchange for two individuals i and j with utility  $U$ . Allocation C allows mutually beneficial moves, while allocations A and B do not.

The idea of Pareto efficiency can also be demonstrated in production. Consider an economy with a single consumer and two products, X and Y. Let the consumer's utility function be represented by  $U_i$  (where  $U_1 > U_2$ ) and the production possibilities frontier by Q as shown in Figure 2.6. Line I is the budget constraint. Point B on the

graph shows a technically efficient resource allocation, since the only way to produce more of one good is at the expense of the other good. If it were possible to produce more of one good without sacrificing the other good, then the allocation would be considered technically inefficient, such as point C. Point B, however, is economically inefficient, because if resources are reallocated so that production takes place at point A, utility will be increased to  $U_1$ . At any other point than A, utility is reduced from that which is possible.

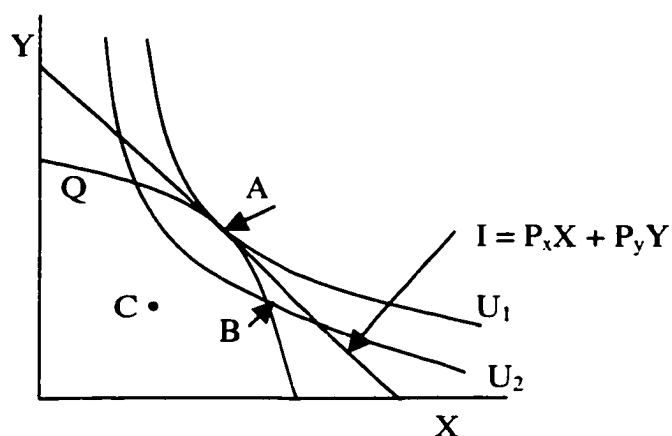


Figure 2.6 Pareto Efficiency in Production.

### 2.3.5 *Mathematical Conditions for Pareto Optimal Allocations*

Pareto optimality can also be demonstrated mathematically. This will set up the basic optimality conditions for an economically efficient allocation. We will first designate two production functions for goods X and Y as:

$$X = f(z_x),$$

and

$$Y = g(z_y),$$

respectively. The variable  $z$  represents an input bundle that can be used for the production of either X or Y and is constrained by:

$$z = z_x + z_y.$$

A single utility function representing society will be assumed and represented by:

$$U = h(X, Y),$$

Where, X and Y represent the consumption levels of goods X and Y. The locus of combinations of X and Y where U is constant defines an indifference curve. The slope of this curve is the marginal rate of substitution (MRS) and is represented by:

$$MRS = \left. \frac{dY}{dX} \right|_{U=U_1}.$$

In order to make the utility maximization problem more realistic, a budget constraint is introduced. If we allow  $P_x$  and  $P_y$  to represent the prices of X and Y, and I to represent the income, then the budget constraint can be represented by:

$$I = P_x X + P_y Y$$

The budget constraint is shown in Figure 2.6. Solving for Y yields the slope of the budget constraint as  $-P_x/P_y$ . Examining Figure 2.6, one can see that if less than the total income is spent then utility will be less than  $U_1$ . Further, for any consumption bundle on the budget constraint not at point A, utility is also less than  $U_1$ . Therefore, it can be seen that utility maximization is achieved at the point where the budget constraint is tangent to a utility curve and the budget is completely exhausted. This can be more succinctly defined as the point where:

$$MRS = -\frac{P_x}{P_y},$$

The corresponding solution on the production side yields the rather straightforward conclusion that producers should produce at point A. The slope of the production possibilities frontier is known as the rate of product transformation (RPT) and is given by:

$$RPT = -\frac{dY}{dX},$$

and represents the productive tradeoffs with Y from producing more of X for a technically efficient allocation of resources. The optimal conditions occur when:

$$RPT = \frac{P_X}{P_Y} = MRS.$$

To see why this is the case, any point within the production possibilities results in lower utility for society. Only point A in Figure 2.3 is both technically efficient and a maximal point of social utility. Thus, the basic conditions for a socially optimal allocation of resources are established.

This optimal allocation implies nothing about the distribution of benefits within society. Potential Pareto improvements merely require that adequate compensation be possible for the losers, not that it actually is paid. The Pareto optimal allocation may not be acceptable by society's ethical standards. A second point is that is that potential Pareto improvements define an infinite set of Pareto optimal points. The Pareto criterion does not help one identify the optimal allocation decision. The conclusion of following the Pareto criterion is that at the maximum position, the marginal welfare per dollar be the same for all people.

In a perfectly competitive market setting, the ability to accurately rank alternative consumption bundles combined with the provision of effective incentives,

guides individual participants so that a market will reach its optimal state. The conditions at the optimal point have the marginal rate of substitution equal to the price ratio of the two goods. The ranking of alternatives does not allow, however, the unambiguous measurement of welfare.

### ***2.3.6 Compensation Tests for Potential Pareto Improvements***

If some people lose while others gain and utility is not interpersonally comparable or cardinal, then judgments cannot be made about the reallocations. In order to get around this problem, compensation tests were developed (Boadway and Bruce, 1984). The most widely used compensation test is that normally attributed to Hicks (1939) and Kaldor (1939). Under this test, one state is deemed superior to another if gainers from a particular reallocation have the ability to fully compensate the losers and still realize a net gain. Still, however, the compensation never actually needs to be paid. These types of reallocations are called potential Pareto improvements.

Compensation tests were introduced as an extension of Pareto's criteria to allow for hypothetical payments to losers of a resource allocation. The advantage of compensation tests is that they allow an examination of social welfare, while avoiding the issue of interpersonal welfare comparisons. These compensation tests allow for potential Pareto improvements.

Probably the most common criticism of compensation tests involves the difference between actual and potential improvements. Potential Pareto improvements do not require that compensation actually be paid. In fact, in a practical setting it is generally assumed that compensation is primarily an imaginary exercise (Bonner,

1986). This is because of the enormous cost associated with determining and making the appropriate payments.

## 2.4 Theoretical Calculation of Utility as Consumer Surplus

The most common method used to measure utility is that of consumer surplus. Consumer surplus provides a money metric proxy for utility. Consumer surplus has been defined as the net benefit that a consumer receives from purchasing a good at a particular price (Pearce, 1994). The concept has can be traced to Dupuit (1844), who proposed using the difference in a good's value in use and value in exchange as a measure of utility. Marshall (1948) points out that consumer surplus is an important concept because of its ability to measure differences in utility between two events. Marshall's argument is that if "the money measures of the happiness caused by two events are equal," then the two events yield essentially identical amounts of happiness (Marshall, 1948). Graphically, the consumer surplus is the willingness to pay/price differential integrated across some quantity, arbitrarily shown as  $0Q^*$  in Figure 2.7.

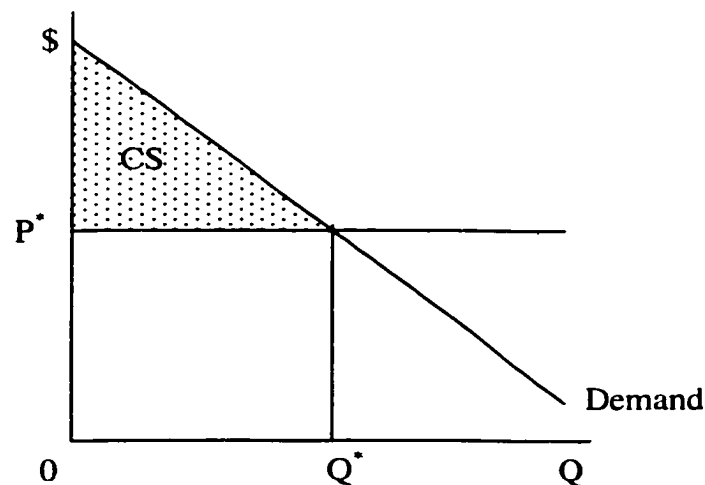


Figure 2.7 Consumer Surplus. The shaded area CS, is the extra benefit received by the consumer because the market price,  $P^*$ , is less than their willingness to pay.

Consumer surplus is the shaded area labeled CS. If the price were any higher, then the quantity demanded would fall leading to a loss of consumer welfare. If the price were lower then consumer surplus would increase from the increase in quantity demanded. Likewise, if it is assumed that the equilibrium point stays the same, then the greater the price elasticity of demand for the good were greater then the incremental increases to consumer surplus are greater.

The demand curve represents the marginal value of the good to the consumer for different quantities of  $Q$ . That is the demand curve represents the marginal points where a consumer's objective function is maximized given different prices levels, all else equal. The optimal output has been defined, according to welfare economics, as the "output combination that would be chosen by individual consumers responding in perfect markets to prices which reflect true costs of production" (Pearce, 1994).

In application, consumer surplus is most commonly used to measure changes in welfare (Pearce, 1994). One limitation of consumer surplus, especially in a developing country setting, is that it assumes that the marginal utility of income is constant across individuals and dollars. If it is accepted that a marginal dollar of income is worth more to the poor than to the rich, then it becomes necessary to incorporate this difference into the economic analysis if distributional issues are important. Improving the methods to estimate the marginal utility of income can help to "bridge the gap between equity and efficiency" (Blue and Tweeten, 1997).

#### ***2.4.1 Marginal Utility as a Valuation of Welfare***

It is widely regarded that resource allocation decisions are made at the margin. It is therefore important that values of utility also be determined at the margin rather

than using total utility values. Marginal decisions ensure that scarce resource will be placed to those uses that are valued most highly. The general approach in economics has been to assume that the marginal utility of income is identical for all people. Unfortunately, the measurement of marginal utility of income in practice has been limited.

Blue and Tweeten (1997) proposed a method of measuring marginal utility by constructing a social welfare function using a Quality of Life Index. They utilized a socio-psychological approach that used personal measures of well being to estimate marginal utility. This differs from the usual methods of using a gamble or preference elicitation technique to estimate marginal utilities. It thus overcomes the difficulty where the expected utility axioms are violated. Blue and Tweeten's findings using curvilinear functional forms showed that the marginal utility of money approached infinity as income approached zero.

#### ***2.4.2 Divergence of value in use and value in exchange***

Adam Smith addressed what is now a classic problem involving the divergence in price between diamonds and water. The problem was that water, a good essential for life, was priced so much lower than diamonds, which are a luxury good and not essential to life. The well-known solution to the problem is that there is a divergence of the value of a good in exchange with the value of a good in use (Samuelson, 1973). The cause is that water is abundant resulting in a low price per unit, whereas diamonds are relatively scarce resulting a higher market price. Jevons (1871) later used the methods of calculus to resolve the paradox of value, confirming that the price of a good is associated with marginal, rather than total, utility. If allocation decisions are made

using social marginal analysis, then it becomes important to examine these divergences in exchange and use values. In fact, it has been shown that the only time aggregate measures of net benefits are a valid indicator of welfare is when the marginal social utility of income is identical for all people (Boadway, 1974).

## **2.5 Resource Allocations in a Market Setting**

Resources can be defined as being synonymous with factors of production (Perman, Ma et al., 1996). The allocation of resources involves the assignment of the resources to specific people or uses. Allocations allow productive activities to occur, thereby creating economic benefits.

An allocation of resources entails two components (Perman, Ma et al., 1996). The first component relates to the productive side of resource utilization. This component involves the choice of inputs used to produce a set of outputs. The second component considers how the productive outputs are distributed. These two components are interdependent in that society must consider both in deciding how best to maximize its objectives.

Opportunity cost is one of the most important concepts in the allocation of resources. The opportunity costs of a resource are “the benefits foregone when a scarce resource is used for one purpose instead of its next best alternative use” (Young, 1996). If there were no constraints on the available quantity of a resource, then no productive activity will ever have to be foregone and opportunity cost will be zero. However, if a limit exists concerning the quantity of a resource so that it cannot satisfy all wants, then a positive opportunity cost is created and the resource is called scarce.

### ***2.5.1 Scarcity and the Importance of Allocation Decisions***

During the ordinalist revolution, economics saw a shift away from material welfare economics and toward scarcity economics (Cooter and Rappoport, 1984). Scarcity exists whenever a resource holds value, but is limited in quantity (Perman, Ma et al., 1996). The main implication of scarcity is that tradeoffs will be involved in the utilization of a resource. It is important that resources are allocated to those uses that society (or an individual or firm) values most. If allocations do not occur in this manner then society is not receiving the maximum benefit available. Some alternative allocation of the resource exists that will yield more benefits.

### ***2.5.2 Efficiency Objectives for Allocation Decisions***

In economics, resource allocations are generally assumed to be directed so that the net benefit realized from their use is maximized. Benefits may be defined as profits, utility, or any other measure the decision maker deems important. Economics attempts to guide resource use so that the use is efficient. Economic efficiency is the condition where the maximum benefit is created for the least cost. Theoretically, an efficient allocation is accomplished by the normal workings of a perfectly competitive market given the well-established assumptions regarding the exchanged goods and market institutions.

### ***2.5.3 Efficient Outcomes in a Perfectly Competitive Market***

It is assumed in economics that a perfectly competitive market will provide an efficient allocation of resources. The perfectly competitive market is comprised of consumers who are maximizing utility and producers who are maximizing profits. Each market participant succeeds in maximizing their personal objective through the

interdependence of supply and demand forces. These forces provide incentives to the market participants by giving signals reflecting the true value of buying or selling different goods. At the equilibrium price and quantity, there is no incentive for buyers or sellers to alter their economic decisions, as it would entail a move away from their objective maximum (Nicholson, 1995). Thus, in the long-run, the market equilibrium is an efficient allocation of resources according to the objectives of society's individual consumers and firms. The optimal output has been defined as the "output combination which would be chosen by individual consumers responding in perfect markets to prices which reflect true costs of production" (Pearce, 1994). As stated before, this outcome is assuming a perfectly functioning market economy and a universal acceptance of the efficiency criterion. The next section examines the case when efficiency may not be the main or only concern.

#### ***2.5.4 Equity and Distribution***

The concept of efficiency as used in economics is normally concerned with allocative efficiency. Efficiency has received the primary focus regarding problems of resource allocation. If efficiency is achieved then no reallocation exists that could increase total net benefits. In economics, efficiency is founded on a set of conditions, that if met ensure that net benefits have been maximized. Generally, the normal workings of a perfectly competitive market can be shown to yield economic efficiency. In this manner, the efficiency criterion seems to avoid many of the value judgment problems associated with the equity criterion, although, a closer examination will show that this is not necessarily true. In applied cases, concerns are often given to the problems of equity and the distribution of net benefits.

Distributional issues examine how the costs and benefits of a given state are distributed among individuals. Equity is primarily concerned with whether a given distribution is fair (Pearce, 1994). Equity can be defined in terms of income, wealth, property rights, or any other measure that society deems important. Fairness can vary in its definition depending upon the parties involved. It is stated that the primary difficulty with equity is that it requires value judgments to be made whereas in market decisions equity is determined by willingness and ability to pay. Many people feel that economics, as a science, should not concern itself with equity (Mishan, 1980). Others, however, believe that despite this difficulty, economics should address the equity issue. As demonstrated later in this chapter, many attempts have been made to incorporate equity concerns into the analysis of allocation problems.

It has been shown that social choices concerning resource allocation can consider both efficiency and equity issues. Economists, however, tend to focus on the efficiency criterion leaving equity concerns to the political process. However, others have questioned the potential to which the two issues can be separately analyzed with government projects. This is because when a government program redistributes benefits there can be an unforeseen change in demand caused by the differences in preference between the receivers and the givers of the redistribution (Eckstein, 1958). There are two problems that arise from concerns over equity. First, equity concerns may put resource allocations into conflict with economic efficiency objectives. Further, adherence to the efficiency criterion may cause the economist's policy recommendations to be detached from the ethics of the society in question (Mishan, 1980). Additionally, the market operations are hampered by market imperfections and

failures. The cause and description of a certain kind of market failure are described in the next sections.

### **2.5.5 Market Failure**

Market failures occur when the market is unable to provide a good at optimal levels as defined by economic efficiency. The most common source of market failures usually lies in the characteristics of the goods themselves (Pearce, 1994). These characteristics include either non-rivalry or non-excludability in the good's consumption. Non-rival means that one person's consumption of a good does not prevent another person from consuming the good. Non-excludability means that a person cannot be prevented from consuming the good based on whether they have paid for the good or not. The implication of the two conditions is that necessary incentives will not be provided in such a way as to encourage the sort of market participation needed for an optimal outcome. The form of market failure most relevant to this study is that of public goods, which is discussed in the next section.

### **2.6 Provision of Public Goods**

Pure public goods are a form of positive externality and are defined as being both non-excludable and non-rival. A public good is a good that has a zero cost associated with its provision to additional people after the good is initially provided (Pearce, 1994). This characteristic makes public goods highly susceptible to the free-rider problem. The free-rider problem exists because the potential to consume the good for zero cost motivates a consumer to hide their preference for the good to minimize personal payment (Samuelson, 1954). The problem then becomes how to optimally provide a public good and at what cost. Samuelson pointed out that solutions to the

problems of determining an optimal quantity to provide of a public good and a just cost sharing burden cannot be separated logically (McGuire and Arron, 1969). Deciding the best way to share the cost burden is a complex problem.

One of the earliest attempts to explain a solution to this problem was provided by Erik Lindahl in 1919 (Nicholson, 1995). Lindahl attempted to show how a system of taxation might lead to an efficient equilibrium. He constructed a two-person economy with a public good. Demand schedules were developed based on the proportion of the public good's cost in terms of tax each would be willing to pay. At higher cost proportions, each party would demand less of the public good. Figure 2.8 shows the graph representing these demand schedules.

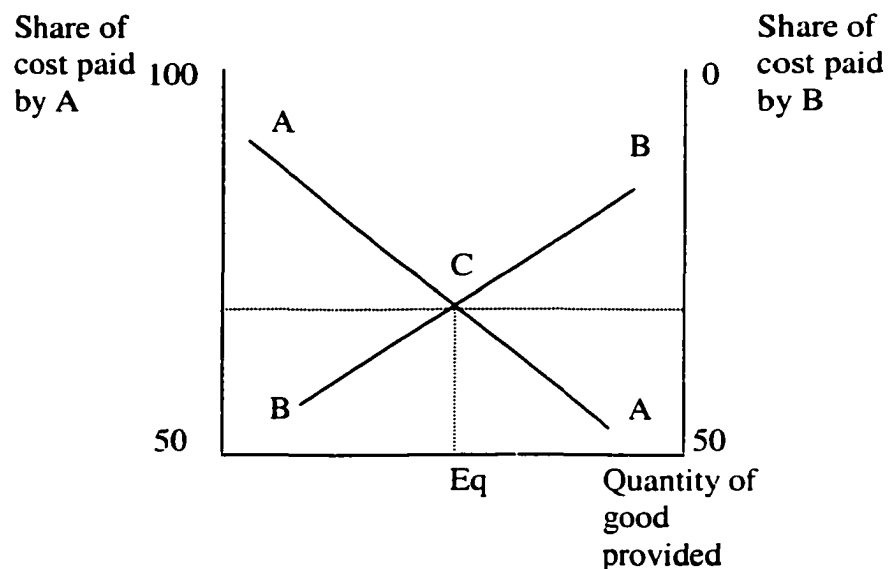


Figure 2.8 Lindahl Equilibrium with Taxed Public Goods.

The demand curves for persons A and B intersect at point C, so that the quantity demanded of the public good is  $Eq$ . Each person is willing to pay a specific tax rate

based on the value of the public good to him or her. Lindahl argued that this represented an equilibrium solution based on the idea that if the good were supplied in quantities less than  $Eq$ , together the two people would be willing to pay more than 100 percent of the total cost of the good. If the public good were supplied in quantities more than  $Eq$ , the total amount the two would be willing to pay would be less than 100 percent of the total good (Nicholson, 1995). The efficiency of this solution can be demonstrated mathematically.

There are two consumers, A and B, and two goods one a pure public good and the other a pure private good, X and Y, respectively. Prices are represented by  $P_i$ . If we let A's share of the public goods cost equal  $\alpha$ , then A's tax share equals  $\alpha P_X$ . A's utility maximizing allocation will be chosen so that:

$$\frac{\alpha P_X}{P_Y} = MRS_A = \frac{MU_A(X)}{MU_A(Y)}.$$

Similarly, B's share of the public good's cost will be  $1-\alpha$ . B's will allocate resources to maximize utility satisfying:

$$\frac{(1-\alpha)P_X}{P_Y} = MRS_B = \frac{MU_B(X)}{MU_B(Y)}.$$

The producers will produce the two goods in a combination to maximize profits, so that:

$$\frac{P_X}{P_Y} = RPT(X \text{ for } Y).$$

Taking the summation of the first two equations equals:

$$MRS_A + MRS_B = \frac{\alpha P_X}{P_Y} + \frac{(1-\alpha)P_X}{P_Y} = \frac{P_X}{P_Y}$$

This is equal to the rate of product transformation for the producing firm, which is the optimality condition as shown previously. Unfortunately, the fatal weakness in this approach rests with the taxing agency's ability to discover each person's preference for tax share ( $\alpha$ ). It has been asserted that this inability to develop a means for discovering true preferences is the sole reason for the breakdown of a joint cost sharing and optimal allocation Lindahl-type solution (McGuire and Arron, 1969).

Later, Samuelson (1954) investigated the optimal public expenditure on the provision of collective consumption goods. He defined collective consumption goods as being purely non-rival. After defining utility (U), production (F), and social welfare (U) functions, Samuelson was able to easily establish the optimality conditions for provision of private and collective consumption goods. These consisted of a Pareto optimal utility frontier,

$$\frac{MU_j^i}{MU_r^i} = \frac{F_j}{F_r},$$

a public expenditure on collective consumption goods condition,

$$\sum_{i=1}^s \frac{u_{n+j}^i}{u_r^i} = \frac{F_{n+j}}{F_r},$$

and a social welfare condition,

$$\frac{U_i u_k^i}{U_q u_k^q} = 1$$

where the lower case  $u$  represent an individual's utility function.

The social welfare function is defined to be consistent with society' ethical preferences for all possible allocations. While the first two equations define an infinite

set of points, it is the third equation that is necessary for a unique solution and this is where the problem lies.

A benevolent government can theoretically solve for the optimal allocation of collective goods and the appropriate taxes to pay for them (Samuelson, 1954). This exercise requires that people disclose their true preferences regarding the collective good, so that taxes can be adjusted until the social welfare function is maximized as a result of individual consumption decisions. However, the free rider problem will prevent optimal taxes from being established, as people will be unwilling to disclose their true preferences. This result makes it impossible for the optimal allocation of collective goods to occur within a *laissez-faire* market.

The characteristic of non-excludability further prevents an optimal allocation of public goods. Excludability allows a supplier to capture the benefits of providing a good because only payers are able to enjoy the good. Without excludability, people can enjoy the good without paying. Since, a private firm will not usually provide goods unless there is a positive revenue flow at least covering their variable costs, they will not have an incentive to provide a public good. Provision of public goods is usually left to governmental or group organizations (Pearce, 1994). This author believes that these organizations will be acting under different objectives than the standard profit maximization rule, such as provision of a good for humanitarian reasons. However, the important point is that public goods may not be allocated in an optimal manner within a private market. It is fundamentally important to distinguish the nature of a good when addressing the problem of allocation.

## **2.7 Extensions to Standard Welfare Theory**

It has been shown that a market system will not allocate a public good optimally based on an efficiency criterion. The difficulties with measuring changes in welfare from resource reallocations were also thoroughly reviewed. For a practical application, a partial ordering using willingness to pay measures is the best one can hope for if the goal is to arrive at an ordering of social states. A considerable gap in modern economic theory exists concerning welfare measures for those in poverty. This difficulty is caused by the divergence in the marginal utility of income with the ability to pay implied by willingness to pay measures usually used as an estimation of utility. Therefore, the standard theories do not reflect an accurate ordering of social states. Furthermore, even if the measurements were accurate, the Pareto criterion does not offer any guidance as to an order along a frontier.

The rest of this chapter moves away from aggregate measures and examines individual decision-making in under conditions of poverty and risk. The motivation for analyzing individual behavior is an attempt to overcome problems of aggregation that hinder an effective analysis of non-efficiency goals. The next two sections review the work done that addresses utility below a poverty line or subsistence level. The final three sections examine the issue of risk in decision-making. These sections will describe the theory behind the approach proposed for this study.

### **2.7.1 *Utility and Poverty***

Utility has been established as a conceptual measure of an individual's level of welfare. Of concern to this study is how utility behaves when poverty is introduced. The divergence in marginal utility of money between rich and poor people has long

been hypothesized (Marshall, 1948). This divergence in marginal utilities has also been tied to food when a person remains hungry in a given state (Pigou, 1951). Essentially, if utility is created from the satiation of needs and needs are more profound for the poor, then the marginal utility of additional income is greater for the poor.

The issue of utility below a poverty line has largely been ignored or only superficially addressed in the literature. One explanation for this lack of attention is the view that below a subsistence level of consumption utility would not exist. This is because a consumption bundle that could not sustain life could not sustain pleasure (Davies, 1994). Other approaches simply allow utility at or below some minimum consumption level to equal zero (McGregor, 1998). However, if utility below the subsistence level did not exist or were zero, then once a person slips below the subsistence level, there would be no incentive to try to escape. This is because there is no positive marginal utility to be gained, which seems an unlikely case.

A study by Coles and Hammond (1995) constructed a general equilibrium model that allowed for non-survival of participants unable to attain a minimum food consumption bundle. In the Coles and Hammond study, market participants were assumed to hold the preference that below some minimum consumption level, “more food is always preferred to less food” (Coles and Hammond, 1995). However, that was the limit of their investigations into the behavior of people living below the minimum consumption level.

A significant offering is given in two papers that utilize a compound utility function, where moves above a minimum level of consumption of some bundle of necessary goods allow for a jump in utility. This utility jump is based on achieving a

minimum consumption of the bundle of necessary goods that allows one to more fully participate in social activities (Lewis and Ulph, 1988); (Rizzi, 1990). That is, a premium is available to those able to move above the poverty line and more fully participate in society's activities. The minimum consumption level of the bundle of necessary goods is defined so that the benefits of attaining it are "so great that a deprived individual would be willing to sacrifice all other discretionary consumption to acquire them" (Lewis and Ulph, 1988). It is also explicitly stated that consumption choices always include two goods, one being the necessary good. This is justified by the condition that all consumption is above the subsistence level. While, the overall purpose of the paper was to derive separate measures of inequality and poverty, it is significant in its offering as a theory involving behavior and poverty.

The current study is primarily concerned with utility below a poverty or subsistence level where existence is no longer assured. It should be noted that poverty and subsistence are not identical definitions, however, both are standards of living that are at or below a level of guaranteed future existence. For the purposes of this study, poverty or subsistence are regions delineated on one side by some minimum level below which a deprived individual would be willing to sacrifice all discretionary income in an attempt to rise above the minimum level. Within this region, more of the critical good is always preferred to less. The definition of the poverty line is not based on the good, but rather on the intent of the economic agent to reach it. Another important departure from most previous studies is that positive utility levels exist below the threshold level. This is consistent with the approaches of Coles and Hammond

(1995) and Lewis and Ulph (1988) that more of the necessary good is always preferred to less, regardless of whether the agent survives.

### ***2.7.2 The Utility of Poverty Graphically***

The section presents a graphical representation of the proposed theory of utility below poverty. Poverty has a definite effect on marginal utility below a poverty or subsistence line. The possibility that indifference curves below poverty might be less than well behaved has been long been suggested (Hicks and Allen, 1934). The effect is similar to the difference in marginal utility between rich and poor people as suggested by Marshall (1948). It is proposed here that below the poverty line, the desperate need to consume more of the necessary good results in a marginal rate of substitution that approaches infinity between any other goods and the necessary one. The effect is demonstrated graphically below.

In Figure 2.9,  $U_1 \dots U_4$  are indifference curves corresponding to higher levels of utility<sup>1</sup>. The horizontal axis represents good X, which is the necessary good. The poverty line is defined as that level of consumption that below which future existence falls into doubt and a person will sacrifice consumption of all other goods to obtain more of the necessary good. The vertical axis represents the bundle of goods, Y, that are not necessary for survival.  $I_1$  and  $I_2$  represent two budget constraints. For any budget, insufficient to raise the consumer above the poverty line then the necessary good is chosen exclusively. Only above the poverty line does a tradeoff between essential and non-essential goods begin to occur.

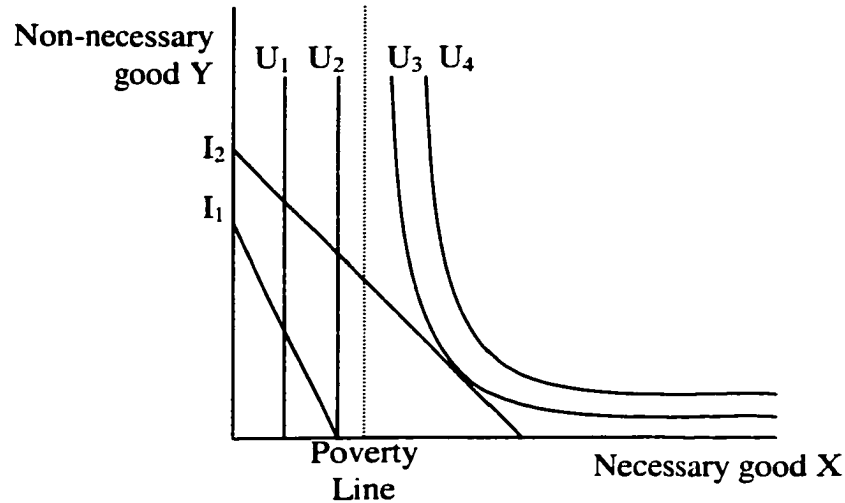


Figure 2.9 Behavior of Indifference Curves Above and Below a Poverty Line.

### 2.7.3 Implications for Equilibrium Conditions

The model of utility holds significant implications for the generally accepted equilibrium conditions. As shown in the graph above, below the poverty line the marginal utility of extra consumption of the necessary good  $X$  approaches infinity. Solving the problem as a constrained maximization problem using the Kuhn-Tucker conditions yields the following solution:

$$\frac{\partial \ell}{\partial X} = \frac{\partial U}{\partial X} - \lambda P_x = 0; \quad X > 0; \quad X \left( \frac{\partial \ell}{\partial X} \right) = 0$$

$$\frac{\partial \ell}{\partial Y} = \frac{\partial U}{\partial Y} - \lambda P_y < 0; \quad Y = 0; \quad Y \left( \frac{\partial \ell}{\partial Y} \right) = 0$$

$$P_y > \frac{MU_y}{\lambda} \quad \text{and} \quad P_x = \frac{MU_x}{\lambda}$$

---

<sup>1</sup> Although drawn perpendicular, the indifference curves  $U_1$  and  $U_2$  may be defined as convex in order to derive more well behaved mathematical solutions.

$$\frac{MU_X}{P_X} > \frac{MU_Y}{P_Y}$$

The last equation shows that on an individual basis, more of the necessary good  $X$  is always desired below the poverty line at the complete expense of the non-necessary good  $Y$ . It is also a violation of the fundamental condition of consumer equilibrium, which requires the two proportions to be equal for interior solutions (Samuelson, 1973). If the marginal utility is infinite, then it is always desirable to reallocate resources so as to help move people above the poverty line. The next section examines the topic of risk.

## **2.8 Risk, Utility, and Resource Allocation Decisions for Individuals**

Another complication with allocation problems is that economic decision-making is often faced with risk or uncertainty. Risk is the condition where outcomes are known and undetermined. Uncertainty is the condition where outcomes are unknown and undetermined (Knight, 1957)<sup>2</sup>. Probabilities of risky outcomes can be either subjective or objective. Subjective probabilities are placed on the alternative outcomes by the decision-maker (Pearce and Nash, 1981). Flood protection projects involve an inherent amount of risk. For this study in particular, risk associated with agricultural production activities will receive particular focus. For people living at or near the poverty line, there is an extreme vulnerability to negative variations in income. If income falls below some crucial level, it may become impossible to meet basic living needs.

---

<sup>2</sup> While some texts also include probabilities in the distinction between uncertainty and risk (Knight, 1957), others do not, claiming that decision makers have to make judgments of the probabilities in every situation (Upton, 1987).

The primary method to examine the incorporation of uncertainty in decision-making is through expected values. The expected value is the sum of the products of the possible outcomes and their probability of occurrence. In other words, the expected value is simply a weighted average. The decision criterion is simply to pick the highest expected value (Pearce and Nash, 1981). However, a preferred approach is to incorporate some measure of the variation in possible outcomes.

If a person is confronted with two options, one uncertain and the other certain, the person will weigh the expected value of a risky option against the definite return of the certain option. The chosen option will reveal whether a person's risk preference is averse, neutral, or loving. A person who is risk-averse will choose options with certainty that are valued less than the expected value of the risky option (Ray, 1998). The risk-averse person prefers a certain outcome to a risky outcome with a higher expected value. That is, the person is operating not to maximize expected profits, but to maximize utility (Pearce and Nash, 1981).

The concept of risk aversion can be demonstrated through expected utility when marginal utility diminishes as income increases as shown in Figure 2.10 (Ray, 1998). In this graph, the point  $Y^E$  is the expected value of  $Y$  with possible outcomes  $Y_1$  and  $Y_2$ . The position of  $Y^E$  is determined by the relative probabilities of  $Y_1$  and  $Y_2$ . As a certain outcome, however, the value of  $Y^E$  is  $U(Y^*)$ . Therefore, the utility value for a certain outcome is higher than for expected utility of a gamble of  $Y_1$  or  $Y_2$ .

### ***2.8.1 Individual Decision-Making under Risk***

Theories that consider decision-making in an agricultural setting include satisficing, lexicographic ordering, and maximization of utility (Upton, 1987).

Satisficing is akin to goal setting. Production decisions are based on meeting a goal. There are, however, no criteria for the optimization of the production decisions and

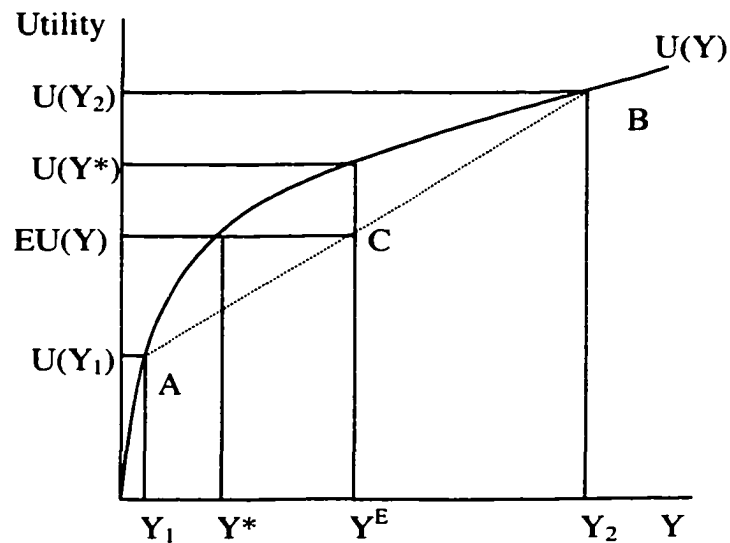


Figure 2.10 Expected Utility of a Risk Averse Person. A certain  $Y^E$  has a higher value,  $U(Y^*)$ , than as an expected outcome,  $EU(Y)$  for a gamble of  $Y_1$  and  $Y_2$ .

therefore, evaluation of alternatives. Lexicographic ordering is similar to ordering preferences in a manner similar to the organization of a dictionary. Again, production decisions are guided by goals. However, there are now higher and lower priority goals. Once all high priority goals are met, production is guided toward meeting secondary goals. This type of approach was used to study individual decision making regarding flooding in the Republic of Korea (Kim, 1989). The motivation for using the lexicographic approach was to account for the lack of information that individuals possessed regarding flood hazards. This does not apply to the present case because decisions are being made by a central planner with knowledge regarding the hazard

probabilities. Additionally, the lexicographical approach requires significant survey data to be collected, which is not always practical or possible in a developing country. Another decision-making theory is expected utility maximization, which has been discussed previously. Despite its complications, utility theory in cardinal form has been used in welfare economics to analyze choices under risk (Harsanyi, 1953).

Risk enters into agricultural production decision-making in three ways; uncertainty regarding environment and associated impacts on yield, uncertainty regarding price fluctuations, and information gaps (Upton, 1987). The general concern is that fluctuations in income are not desirable; especially the closer one is to a minimum subsistence level (Miracle, 1968). Two components influence a person's risk attitude. The first component is the person's wealth level and the second is the diversification of earning sources (Ray, 1998). The fewer income options a person has and the lower their income the more vulnerable they are to negative income fluctuations.

Several methods for considering decision-making under risk include the mean-variance criterion (Markowitz, 1952), the expected utility maximization criterion (Boisvert, 1972), and the safety-first criterion (Roy, 1952). The mean-variance criterion utilizes both the expected value and the variance of the outcomes. Variance represents the risk associated with an event (Nicholson, 1995). The value of final wealth is a function of both expected value and variance. While simple to use and intuitively appealing, most people judge a risky situation either by its potential upside or its potential downside effect on their final wealth. That is, the mean variance criterion

“gives equal weight to both positive and negative deviations” from a lottery’s expected value (Eeckhoudt and Gollier, 1995).

### **2.8.2 Safety-first Rules for Farmer Decision-Making**

Safety-first criteria are concerned with the possibility that an uncertain return will fall below some designated threshold of minimal acceptability. This risk is often expressed as a probability statement in the form:

$$pr\{x \leq t\} \leq \beta,$$

where  $x$  is the return,  $t$  is the minimum threshold, and  $\beta$  is the acceptable probability limit of failure (Bigman, 1996). The minimum threshold is alternatively referred to as the safety threshold or the disaster level.

There are three approaches to incorporating a safety-first constraint into economic decision-making. The approaches are to minimize the probability,  $\beta$ , of the return falling below the safety threshold (Roy, 1952), to maximize the expected return,  $x$ , given acceptable level of risk (Telser, 1955), and to maximize the safety threshold,  $t$ , for a given failure probability (Kataoka, 1963).

The safety-first criterion assumes that the decision maker judges the alternative strategies as to whether they exceed a threshold, below which final wealth must not fall (Eeckhoudt and Gollier, 1995). This type of criteria has been shown to be a good model for decision-making by subsistence farmers (Sands, 1989); (Ellis, 1998). For this criterion, rather than variance, a semi-variance is incorporated into the decision model. The variance is examined only from the lowest possible bound on final wealth up to the threshold level. The semi-variance is then incorporated into the evaluation of the alternative strategies, which are valued by:

$$V(w_f) = E(w_f) - k\sigma^{2-}(t)$$

Where,  $V(w_f)$  = the value of final wealth adjusted for risk preference,  
 $E(w_f)$  = the expected value of final wealth for a given state of the world,  
 $k$  = a measure of risk aversion,  
 $\sigma^{2-}(t)$  = semi-variance of possible outcomes below the threshold.

The values of the alternative strategies are compared and the one with the highest value is chosen. The obvious question concerns whether this allocation decision rule will lead to an optimal outcome that is economically efficient.

The variable  $k$  can assume any value. If  $k$  equals zero, then the decision maker is risk neutral. For positive values, the decision maker is risk averse and gives greater weight to the negative deviations than to the expected value of the possible outcomes. The values of alternative strategies are compared and the strategy with the highest value is chosen.

A widely adopted approach for incorporating the safety-first semi-variance is through the use of lower partial moments. This approach is useful when the distribution of the potential outcomes is asymmetrical (Bigman, 1996). Fishburn (1985) defined a general class of lower partial moments given by:

$$\rho(\alpha, t) = \int_{-\infty}^t (t-x)^\alpha f(x) dx$$

where,  $t$  = the threshold,  
 $x$  = the final income  
 $f(x)$  = the probability of some outcome occurring, and,  
 $\alpha$  = some constant greater than zero.

Fishburn proved that for  $\alpha \geq 1$ , the solution will be a subset of a second-degree stochastically dominated set (Fishburn, 1977). For all  $\alpha \geq 2$ , the solution will be a subset of a third-degree stochastically dominant set. The lower partial second moment measures the variance only over the range from negative infinity to the threshold (rather than the mean) and the variance is expressed relative to a threshold rather than an average income. Lower partial moments can provide a sharper upper bound on the probability of disaster, thereby avoiding the more conservative results of other techniques.

The primary criticism aimed at safety-first models is their general inconsistency with utility theory (Bigman, 1996). Boisvert (1972) demonstrated that for any optimal point chosen by a utility maximizing individual, a unique threshold or a unique probability can be determined. Therefore, if a person following Roy's criteria adopts that threshold, or a person following Kataoka's criteria adopts that probability, then they will choose the same portfolio as the utility maximizing person. However, when working backwards from a safety-first solution to utility maximization, there are an infinite number of utility functions that would yield a solution identical to the safety-first solution. Further, since a person following Telser's criteria must choose two decision parameters, there is also no unique relationship between the expected utility and Telser's criteria (Boisvert, 1972).

Boisvert prefers the use of expected utility maximization to safety-first criteria because expected utility maximization is consistent with both economic theory and observed behavior. However, in practical application Boisvert's approach has a major weakness concerning tractability. Boisvert, by his own admission, relates that each

utility function must be determined uniquely for each person. The results of one solution may not be generalized to a broader group, whereas, using the minimum- $\beta$  approach, the safety threshold can be broadly established, allowing a much more tractable and general solution.

Sen (1995) proposed that resource allocations could be more effectively judged by enriching the information base upon which we make decisions (Sen, 1995). Sen's approach called for the admission of non-utility information and an allowance of interpersonally comparable utilities. In light of the risk and poverty involved with the current study setting, it is proposed that projects be evaluated based on traditional theories. Projects that meet the potential Pareto criterion will then be evaluated using a safety-first criterion for benefits accruing to the target group. This will allow an ordering that is consistent with national goals (the decision maker's value judgments). The next chapter examines the theory and methods of cost-benefit analysis. It also examines the methods proposed and used to incorporate distributional goals into project analysis.

## **CHAPTER 3: COST-BENEFIT ANALYSIS**

### **3.1 Cost-Benefit Analysis: Applied Welfare Economics**

Cost-benefit Analysis is the practical application of welfare economics. Cost-benefit analysis has been described as a formalization of a “common-sense concept of rationality” in the sense that people will weigh, even informally, the benefits against the costs of making some investment” (Pearce and Nash, 1981). In a social setting, cost-benefit analysis represents a collective rationality based on money votes concerning alternative allocations. Cost-benefit analysis attempts to estimate a numerical calculation of net social benefits resulting from alternative states (Mishan, 1980). Analysis results are then used to judge whether a reallocation of a nation’s resources represents an improvement over the base case and if it is the best reallocation among possible alternatives. Typically, cost-benefit analysis is conducted by simply adding up total money costs and benefits with no concern of distributional issues (Boadway, 1974). This is reflected by the tendency of economists to focus on the efficiency issue at the expense of equity in applications of cost-benefit analysis (Blue and Tweeten, 1997).

The traditional cost-benefit analysis technique is based on two underlying values. The first is that individual preferences matter and the second is that the current income distribution is appropriate for estimating dollar weights for calculating net benefits (Pearce and Nash, 1981). In addressing the ethical grounds on which the

efficiency criteria might be justified, it has been argued that cost-benefit analysis precludes consideration of other goals such as equality or distribution (Gillroy, 1992). Gillroy (1992) argued that cost-benefit analysis as a policy appraisal tool is based on the assumption that welfare improvements imply preferences and consent of the individual. However, individual preferences and consent cannot be defined by the potential Pareto criterion, leaving cost-benefit analysis without a solid ethical justification. If non-efficiency goals are important, then they will have to be considered in a different context, or risk being reduced to efficiency goals because of the assumptions inherent in cost-benefit analysis.

### ***3.1.1 The Basic Concept Behind Cost-Benefit Analysis***

Cost-benefit analysis is a technique used to compare and rank alternative resource allocations through the calculation of a single measure of the effects of alternative allocations (Londero, 1996). This requires that a decision be made regarding the methods of measurements, comparison, and judgment for alternatives (Londero, 1996). The previous chapter on the economic theory underlying cost-benefit analysis established that it is deemed desirable that social welfare should be a function of individual welfares. It was also established that theoretically there are difficulties in aggregating these individual preferences. Because of problems with measuring utility, welfare economics has moved to measures of valuations of benefits and away from measures of utility. This was a result arising from the fact that utility may not be interpersonally and cardinally measurable. Further, compensation tests were adopted which allow additive, aggregate measures of net benefits to be made. This brings us to

applied welfare economics or cost-benefit analysis. This section will examine the mathematical construction behind cost-benefit analysis.

### ***3.1.2 Discounting of Future Net Benefits***

Cost-benefit analysis examines the effects of alternative actions over time. Therefore, it is necessary to use a method capable of making intertemporal welfare comparisons. It is generally assumed that a person prefers present consumption to future consumption. In order to cause a person to defer present consumption, a premium must be attached to income saved for future consumption. This is the idea behind interest rates. If one has  $X$  dollars in period one, then to defer spending until period two they must be paid some interest rate that will cause the value of the future consumption to become equal with the value of the present consumption. This can be shown as  $X_0 = X_1(1+i) = X_2(1+i)^2$  where  $X_j$  is the value  $X$  in period  $j$  and  $i$  is some interest or discount rate<sup>3</sup>. The implication is that the value of  $X$  in the present is diminishing at a constant rate the further off in time consumption is delayed. Equivalently, the value of  $X$  in any period  $j$  can be found in terms of the initial value of  $X$  given by:

$$X_j = \frac{1}{(1+i)^j} X_0.$$

This shows a person's discounting factor for consumption in any period as  $1/(1+i)^j$  and yields a value of  $X_j$ . The value  $X_j$  is termed the present value of  $X$  in dollars in period  $j$ . Discounting allows project benefits to be aggregated and evaluated, so that alternative

---

<sup>3</sup> The literature on the estimation of a "proper" discount rate is abundant, however, it is beyond the scope of this study to investigate this issue beyond the general concept. See (Lind, Arrow et al., 1982) and (Harberger, 1972) for discussions on this topic.

projects can be compared and a decision made. There are, however, several ways to calculate these decision criteria.

### **3.1.3 Criteria for Decision-Making among Alternative Projects**

It was shown in Chapter 2 that an acceptable measure of social welfare should be a function of individual welfares. However, because of difficulties in measuring and aggregating utility, welfare economics has moved to valuations of benefits. One of the most common decision criteria in cost-benefit analysis that meets these two requirements is the net present value.

The net present value is currently recommended by UNIDO, the World Bank, and the Asian Development Bank in making judgments about whether a given project presents an acceptable investment (UNIDO, 1978); (Squire and Tak, 1975); (Asian Development Bank, 1997). This concept is a simple extension of discounting. If a project is to yield  $B$  benefits and  $C$  costs in a given year  $t$ , then the net benefits are simply  $B$  less  $C$ , which will be designated as  $NB$ . If the project will create net benefits in a future period, we can compare the net benefits in both periods by using the present value of the future period's net benefits. If the project will create these net benefits for every year of the life of the project, then the present value of each period's net benefits can be summed together to give an intertemporal measure of the present value of total project benefits. This is termed the net present value and is the discounted stream of project costs and benefits. The net present value can be represented by the following equation:

$$NPV = \sum_{t=0}^N \frac{B_t - C_t}{(1 + \rho)^t}$$

where,  $\rho$  is the chosen constant discount rate and the project lasts for  $N$  years. The variables  $B$  and  $C$  represent aggregate costs and benefits in time period  $t$ , respectively.

The decision criterion for the net present value is that a project is deemed acceptable if it has a positive net present value. Projects with negative net present values should be rejected from consideration. When comparing different projects, the project with the highest net present value is the best project.

It can be seen from the above equation that the net present value is simply a summation of net benefits across society, unadjusted for the manner in which the net benefits are distributed. As long as at least one person gains enough benefit to outweigh the total costs, then the project is acceptable because it has a positive net benefit. This is simply an applied version of the potential Pareto criterion using benefit valuation rather than utility. The net present value is therefore, truly, a social welfare measure. However, it clearly does not embody any concerns over distribution of project benefits.

The major benefit of the net present value is that it yields a simple aggregate measure of all project effects. It is exactly this kind of measure that is implied by the potential Pareto criterion. As long as the marginal utility of income is the same for all people, then a positive net present value means that the gainers can at least compensate the losers so that no one is worse off.

The main disadvantage with the net present value is that a judgment of project acceptability is not connected to the distribution of benefits. Calculated using traditional cost-benefit methodology, the resulting net present value implies that the existing income distribution is the appropriate income distribution to use (Pearce and Nash, 1981). The net present value will allow a project that benefits everyone to appear

less favorable than a project that yields greater total net benefits, but only benefits a few individuals.

Another popular decision criterion is the internal rate of return. The internal rate of return is recommended in the classic texts for UNIDO and the World Bank (UNIDO, 1978); (Squire and Tak, 1975). Calculation of the economic internal rate of return was a required item for project work related to the current case study. This internal rate of return calculates a discount rate so that the net present value of a project becomes zero. The internal rate of return is found by solving the following equation for  $\rho$ :

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

where,  $\rho$  is now the internal rate of return (Harberger, 1972). The variables  $B$  and  $C$  represent the costs and benefits of the project in time period  $t$ , respectively and the project lasts  $N$  years. The internal rate of return can then be compared with some benchmark rate, for example the opportunity cost of capital, to see if a project is acceptable. If the internal rate of return is higher than the benchmark rate, then the project is acceptable. Alternative projects with rates of return at least as high as the benchmark rate can be compared for the highest internal rate of return to identify the most preferable project.

An advantage of the internal rate of return is that it presents project analysis results in a fashion with which investors are familiar (Schmid, 1989). The internal rate of return also has the advantage that it can be calculated relatively easily (Harberger, 1972). The primary disadvantage with the internal rate of return is one of uniqueness. If a project covers  $N$  time periods, there will be  $N$  roots, so that the interpretation of the answer may not be clear (Sassone and Schaffer, 1978). This is especially true in the

case where the flow of net benefits fluctuates between negative and positive values several times over the life of the project (Harberger, 1972). Finally, the internal rate of return may not be consistent with recommendations based on the net present value (Sassone and Schaffer, 1978).

#### ***3.1.4 Information Aid or Decision Tool***

The last section discussed the two most common investment decision criteria. The net present value was shown to be an additive measure of social welfare comprised of measures of individual benefits. Since, the measure is monetary it is both cardinal and interpersonally comparable. The internal rate of return is constructed in a similar fashion yielding a measure of return that can be compared to some benchmark rate. Therefore, both measures overcome the problems of ordinality and non-comparability. This has the advantage of allowing social decisions to be made regarding aggregations of individual welfare. However, using this measure of benefits implies that the marginal utility of income is identical for all people. This was shown to be an unlikely case in a developing country setting. The question is then, what information does cost-benefit analysis really convey and can results be used as a stand-alone decision criterion? That is, do cost-benefit analysis results offer a decision tool or an information aid?

Practically speaking, results would be relegated to an information aid. Most cost-benefit analyses are part of a feasibility study that contains several components, each used by the decision-maker in his decision making process. Theoretically, it has been shown that welfare economic theories do not allow for the incorporation of alternative or additional social goals except for allocative efficiency. If alternative

social goals are to be incorporated, then traditional cost-benefit analysis methods must be adjusted or augmented. Some of the questions concerning what information is really being conveyed by cost-benefit analysis can be answered by exploring issues involved with making the transition from theory to practice.

### **3.2 From Theory to Practice**

In moving from the theory of welfare economics to the application of cost-benefit analysis, some concerns must be addressed. One of these concerns involves a departure from the theory and one concern involves the acceptance of an important assumption. These concerns are discussed in the next two sections.

#### ***3.2.1 Moves towards Optimality vs. Optimal Allocations***

The theory of efficient resource allocations with potential Pareto improvements involves the determination of that allocation where it is impossible to further increase aggregate net benefits. The theoretical judgment of alternatives involves identifying Pareto Superior reallocations, that is, allocations where someone can be made better without making someone else worse off. When no Pareto Superior allocations remain, then an economically efficient allocation exists. Cost-benefit analysis, however, uses the potential Pareto improvement criterion to judge alternative actions. Therefore, cost-benefit analysis simply points in the general direction of an efficient allocation, but it does not help identify the efficient choice (Bentkover, Covello et al., 1986).

#### ***3.2.2 Reliance on Compensation Tests***

A final issue confronting the cost-benefit analyst is that standard techniques imply an acceptance of the compensation tests. As shown with the net present value and internal rate of return, cost-benefit analysis makes use of unity-weighted aggregate

measures of net benefits. This implies an acceptance of the Kaldor-Hicks Compensation Principle, which states that one state is to be preferred over another if the gainers from the move can compensate the losers for their losses and still be better off. Compensation tests allow the economic analyst to avoid making interpersonal comparisons of welfare. This fact combined with cost-benefit analysis' seemingly unambiguous results maintains its popularity as a tool for policy recommendations (Mandler, 2000).

Boadway (1974) showed that with the Kaldor-Hicks-Scitovsky forms of compensation tests that a positive sum of individual compensating variation was insufficient to satisfy the tests. Therefore, the compensation tests do not allow us to conclude that projects are potential Pareto improvements if a positive aggregate net benefit is calculated.

Another criticism regards the use of compensation tests as possibly being impractical. It is possible that the political process will restrict the available set of options so that Pareto improvements or Pareto optimal allocations are not feasible (Mandler, 2000). For instance, income redistributions from the rich may be impossible to realize if the rich hold substantial political influence.

### ***3.2.3 Willingness to pay as a Measure of Benefits***

The demand curve for a good has been equated with the marginal willingness to pay or marginal benefit function of a good (Freeman III, 1974). Marginal willingness to pay is measured as the value a consumer would be willing and able to pay at the margin for additional consumption of a good. The willingness to pay approach is often used as

an indirect measure to value non-market goods or attributes<sup>4</sup>. Willingness to pay measures are generally accepted as the appropriate benefit valuation of economic benefits for cost-benefit analysis.

The standard willingness to pay estimation procedures have been criticized for failing to account for rationing and supply acquisition policies (Mummy and Hanke, 1975; Hanke, 1981). When these policies are not accounted for, then an inconsistency develops between the evaluation and pricing criteria (Mummy and Hanke, 1975). Mummy and Hanke (1975) showed that if output were not rationed by a price equals marginal cost policy and benefits were equally available to all, then standard cost-benefit techniques would not guarantee the correct scale of the project. To correct this, Mummy and Hanke devised a modified investment criteria, where the proper investment level occurred when the average demand price equaled the marginal cost. Their approach is dependent upon demand being defined everywhere over all levels of output.

#### ***3.2.4 Goal of Government Policy and Project Appraisal***

Government policy, within the context of welfare economics, has the twin goals of distribution and efficiency. That is, the government must balance the efficient use of resources with what society deems is an acceptable distribution of income and benefits. Perfectly competitive markets will allocate resources efficiently, but may miss the target regarding equity. As such, government intervention will be required when markets fail to allocate resources in such a way that social goals are met.

---

<sup>4</sup> For example, willingness-to-pay techniques have been used to value reductions in air pollution (Freeman III, 1974), work place risk reduction (Herzog and Schlottmann, 1990), life and injury risks (Shanmugam, 2000), and flood hazard reduction (Driscoll, Dietz et al., 1994).

As discussed in Chapter 2, one such market failure is that of public goods. The dyke system analyzed in the case study is an example of a public good. Since, a dyke system is controlled by the weakest-link rule, it is important that all sections of the dyke meet design specifications, which may not be possible under a market system (Hirshleifer, 1983).

### **3.3 Impact of Cost-Benefit Analysis on Poverty Alleviation Concerns**

The traditional approach to cost-benefit analysis implies acceptance of a voting system where those with higher incomes have more voting power (Pearce and Nash, 1981). This is caused by the use of willingness-to-pay measures, which are market-derived values. While this is a convenient approach regarding the calculation of costs and benefits, it may not be consistent with social values, especially when poverty alleviation is a concern. As shown in the previous chapter, poverty holds significant implications for standard market equilibrium conditions. Therefore, markets may not be able to effectively allocate resources which impact poverty in accordance with social goals. Further, cost-benefit analysis is unable to adequately analyze flood protection projects when poverty alleviation is a concern. This section will describe the impacts that flood protection has on poverty and the impacts that poverty has on cost-benefit analysis. People with weak economic bases are most vulnerable to natural disasters (Albala-Bertrand, 1993).

Cost-benefit analysis techniques potentially offer policy makers a powerful method for rationalizing poverty alleviation projects (Buss and Yancer, 1999). Unfortunately, the evaluative power of cost-benefit analysis is often diminished through political concerns. Buss and Yancer (1999) examined the role poverty plays on cost-

benefit analysis. They found that poverty is usually relegated to a low priority position, despite the fact that poverty alleviation is often stated as a primary motivation for development projects.

The low priority status that poverty alleviation receives in cost-benefit analysis was determined to be caused by four main reasons (Buss and Yancer, 1999). All are directly related to beliefs held by policy makers. First, policy makers believe that maximizing economic returns from a development project will allow the local economy to adequately provide for the poor. Second, policy makers often consider growth and equity to be incompatible goals. Third, wealth redistribution plans hold potentially negative political consequences. Fourth, poverty reduction is seen as the responsibility of the government.

Poverty alleviation concerns may also be adversely affected by the improper execution of cost-benefit techniques. Potential problems in cost-benefit analysis include an inadequate comparison of alternative projects, a lack of analysis on opportunity costs, influence of sunk costs, and concentrating on before-and-after project baseline comparisons (Buss and Yancer, 1999). These problems will impact the net benefits calculation. Specifically, in regard to poor people the failure to include opportunity costs is the cost-benefit analysis “practice most hurtful to poor people” (Buss and Yancer, 1999). This is because poor people are most often excluded when forgone benefits are not considered. Sunk costs of a project can influence project appeal because of the potential political fallout from abandoning expensive projects. This can harm poor people by favoring projects that are not likely to ever be beneficial to the exclusion of projects that are potentially helpful for the poor.

Probably the most significant impact poverty has on cost-benefit analysis comes from the use of willingness to pay estimates to measure project benefits. Hicks and Allen (1934) point out that an individual's demand for a good depends on the prices of all commodities and on income. Therefore, demand is based on ability to pay, which ignores the possibility that the value in use may exceed the market price. If demand represents willingness to pay, then it must be that cost-benefit analysis will estimate willingness to pay on the assumption that a dollar holds equal value for the poor and rich. The implication is that standard cost-benefit analysis will penalize those segments of the population that are unable to afford to purchase the benefits. Therefore, if money measures of consumer surplus cannot guide action, then it may be necessary to incorporate measures of the marginal utility of money into cost-benefit analysis (Boadway, 1974).

In the related context of famines, it has been argued that a *Laissez-Faire* policy may be inadequate for food when situations of scarcity arise (Rashid, 1980). This is in direct contrast to the normal assumed welfare and efficiency maximizing operations of a competitive market. This conclusion was based on two conditions. First, it was recognized that if a person held inadequate means to purchase a subsistence bundle of food, then market forces would "doom him to starvation" (Rashid, 1980). Second, it ascribed to an old welfare principle that no law could be above the subsistence of the people. The cause of the poor market operations is a lack of information regarding the scarcity. Suppliers, anticipating a higher future profit, would withhold delivery of their crops, further compounding the perceived magnitude of the scarcity.

### ***3.3.1 Impact of Flood Risk Reduction on Poverty Alleviation***

Flood Protection projects reduce the risk of loss, which is measured as a gain in expected income. People with weak economic bases are the most vulnerable to natural disasters (Albala-Bertrand, 1993). Reduction of risk is, in general, beneficial for any risk-averse producer (Upton, 1987). This is because a reduction in risk boosts utility as well as freeing a producer to concentrate on the maximization of profits. Additionally, the minimization of risk as an obstacle to innovation is essential for agricultural and rural development (Todaro, 1996).

### ***3.3.2 Impact of Risk and Uncertainty on Cost-benefit Analysis***

Risk has often been examined in regard to decision-making by poor farmers. Risk in decision making is extremely important in the context of examining farmers who are at or near subsistence. In the case of negative impacts on a farmer's production, the farmer's objective may not be one of profit maximization, but maximization of chances for survival (Todaro, 1996) as below the subsistence level, the marginal utility of income approaches infinity (Blue and Tweeten, 1997). This can pose substantial problems for analyzing the economic costs and benefits of people near or below the poverty line.

If one were to adjust cost-benefit analysis to incorporate risk, it would seem that the easiest approach would be to subtract the expected value of the costs of bearing risk from the initial non-risk calculation of net benefits. These costs would be discounted in a similar fashion as to the other costs and benefits (Pearce and Nash, 1981). The real difficulty lies in the estimation of the costs of bearing risk. The estimation of risk

values has been shown to be accomplished through the use of utility functions, which are difficult to specify.

### ***3.3.3 Impact of Poverty on Cost-Benefit Analysis***

Some believe that the identification of a Pareto optimum does not require that any value judgment be made regarding the resulting distribution of costs and benefits (Londero, 1996). Others argue that the Pareto criteria implicitly implies acceptance of a unity-weighted net benefit function (Brent, 1990). The standard benefit measure is based on existing income and asset positions, therefore alternative projects will favor those areas where the highest production and asset values are held regardless of who holds them. This is especially true with flood protection projects. Further, there will be infinite Pareto optimal points corresponding to the possible resource allocations. The implication is that the Pareto criterion does not help in identifying the preferred allocation of resources if anything other than the efficiency criteria is considered.

### **3.4 Incorporating Poverty Alleviation Concerns into Cost-benefit Analysis**

If poverty alleviation is a goal in addition to efficiency, then the analyst must address the issue of how poverty alleviation concerns can be incorporated into the project appraisal process. There have been several proposals to incorporate non-efficiency goals into cost-benefit analysis such as poverty impact ratios (Asian Development Bank, 1997), a point system (Clements, 1993), benefit weighting (Buss and Yancer, 1999), and enriched information sets (Sen, 1995). All of these approaches have weaknesses, especially within the context of flood protection projects. The rest of this chapter discusses these alternative approaches in addition to the proposed use of a safety-first rule.

### **3.4.1 Poverty Impact Ratio**

The method for analyzing impacts of projects on poverty alleviation suggested by the Asian Development Bank is the Poverty Impact Ratio (Asian Development Bank, 1997). The Poverty Impact Ratio analyzes the impact that a project has on the poor in the following way. First, an analysis of the distribution of net economic benefits to different groups of beneficiaries is conducted. Second, the distribution of the difference between economic and financial costs and benefits needs to be determined. Financial costs are costs incurred by and analyzed from the point of view of the operating entity, whereas economic costs are costs incurred by society. The Poverty Impact Ratio is calculated as the ratio of the share of net economic benefits to the poor to the total net economic benefits of the project. The Poverty Impact Ratio can be used to demonstrate that the impact of a project on the poor is to a higher proportion than other groups.

One problem with using a Poverty Impact Ratio in a flood protection project is that benefits are measured in terms of protected assets and production. Project benefits will accrue to richer people to a greater proportion than poor people who own fewer assets. This is a result of the manner in which flood benefits are estimated. If one person has twice as many assets as another person, but both suffer a 20 percent loss of assets from flooding, then the richer person will receive more benefit from a flood protection project. For this reason, the poverty impact ratio approach has limited appeal for the current case study.

### **3.4.2 Point-Cost and Cost-Effectiveness Analyses**

A point system offers another approach to cost-benefit analysis. This approach is based on a practical application of cost-benefit analysis. In this approach, points are assigned based on some definition of poverty, transforming the analysis into a cost-points analysis (Clements, 1993). Essentially, the best project is the one that delivers the most points for the least costs incurred.

The advantages of the point system approach are that points are assigned throughout the life of the project encouraging commitment from the supporting staff. A lack of staff commitment has been identified as a major detriment to project success in practical applications (Clements, 1993). This approach is also egalitarian, in that points compare identically for improvements above a given starting point. Extreme poverty can be factored in by assigning more points to those cases.

The disadvantages are in deciding on the definition of poverty and on how points would be assigned in a consistent and meaningful manner. Since, total points count towards funding decisions, the incentive exists to overrate a project's success. This complaint, however, can be leveled at all project appraisal methods where the appraiser depends on the project being funded. The real difficulty, as Clements points out, is in the conceptualization of the point system. His final, and uncomfortable, conclusion is that mistakes made with a point system "are not likely to be worse than current practice" (Clements, 1993).

This approach is conceptually similar to a multi-attribute utility theory approach in that accurate financial measures are dispensed with in favor of achieving a given end (Anand, 2000). This approach is also akin to cost-effectiveness analysis, which has

been applied to basic needs. Cost-effectiveness has the advantage in that it avoids the difficulty of valuing benefits that can be quite difficult and controversial for non-market goods. Brent (1990) lists several difficulties with the cost-effectiveness approach. The first is that solutions may not be financially feasible. The second difficulty concerns the theoretical issue that cost effectiveness does not address private preferences, but only social preferences. Finally, if there is more than one basic need, cost effectiveness fails to lend guidance. That is, a basic needs cost-effectiveness analysis is limited to a single dimension.

### ***3.4.3 Weighting of Benefits across Different Income Groups***

The most common method for addressing distributional concerns is that of benefit weighting. The Pareto approach is often given the status of offering a method of valuation that is “value free” (Lal, 1974). It has been argued that a non-weighted approach, the potential Pareto criterion approach, is simply a unity-weighted approach implicitly accepting the current distribution of income (Brent, 1990). Therefore, what is normally termed benefit weighting is really just making the value judgments underlying the weighting scheme explicit.

A justification given for the use of weights is that it will help avoid the administrative costs of redistributing benefits via taxes (Brent, 1990). Another justification is given by the alternative of leaving the weighting of benefits up to the decision-makers. The contribution of a project to different goals is derived from technical data, however, the value of these contributions to the goals is set by the policy makers (Tinbergen, 1964). In this case, it is generally believed that benefits will be weighted in an inconsistent and non-systematic fashion (Lal, 1974). However, the

most common reason is that benefit weighting helps to analyze a project from a policy objective point of view, for example, poverty alleviation.

However, the weighting of benefits may not offer any aid in choosing a unique project among alternative projects that fall on a possibilities frontier. This is because weighting simply creates a new frontier. The weighting system simply makes it easier to approve projects that meet government or social objectives. The effect of benefit weighting is shown in Figure 3.1 and may be compared to the potential Pareto improvement shown in Figure 2.2. Benefit weighting now makes alternative D acceptable because it benefits target group Y. However, it is still possible that project E is approved which benefits the non-target group at the expense of the target group.

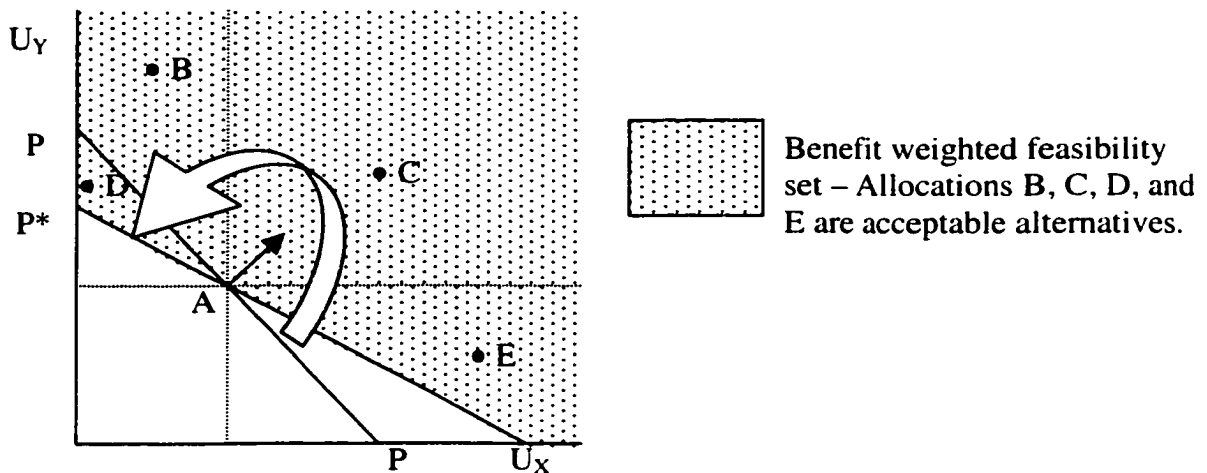


Figure 3.1 Rotation of Utility Possibilities Frontier caused by Benefit Weighting.

A typical method proposed for incorporating equity or distribution goals into the project analysis involves the use of weighting benefits across different target groups.

This is based upon the recognition that when income is not distributed equally, then monetary expressions of preference will be limited for those possessing less income. That is, the market accepts the divergence between ability to pay and willingness to pay (Brent, 1990). The most frequent criticism of weighting concerns the arbitrary and/or political methods used in determining the weights (Mishan, 1980).

There are several methods for determining the magnitudes of the weights including UNIDO (1972), Squire and van der Tak (1975) and Little and Mirrlees (1974). Squire and van der Tak's method is based on the idea that the key to economic growth is investment and that the government is the main source of investment in developing countries (Brent, 1990). Therefore, the Squire and van der Tak method seeks to weight more heavily those project benefits that are kept in the public sector. This assumes that private benefits will be devoted entirely to consumption and that the public sector is efficient at carrying out public investments. Their social valuation of project benefits is given by the following equation:

$$S = E - C(\beta - \omega),$$

which is essentially the net project benefits,  $E$ , less the value of private consumption converted to its real resource border price equivalent value (Brent, 1990). The beta conversion factor adjusts for market imperfections and is calculated as:

$$\beta = \frac{M + X}{M(1 + t_m) + X(1 - t_x)},$$

where  $M$  and  $X$  represent imports and exports, respectively. The  $t$  variables are the average tax applied to imports and exports as designated by their subscripts. The  $\omega$  is the parameter more relevant to this study.

The  $\omega$  variable is defined as the ratio of the marginal social value of private consumption,  $W_C$ , to the marginal social value of government resources,  $W_G$ , which are available for investing. To see how this addresses equity concerns, one can examine a particular income group and the group's associated average consumption level. By dividing both the numerator and denominator by the marginal social value of consumption at the average level of consumption,  $W_{C^*}$ , then the ratio is left unchanged, however, now a distribution tradeoff can be examined. The ratio becomes:

$$\omega = \frac{W_C / W_{C^*}}{W_G / W_{C^*}}$$

The numerator gives the relative value of the project's social value of private consumption for a particular group relative to the marginal social value of average consumption. The numerator captures the intragenerational distribution effects. The denominator is the social value of government resources relative to a particular group's social value of consumption, which represents the intergenerational investment and consumption tradeoffs. The ratio shows the tradeoff between raising consumption levels of the poor and increasing economic growth (Little and Mirrlees, 1974).

Another approach used by UNIDO differs from Squire and van der Tak's method in that the estimation of the weights involves an imputation approach. Essentially, estimates for weights are made based on previous government decisions. The weakness of this approach is that it may fail to accurately reflect current social goals and ethics.

A more relevant approach offered by Harberger (1984) to weighting addresses the basic needs of society. This approach proceeds from the point of view of social preferences for meeting society's basic needs. The willingness-to-pay estimates of

consumption are adjusted up by the assumption that the rich receive indirect benefits when the poor are able to consume more.

Social demand was defined as the summation of demand by the rich and demand by the poor. A basic needs gap was defined as the shortfall between demand by the poor and the basic needs target consumption level. The indirect benefits arise because, “the rich feel worse off the greater the gap” (Brent, 1990). Therefore, consumption by the poor becomes a public good. The value of basic needs below the target level is ratcheted upwards.

A closely related study makes the assumption that instead of consumption by the poor being valued according to the rich, the valuation is based on a social agent acting on behalf of the poor (Scandizzo and Knudsen, 1980). The social agent imposes a minimum consumption level ensuring that consumption does not fall below this level. Above the minimum level, consumption is guided by private preferences. The formulation of the compound demand is given by:

$$P < PR : D_a = 0, \text{ so that } D_s = D_p$$

$$P > PR : D_a = R - D_p, \text{ so that } D_s = D_a + D_p = R \text{ (Brent, 1990).}$$

Where,  $P$  is the price level

$PR$  is the price level where everyone can afford the basic consumption level

$D$  is the demand of the agent,  $a$ , social demand,  $s$ , or the poor,  $p$

$R$  is the minimum consumption level necessary for subsistence.

The graph of the social demand is given by line  $abc$  as presented in Figure 3.2 where all variables are defined as above. The interesting result of this approach is that at the minimum consumption level  $R$ , demand is vertical which lends an infinite weight to

additional consumption. This is consistent with the research findings of Blue and Tweeten (1997), where as income approaches zero the marginal utility of income approaches infinity. This can cause problems for determining weighting of costs and benefits for low-income people.

#### 3.4.4 Safety-first Valuation

The standard cost-benefit technique and the benefit-weighted approach do not offer guidance for alternative states where utility conflicts exist. Moves along a utility indifference curve, for instance, are by definition equally efficient, but possibly not equally desirable. In this sense, cost-benefit analysis cannot offer a complete ordering of alternative states (Boadway and Bruce, 1984). In order to gain more information to determine a more complete social ordering, a safety-first valuation of alternatives is proposed as an additional step in cost-benefit analysis of flood protection projects.

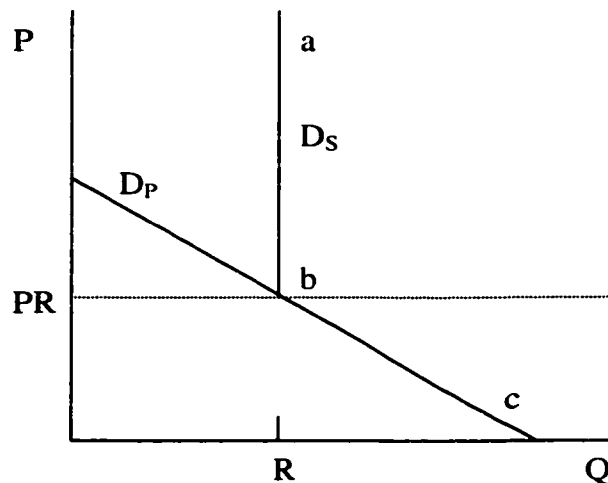


Figure 3.2 Social Demand for Basic Needs Consumption Level. A social agent exists who will augment any shortfall in private demand,  $D_p$  to create sufficient social demand,  $D_s$ .

The safety-first valuation can offer guidance as to the ordering of alternative states in accordance with a project's effect on some social goal. Use of a safety-first valuation is proposed in addition to the potential Pareto criterion for evaluating alternative projects. The safety-first valuation has been shown to be consistent with farmer behavior regarding risk, project goals of income vulnerability reduction, and national development goals of natural hazard mitigation and poverty reduction. It is further consistent with risk-averse decision-makers where people are concerned with minimizing the risk of experiencing catastrophic failure.

The strict use of the safety-first rule necessarily involves a tradeoff with strictly using the net present value or internal rate of return. The main tradeoff is a rejection of an aggregate measure in favor of a representative value of a member of the target group. However, the approach offered here is closer to a lexicographic approach. The lexicographic approach has been used to analyze flood protection in Korea (Kim, 1989). The idea behind the lexicographic approach is prioritized optimization of multiple objectives with the highest priority objective being met first. Then the second priority objective is addressed, and so forth to the lowest priority.

The approach proposed here would first ensure that an economically viable set of projects is assembled based on traditional cost-benefit analysis criteria. Then a safety-first rule will be applied to analyze the project's impact on the target group and on meeting national goals. A disadvantage of this approach is that the safety-first measure of the project does not involve an aggregate analysis. The benefit of this approach is that guidance will be lent as to the preferred project among projects that

have a similar value from the traditional cost-benefit approach. This is superior to the benefit weighting approach, which offers no guidance for equally valued projects. In the case where one acceptable project's net present value is higher than an alternative project's, but ranked lower according to the safety-first rule, then this approach offers no guidance as to the preferred project. However, the proposed approach offers an enriched information set that can be used by the decision maker.

## **CHAPTER 4: FLOOD PROTECTION BENEFITS: A REVIEW**

Flooding has been defined as, “the existence of excess water in an area or region such that normal activities in the area are either hampered or stopped” (El-Jabi and Rouselle, 1987). Flood protection projects lower the frequency of flood events occurring through the implementation of measures designed to prevent excess flows from reaching the protected area. The current case study examines the benefits arising from a dyke rehabilitation project in Vietnam. Following a review of dykes, this chapter reviews the estimation of flood protection in the United States and Vietnam.

### **4.1 Dykes**

A dyke is an embankment parallel to the flow of the river designed to provide flood protection from seasonal high water. A dyke is a suitable flood damage reduction option in the case where damageable property is clustered geographically (U.S. Army Corps of Engineers, 1996). Dykes are generally only subject to water forces for a short period of time, ranging from a few days to a few weeks per year (U.S. Army Corps of Engineers, 1996). A dyke provides flood protection by blocking channel overflow and thus reducing the flood stage in the protected area. In the absence of a physical failure, a dyke will prevent damage for flood stages that fall below the dyke height. Dyke overtopping occurs and damage is incurred when the flood stage equals or exceeds the dyke height.

Dyke failure can occur for a variety of reasons. In the Red River Delta of Vietnam, for example, increased risk of failure is attributable to poor foundations, rodent and termite induced voids in the dyke body, improper human activities adjacent to the dyke, and ponding of water in old borrow pits at the toes of dykes (Lustig, 1993b). Overtopping of the dyke is another form of dyke failure. The probability of failure of a dyke is based on the complex interaction of many factors including construction specifications and river height. The calculation of dyke failure probabilities is currently an imperfect and emerging science (Burrell, 2000)

#### **4.2 Estimating Flood Control Benefits in the United States**

The history of estimating flood mitigation benefits in developing countries has tended to follow political trends. In the United States before 1936, flood mitigation benefits were estimated based on the increase in land values and incomes. The driving motivation for estimating benefits during this time was project cost recovery (Shabman, 1997). In general, increases in the land value were predicted and a cost-benefit ratio was constructed. The local authorities then went about collecting an appropriate tax. Around the time of the Great Depression flood protection analysis de-emphasized cost-benefit criteria and, instead, justified projects on the need to stimulate national employment.

In 1936 and 1938, the U.S. Government adopted two flood control acts which shifted planning, construction, and financing responsibilities to the Federal Government. These acts declared that flooding posed an unacceptable threat to the national economy. At this point, estimates of avoided property damage became the preferred method for benefit estimation (Shabman, 1997). This change fit in with the

policy change concerning flood mitigation, as the reduction in flood damages was viewed as a catalyst for increased economic development and growth. In 1972, the property damage avoided estimate was accepted as a measure of willingness to pay.

Today, in the United States, growing opposition to the construction of new projects, and environmental and insurance concerns are encouraging the development of flood plain evacuation plans. Under these plans, flood prone land is bought away from the current owners, who move out of the floodplain. These plans rely on willingness to pay estimates of alternative land use in the floodplain more than on property damage avoided estimates<sup>5</sup>. In a pure sense, however, evacuation plans are not flood mitigation projects, but rather flood damage mitigation projects. Floodplain evacuation plans have extremely limited potential for application in Vietnam. In Vietnam, the Mekong and Red River Deltas represent about 15 percent of the total land area and are too densely populated to consider evacuation plans. In addition, while land use rights can be traded, this is a relatively new development and no often carried out in the Red River Delta. Thus, land use values will not be considered in the present study.

Currently, flood mitigation benefits are most often estimated using the property damage avoided approach (Young, 1996). This method is also recommended by the Principles and Guidelines issued by the U.S. Government for estimating benefits of flood hazard reduction projects (U.S. Water Resources Council, 1983), although, it makes provisions for changes in land use values. As stated above, land use values will not be considered in this study.

---

<sup>5</sup> Assuming flooding risks have a negative effect on land values, expected damages will be reflected in the land values. Therefore, estimating land value benefits of an evacuation project precludes property damage avoided estimates, as it would be a form of double counting.

Property damage avoided benefits are measured as the difference in real expected losses with and without the flood protection measure. The replacement and repair costs of structures that could be damaged are estimated for a range of flood water levels with and without the flood control measure. Each flood water level is weighted by its probability of occurrence, and then all flows are summed to estimate an expected annual benefit from the flood control measure. In order to estimate the net present value of the flood control measure, estimates are made for each year of the project-planning period, discounted by an appropriate rate, and summed. While developed countries continue to embrace more complicated and precise analytical techniques, developing countries continue to be hampered by data scarcities. The next section examines the estimation of flood control benefits in the country used for this study's case study, Vietnam.

#### **4.3 Estimating Flood Control Benefits in Vietnam**

A previous study of flooding in Vietnam examined the economic feasibility of a plan to upgrade the Red River dyke around Hanoi, Vietnam (Lustig, 1993a). In order to accomplish this analysis, expected damages from flooding were calculated for the affected area. Three specific sections of the dyke system were considered. Selection of the dyke section was based on previous studies that indicated what sections were at risk of being weakened by bank erosion in the river. In order to examine the degree of expected flood inundation if the dyke was breached, detailed calculations were made to derive the degrees of scouring and backwash in the study area. This allowed the extent of flooding to be more accurately tied to specific river floodwater heights.

Damage to households, commercial businesses, industry, and agriculture were estimated. Household and commercial assets susceptible to flood damages were based on a secondary survey conducted by the World Bank with adjustments made by Lustig (Lustig, 1993a). Losses to industry were divided between losses to plant and equipment, and losses to material and production. The difference being that plant and equipment losses were a one-time loss based on flood height and losses to materials and production were based on lost production time while recovering from a flood event. Potential losses to agriculture were based on existing crops and a percentage of the previous crop still in storage.

A percentage of assets damaged was assumed based on low flood water levels and high flood levels with one-meter flood water level acting as the separating point. Households, shops, and industries were further categorized by the elevation at which they were located. Damages were then calculated for a range of flood water elevations, weighted by the probability of occurrence. Summing the resulting damage values yielded an estimate of average annual damage from flooding. Estimates of damage for the historical flood of 1971 yielded an estimate of US\$ 393,200,000. The estimate for average annual damage in the study area measured US\$ 59,400,000.

Later in 1993, Lustig conducted a rapid assessment of flood mitigation strategy benefits for North and Central Vietnam (Lustig, 1993b). The main difference in approach from his previous study was the use of more simplistic calculations of asset values and extent of flooding. Lustig was interested in comparing the economic benefits for two systems of dyke management. The first system considered an improved dyke monitoring and repair system. The second system considered an

improved early warning and storage system. Surveys were conducted for several households in four districts within the Red River Delta that had suffered flood damages in the past. Results were then extrapolated to the entire Red River Delta. Data were collected on the monetary value of damage to houses, agricultural losses per household, and agricultural losses per hectare. Estimates of damage to houses ranged from US\$ 230 to 680. Agricultural loss estimates ranged from US\$ 1,300 to 6,520 per hectare. Agricultural losses were assumed to be US\$ 1,300 per hectare. Parameters about agricultural productivity and prices were developed to estimate values for losses from flooding.

Businesses were estimated to be 3 percent of households and suffer a 50 percent loss of inventory. Similarly, a 25 percent loss of plant and equipment relative to production was assumed to be the loss from flooding for industries. The period of disruption was estimated to be one month for a flood between 1 and 2 meters.

Data about population, industrial production, and agricultural area were combined with the prior assumptions in order to calculate maximum flood damage. In order to calculate an expected average annual damage estimate, probabilities for flooding and dyke failure were developed.

In order to derive failure probabilities, Lustig relied on interviews with dyke monitoring engineers in the Department of Dyke Management and Flood Control of the Ministry of Agriculture and Rural Development. Probabilities were given for estimates of dyke failure depending on river water heights. The engineers also gave estimates of percentage of area flooded following a failure of critical dyke sections. The failure probabilities were combined with the estimated area of damage and loss estimates based

on the economic structure of the region. Estimates of average annual damage amounted to US\$ 48 million under the then current system of dyke monitoring.

To demonstrate the benefits of a new dyke monitoring system, new probabilities of dyke failure were estimated by Lustig for the new dyke monitoring system. Using these probabilities, new expected annual damage estimates were calculated at US\$ 39 million.

It can be seen from the above discussion, that a new flood mitigation measure alters one of the probability functions associated with flooding. Either the flood frequency probabilities or the dyke failure probabilities are altered because of the project. Therefore, flood damage estimates are weighted by the differing probabilities and differenced in order to isolate the benefit from a particular flood protection measure (Young, 1996).

## **CHAPTER 5: BACKGROUND OF RELEVANT TOPICS IN VIETNAM**

### **5.1 Institutional Setting**

The institutional setting for economic decision-making in Vietnam has undergone many changes since 1986. These changes affect the manner in which flooding, poverty, and water resource management economic decisions are addressed. The following section reviews the policies, laws, and institutional setting in Vietnam regarding economic decision making for water resources.

#### **5.1.1 National Policies**

In broad terms, the most important change undertaken by Vietnam was the adoption of the *Doi Moi* (Renovation) policy. *Doi Moi* is a general concept of initiating policies aimed at economic liberalization which began in the late 1980s. *Doi Moi* initiated the move toward allowing a market mechanism to guide the allocation of resources. *Doi Moi* policies greatly aided the increase in the growth of Vietnam's economy, which experienced an average annual GDP growth rate from 1991 to 1995 of 8.2 percent (World Bank, 1995). The GDP Growth rate in 1997 was 8.2 percent, which slowed to 5.7 percent during 1998 as a result of the Asian financial crisis (General Statistical Office, 1999). Despite these impressive growth rates, however, poverty, remains a persistent and widespread problem in Vietnam.

Current Red River Basin economic development goals in Vietnam give priority for investment to the agriculture, forestry, and rural sectors. Basic aims are to increase

productivity through extension of credit, transfer of technology, improvement of processing, and construction of rural infrastructure. Land development policies include providing written certification of long-term land use rights to farmers for state owned land.

Poverty alleviation is one of the most important goals within the Red River Basin. Plans call for a reduction in the number of poor households down to 10 percent, from the current 19.6 percent (Asian Development Bank, 1999). The goal calls for the promotion of production and the creation of more job opportunities. Currently, the Government of Vietnam is formulating a poverty reduction strategy with the goals of creating opportunity, ensuring equity, and reducing vulnerability. Vulnerability to floods is a major obstacle to further development among the Red River Delta's rural poor. Other government policies for the Red River Delta include The Flood Protection Plan for the Red River Delta of November 1999 and the 2010 Water Resources Development Strategy, prepared by the Ministry of Agriculture and Rural Development's Department of Water Resources and Hydraulic Works Management.

In 1991, the Vietnamese government adopted a Socio-Economic Stabilization and Development Strategy to the Year 2000. Goals of the strategy include doubling per capita GDP, increasing daily caloric food intake, selecting infrastructure projects based on economic criteria, protection of the environment, and protection and proper use of natural resources (World Bank, Asian Development Bank et al., 1996). While the strategy is outdated, the core concepts will continue to guide Vietnam's development actions for the near term.

Also in 1991, the Vietnamese government approved the National Plan for the Environment and Sustainable Development. Among other things, the plan calls for the control of natural disasters such as flooding (Veilleux, 1994/95). To date, the success of this plan has been limited, because environmental goals of the plan often conflict with other national goals for developing the economy.

### **5.1.2 Institutions**

With respect to administrative bodies, the National Assembly is the highest level of authority in Vietnam. The National Assembly is responsible for passing national laws. The Government<sup>6</sup> is the executive institute of the country and is responsible for implementing the laws passed by the National Assembly. The Government fulfills responsibility through the issuance of decrees, circulars, and other laws.

The Ministry of Agriculture and Rural Development has the responsibility to manage the nation's water resources under Article 58 of the Law on Water Resources<sup>7</sup>. The Ministry is directly answerable to the Government and has been given the duty to develop water resource planning on a basin wide level. This ministry is additionally responsible for analyzing, evaluating, and building a database from results of surveys on the country's water resources. Under the Ministry of Agriculture and Rural Development are several departments with important and specific duties related to water resources and flood protection. The most important departments relevant to this study are discussed below.

---

<sup>6</sup> The Government is a term for a distinct division within the overall government structure. For the remainder of the paper following this section, however, the term government will refer to the entire administrative structure.

<sup>7</sup> The official translation of the Law on Water Resources was printed in Vietnam Law & Legal Forum, Cong Bao (Official Gazette), No. 21, July 31, 1998, pages 25-48.

The Department of Management for Water Resources and Hydraulic Works is responsible for developing plans concerning water availability, water balances, water resource development and conservation, water pollution, and management of water use. They have the additional duty of drafting laws, policies, and regulations concerning water resources. They are also responsible for aiding in the implementation of these laws.

The Department of Dyke Management and Flood Control is responsible for the construction and management of the dyke system and daily flood management. It is also responsible for drafting related laws, policies, and regulations. The Department of Dyke Management and Flood Control carries a high level of power relative to other departments in the Ministry. This is a result of the critical importance attached to their responsibilities.

In regard to flooding, there are two important national committees in addition to the relevant departments in the Ministry of Agriculture and Rural Development. The Central Committee for Storm and Flood Control is responsible for emergency response during storms; and the National Committee for the International Decade of Natural Disaster Reduction, which was established to increase capabilities in prevention of and responses to flood disasters (World Bank, Asian Development Bank et al., 1996). In addition, the General Department of Hydrometeorology, under the Office of Government, collects data on hydrology and meteorology. This general department is also responsible for making flood forecasts during the flood season.

The administrative boundaries in Vietnam are organized as follows. The national bodies represent the country as a whole. The next division is the province

followed in decreasing size by districts, communes and villages. Communes in the project area average about 600 hectares in size with a population of around 7,000 people.

### **5.1.3 Legal Setting**

The most important law related to this study is the Law on Water Resources which became effective in January 1999. Currently, efforts are being made to develop an implementation plan for the new law with the aid of international organizations, such as the Asian Development Bank, World Bank, United Nations, and other bilateral agencies.

The Law on Water Resources (1999) reserves ownership and management of water resources for the State. In general, the State policy is for “managing, protecting, rationally, economically, and efficiently exploiting water resources.” Article 5 of the Law states that use must be carried out in consideration of a basin-wide plan, development of water resources must be linked with the development and protection of the forests, and that water development projects must contribute to socio-economic development. Article 6 of the Law states that the users of water resources shall contribute manpower and finances to the building of works for the “protection, exploitation and use of water resources.” The Law also states that exemptions and reductions of the tax burden shall be granted for areas experiencing “difficult socio-economic conditions.” Rights granted by the Law include the right to use and benefit from use of water resources, the right to compensation for premature removal of water use rights, and the right to pursue legal recourse for violations of water use rights.

The law also provides a comprehensive legal framework for managing water resources. Water use must simultaneously meet use standards, protect the water resource, be developed in conjunction with the development of forests, work to prevent harm caused by water, contribute to socio-economic development, and ensure the life of the population. The national goals and the new Law on Water Resources demonstrate a desire on the part of the Vietnamese government to develop water resources in a manner that uses an integrated, basin-wide approach governed by economic forces.

#### ***5.1.4 Development Policies of the Asian Development Bank***

In line with the Asian Development Bank's overarching goal of poverty alleviation, the Asian Development Bank's emerging Country Operational Strategy in Vietnam emphasizes poverty reduction. Flooding in Vietnam presents an annual threat to the nation's poor and impoverished. Flood protection projects can reduce poor people's vulnerability to flood induced disasters.

As a project of the ongoing Asian Development Bank Project Loan No. 1344 VIE (SF) *Red River Delta Water Resources Sector Project*, this project is also guided by the Asian Development Bank's Policy on Water. The Water Policy calls for a more comprehensive and integrated approach to managing water resources. Approval of Asian Development Bank sector loans requires the Government to submit a sector investment plan, along with relevant sector policies.

## **5.2 Water Resources in Vietnam**

Ten river basins cover 80 percent of Vietnam's total land area, accounting for 70 percent of the annual flow. The Mekong River is the biggest contributor accounting for 59.2 percent of total annual discharge and the Red River is the second largest

contributor to total annual discharge accounting for 15.6 percent (World Bank, Asian Development Bank et al., 1996). Total annual discharge in Vietnam averages 879 billion cubic meters (31 trillion cubic feet).

Water resources in Vietnam are strongly influenced by the country's climate and topography. Strong monsoon rains dominate the climate in the summer, which can see rivers deliver 20 to 30 percent of their total annual flow in a single month. During the dry season, river flows can drop to 1 to 2 percent of the total annual amount for a single month. Average rainfall for Vietnam measures approximately 2,000 mm (78.74 inches) per year (World Bank, Asian Development Bank et al., 1996). These factors lead to the two largest natural hazards related to water resources in Vietnam, flooding and drought.

During the last century, Vietnam's watersheds suffered from widespread destruction of their forests and increasing intensification of shifting agricultural practices. Forest cover has been reduced from over 70 percent in the 1940s to less than 30 percent in the 1990s (World Bank, Asian Development Bank et al., 1996). This has greatly exacerbated the negative effects of flooding.

### ***5.2.1 Red River Basin in Vietnam***

The Vietnamese portion of the Red River Basin is located in the northern region of Vietnam as shown in Figure 5.1. It covers a total area of 169,000 km<sup>2</sup> (65,250 sq. mi.) with about half that amount lying inside of Vietnamese boundaries and the remainder lying within China. The Climate in the basin ranges from tropical to sub-tropical, dominated by three monsoon patterns during the year. Annual rainfall over the Vietnamese portion of the basin ranges from 1,200 mm to 4,800 mm (50 to 190 inches) (Binnie & Partners, 1994). Rainfall in the Chinese portion of the river averages 1,250



mm (50 inches), annually producing a stream flow of 45 billion cubic meters (1.6 trillion cubic feet) per year, or 40 percent of the annual flow as measured at Son Tay located just upstream of the capital city Hanoi (Food and Agriculture Organization, 1992). About 80 percent of the annual rainfall is generated during the months of May to September. Rainfall intensity can reach 200 to 400 mm (7.9 to 15.8 inches) per hour (Sharma, 1992).

The Red River Basin is densely populated, with 1999 estimates of 28 million people or 277 people per square kilometer (446 people per sq. mi.)(Asian Development Bank, 1999). The majority of the population resides in the Red River Delta at the southern end of the Basin.

### **5.2.2 Red River**

The Red River has an annual mean discharge of 4,100 cms (145,000 cfs). Maximum discharges occur from June to October, and minimum discharges occur from January to April. The flow of the Red River follows the seasonal rain patterns with about 40 percent of the annual runoff occurring during the month of August. In March, the lowest flows of the year are realized when only 0.5 to 2.5 percent of the annual runoff is realized (Food and Agriculture Organization, 1992). The maximum discharge recorded at Son Tay measured 34,000 cms (1.2 million cfs) and minimum discharge measured 370 cms (13,068 cfs) (Binnie & Partners, 1994). The river system in the Delta is complex with several tributaries and distributaries. At Son Tay, the average annual flow is about 3,800 cms (134,216 cfs), but by the time it reaches Hanoi a few kilometers downstream, the Duong River has received 950 cms (33,544 cfs) and flow is only 2,854 cms (100,803 cfs).

### **5.2.3 *Duong River***

The Duong River is a distributary of the Red River running through the four provinces of Hanoi, Hung Yen, Bac Ninh, and Hai Duong. The river is estimated to carry between 25 to 35 percent of the Red River flows annually. Large areas of the four provinces are protected by two dykes built along the north and the south banks of the Duong River. The south dyke is 60.1 km in length and the north dyke is 51.9 km long.

The two dykes are built in compliance with the Department of Dyke Management and Flood Control's design flood level. However, local sandy soils used for dyke construction allow infiltration through the dyke body under flood conditions. In addition, termite infestation that cause voids in the dyke body has additionally decreased the safety of the dyke. In 1971, the Duong River dyke suffered several failures causing major flooding both to the north and south of the dyke.

### **5.2.4 *Project Area***

The project area includes parts of four provinces of Hanoi, Hung Yen, Bac Ninh, and Hai Duong. Total land area of the project area is estimated at 292,069 hectares. Agriculture accounts for approximately 83 percent of land use. Population density in the project area measures about 1,400 people per square kilometer according to the GIS database developed for disaster mitigation in the Red River Delta (UNDP/DMU, 1999).

Economic statistics for the specific project area are unavailable. Statistics for the different provinces and the regions, however, are available from the General Statistical Office. In 1998, the Gross Domestic Product of the Red River Delta Region was US\$ 4.3 billion (VND 59,974 billion) (General Statistical Office, 1999). The structure of GDP was comprised as 38.7 percent by agriculture, forestry, and fisheries;

25.2 percent by industry, and 34.4 percent by services. In 1997, average per capita income was US\$350 (VND 4.7 million) in the Red River Delta (General Statistical Office, 1999).

In Hanoi for 1999, the major center for industrial development in the project area, agriculture accounted for only 3.9 percent of Gross Domestic Product (Hanoi Statistical Office, 2000). However, in Hai Duong province, agriculture, forestry, and fisheries accounted for 35.4 percent of gross domestic product in 1997 (Hai Duong Statistical Office, 1998). In the Delta, agriculture accounted for 75 percent of employment in 1993 (Binnie & Partners, 1994).

Industrial development is currently concentrated in the cities of Hanoi and Haiphong. Between 1995 and 1998, industrial growth averaged 13.4 percent. Most industrial goods produced in the Delta are also consumed there. Only about 3 to 4 percent of the Delta's industrial output is shipped to the central or southern regions of Vietnam (Binnie & Partners, 1994).

### **5.3 Flooding in Vietnam**

Floods present a major problem for Vietnam every year as shown in Table 5.1. Recent flood damage estimates for Vietnam were reported at US\$ 598 million for 1997 and US\$ 126 million for 1998 (UNDP/DMU, 1999). The Red River Delta is protected by an extensive system of dykes, while the Mekong Delta and central regions remain largely unprotected. Flood levels are classified by four alarm levels, I, II, III, and III+, based on river gauge heights. Alarm level one represents the lowest possible flood damage potential and alarm level III+ represents extreme emergency flood conditions.

Table 5.1 Flood Damage for Vietnam, 1971-1999.

Year	Value of losses (USD\$)	Deaths	Rice fields submerged (km <sup>2</sup> )	Unharvested rice (km <sup>2</sup> )	Loss rice production (tonnes)	Houses Damaged (thousands)
1971	78,000,000	n/a	n/a	n/a	288,700	158
1973	57,000,000	n/a	n/a	n/a	400,000	18
1977	5,000,000	153	928	n/a	222,600	163
1978	20,000,000	675	12,976	6,359	1,343,400	652
1979	n/a	46	1,642	1,076	n/a	35
1980	10,000,000	403	27,783	1,864	324,000	225
1981	n/a	274	1,056	404	n/a	49
1982	n/a	97	1,044	704	n/a	175
1983	19,000,000	818	3,932	798	186,800	357
1984	n/a	464	4,174	2,284	n/a	282
1985	n/a	1,013	5,304	2,195	n/a	344
1986	110,000,000	797	3,543	321	1,097,800	787
1987	28,000,000	140	1,332	78	166,000	242
1988	35,000,000	292	1,429	626	169,500	284
1989	74,000,000	481	6,428	1,642	805,500	1,290
1990	17,000,000	354	1,722	455	169,400	220
1991	44,000,000	480	2,019	767	n/a	398
1992	62,000,000	352	n/a	456	n/a	277
1993	82,000,000	387	2,300	896	n/a	257
1994	259,800,000	507	5,793	892	1,000	634
1997	598,300,000	943	5,810	513	n/a	116
1998	126,000,000	483	1,957	305	n/a	555
1999	387,000,000	824	1,310	534	n/a	1,073

Source: United Nations Disaster Management Team, "Emergency Relief and Disaster Mitigation in Viet Nam." April 1995. Figures for 1997 to 1999 from the UNDP's Disaster Management web site at [www.undp.org.vn/dmu](http://www.undp.org.vn/dmu).

The Government of Vietnam funds capital costs for flood control out of the general budget. Remaining funding comes from the provincial budget. However, no effective tax currently exists for benefits received from flood control projects. A lack of funding is often cited as a major constraint to improving flood control measures (World Bank, Asian Development Bank et al., 1996).

In the World Bank's Water Sector Review (1996), several development issues and priorities related to flood protection are given. These included financial and human risks, which will continue to increase as economic development and population continue to increase; watershed management, which links flood protection with watershed degradation; and finances, which acknowledge the constraints placed on the Government by the general lack of funds (World Bank, Asian Development Bank et al., 1996).

### ***5.3.1 Flooding in the Red River Delta***

Flooding is widely considered the greatest natural threat to the Red River Delta. Flood control in the Delta is accomplished primarily through the approximately 3,000 km (1,800 mile) long system of dykes, some over 800 years old. The dykes are between 6 to 8 meters (19.7 to 26.3 ft) in height, but can be as high as 11 m (36 ft) in some locations. About 93 percent of the Red River Delta's agricultural land and population live behind the dykes (Lustig, 1992). Many of the dykes, however, are in a poor state of repair, increasing their chance of failure. Over the years, the riverbed located within the dykes has tended to fill with sediment raising the bed level of the contained water above that of the surrounding land.

Floods are most often caused by episodes of intense rainfall. Such storms are most frequent in July and August. During this period, about 50 percent of the tropical depressions in the region occur (Binnie & Partners, 1994). At Hanoi from 1902 to 1993, flood alarm level 2 was exceeded 78 times, and flood alarm level 3 was exceeded 27 times (Binnie & Partners, 1994). The maximum flood level recorded at Hanoi was 14.7 m to 14.8 m during the flood of 1971. Probabilities for various flood levels at

Hanoi, as reported by the World Bank are 1 in 2.5 years for 10 m (32.8 ft) with a 20 percent chance of dyke failure; and 1 in 59 years for 13 m (42.7 ft) with an 80 percent chance of dyke failure (World Bank, 1995). Estimates of losses from a major dyke failure were given at US\$ 1,000 to US\$1,200 per household and 40,000 ha (about 100,000 acres) of lost rice production.

The flood of 1971 represents one of the most devastating flood events recorded in the Red River Delta. During the 1971 flood, three sections of the dyke system in the Delta broke causing the inundation of 250,000 ha (620,000 acres) with an impact on some 2.7 million people (Asian Development Bank, 1999). The area of the 1971 flooding is shown in Figure 5.2. The 1971 flood is reported to be a 1-in-100 year probability occurrence. Estimates of economic loss for the 1971 flood are on the magnitude of US\$ 78 million.

#### **5.4 Poverty in Vietnam**

Vietnam, with a per capita income of around US\$ 300 (VND 4,194,000), ranks as one of the world's poorest countries. In 1998, 37 percent of the country's population lived below the poverty line (World Bank, 1999). The poverty line is defined as the income sufficient to meet nutritional plus basic non-food needs, such as clothing and housing. The poverty line for Vietnam was estimated to be about US\$ 128 (VND 1,790,000) per capita. Poverty in Vietnam is highly concentrated in the rural agricultural areas. In 1998, 45 percent of the rural population and 9 percent of the urban population lived below the poverty line. Fully 79 percent of people living in poverty were engaged in agricultural occupations (World Bank, 1999).

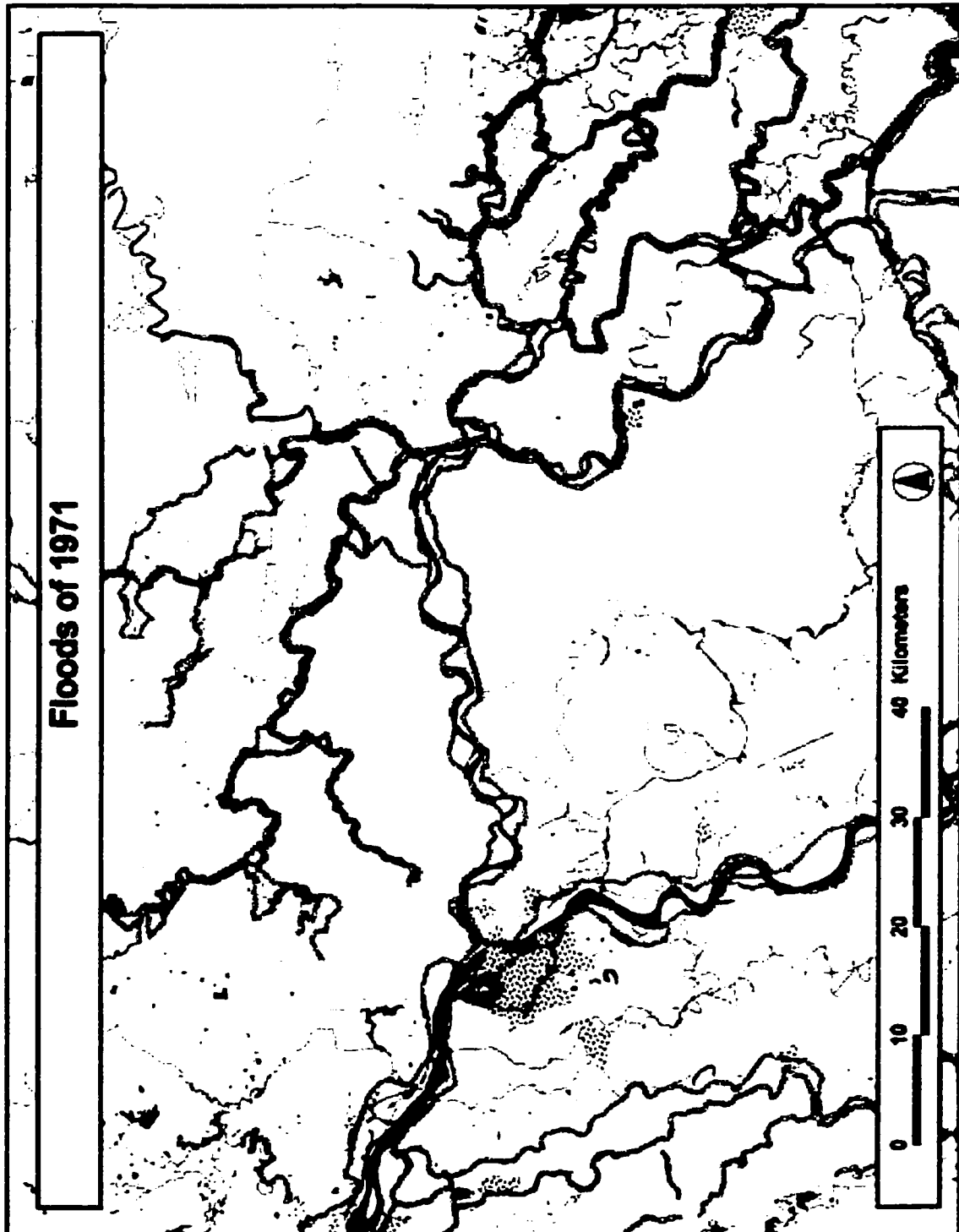


Figure 5.2 Flood of 1971 in the Duong River Area.

Since the *Doi Moi* reform program began in 1986, alleviating poverty has received significant attention from the government. As a result, Vietnam has experienced one of the sharpest drops in poverty in the world, dropping from 58 percent to 37 percent during the period 1993 to 1998. The poverty rate dropped from 66 percent to 45 percent for the rural population and from 25 percent to 9 percent for the urban population (World Bank, 1999). In the Duong River project area, the rural poverty rates are 35.5 percent for Ha Noi City, 40.4 percent for Hai Duong Province, 47.7 percent for Hung Yen Province, and 47.2 percent for Bac Ninh Province (Baulch, 2000).

Reasons for the high rate of persistent poverty are many, with one of the most important factors in the rural sector being small farm size. The average farm in Vietnam is very small in area; about 6490 m<sup>2</sup> in the Red River Delta. Despite large increases in crop diversification on a percentage basis, rice still accounts for 55 percent of all crop revenues. Crop diversification is limited by a lack of technical knowledge and access to appropriate markets. In response, production activities are quite limited, in both diversity and quantity. This puts farm households at high risk to crises or shocks. While this can include death or illness of a family member, it also can include the loss of crops or livestock due to natural disasters, such as flooding.

Maintaining growth in the agricultural sector presents a challenge to the Vietnamese government. Most good agricultural land has already been allocated, leaving only lower quality land for new farm households. Further, farm plots are already very small and a growing population places even more pressure on available land. In the Red River Delta, further crop diversification is required to maintain growth

in the agricultural sector. On-farm productivity and off-farm job opportunities will need to be increased to prevent a reversal of recent gains. Moreover, a major future flood in the Red River Delta can easily wipe out all the economic gains achieved over the last decade.

## **CHAPTER 6: METHODOLOGY**

### **6.1 General Introduction**

This chapter introduces the specific methods used for conducting the economic cost-benefit analysis of the case study. The case study is a dyke rehabilitation project on the Duong River in the Red River Delta of Vietnam. The Duong River Dyke Rehabilitation project was chosen for consideration by the Asian Development Bank because it will help reduce losses from flooding and benefit the poor. This project is one subproject under the Asian Development Bank's *Third Red River Basin Water Resources Sector Management Project*. The case study was adopted for the current study because of the unique situation it allowed to study flood mitigation benefits where poverty alleviation was a major concern. The following sections review the fundamental concepts underlying the execution of cost-benefit analysis for the project.

### **6.2 Scope of Economic Analysis**

Economic analysis is conducted as a means of testing the economic viability of a project. Economic viability measures whether the benefits arising from an investment decision outweigh the costs involved with implementing the project. Additionally, the economic viability of a project concerns the distribution of costs and benefits, in particular the impact of the project on poverty alleviation.

Economic analysis is also conducted on projects to ensure that scarce resources are used in an economically efficient manner. Economic analysis can help ensure that

resource use will be effective in meeting overall development and sector goals. Results will lend guidance in picking the option that uses the least resources to achieve the desired level of output.

### **6.3 Financial versus Economic Analysis**

While similar, financial and economic analyses have significant differences. The financial analysis is conducted from the viewpoint of the operating entity and is concerned with whether a given project will generate sufficient revenues to cover its expenses. Financial analysis estimates the net benefits of a project according to constant market prices. These prices are not adjusted for distortions caused by government interventions or market structure. A project must be financially sustainable to be economically viable.

Economic analysis is concerned with the value a project holds for an individual or society as a whole. Observable market prices may be distorted by government interventions, market structure, or the characteristics of the resources, such that prices do not reflect their true value. It is also possible that goods or services do not have observable prices, such as with non-market goods and services. Even though an observable price does not exist, these non-marketed goods and services may hold value for individuals or society. Economic analysis utilizes social values of costs and benefits by adjusting market prices to reflect distortions. By including these adjusted prices in the economic analysis, the true value of a project to society can be estimated.

For all investment projects, both the financial and economic analyses must be conducted. However, for developing country flood protection projects, the financial analysis will normally concentrate on whether adequate funding has been secured to

guarantee the sustainability of project benefits. This is because most flood protection projects are public goods projects and, at least in Vietnam, will generate no revenue for the Government. The public works project will be considered economically solvent as long as aggregate social benefits outweigh the social costs.

#### **6.4 Cost Analysis of the Flood Control Project**

The economic cost-benefit analysis of the Duong River Dyke Rehabilitation Project follows the economic analysis guidelines issued by the Asian Development Bank and detailed in *The Guidelines for the Economic Analysis of Projects* (Asian Development Bank, 1997). This section reviews the cost analysis procedures relevant to the present study and how they were applied to a flood protection project. Figure 6.1 gives a detailed flow chart of the logical progression for conducting the cost analysis, which is discussed in the following sections.

##### **6.4.1 Construction Activity and Price Information for Cost Analysis**

Based on consultations with Vietnamese dyke engineers, a list of construction activities required for the flood protection project was compiled. The list of construction activities gives both a description of each activity and the input units used for each activity, for example cubic meters. Construction activities were compiled for the different sections of the dyke targeted for rehabilitation.

General unit prices for the construction activities were calculated based upon Vietnamese Government standards. The unit price is given per input unit of the construction activity that will be undertaken, for example, cubic meters of excavation. The input costs include processing, transportation, distribution, and handling costs required to deliver the input from its source location to the project location.

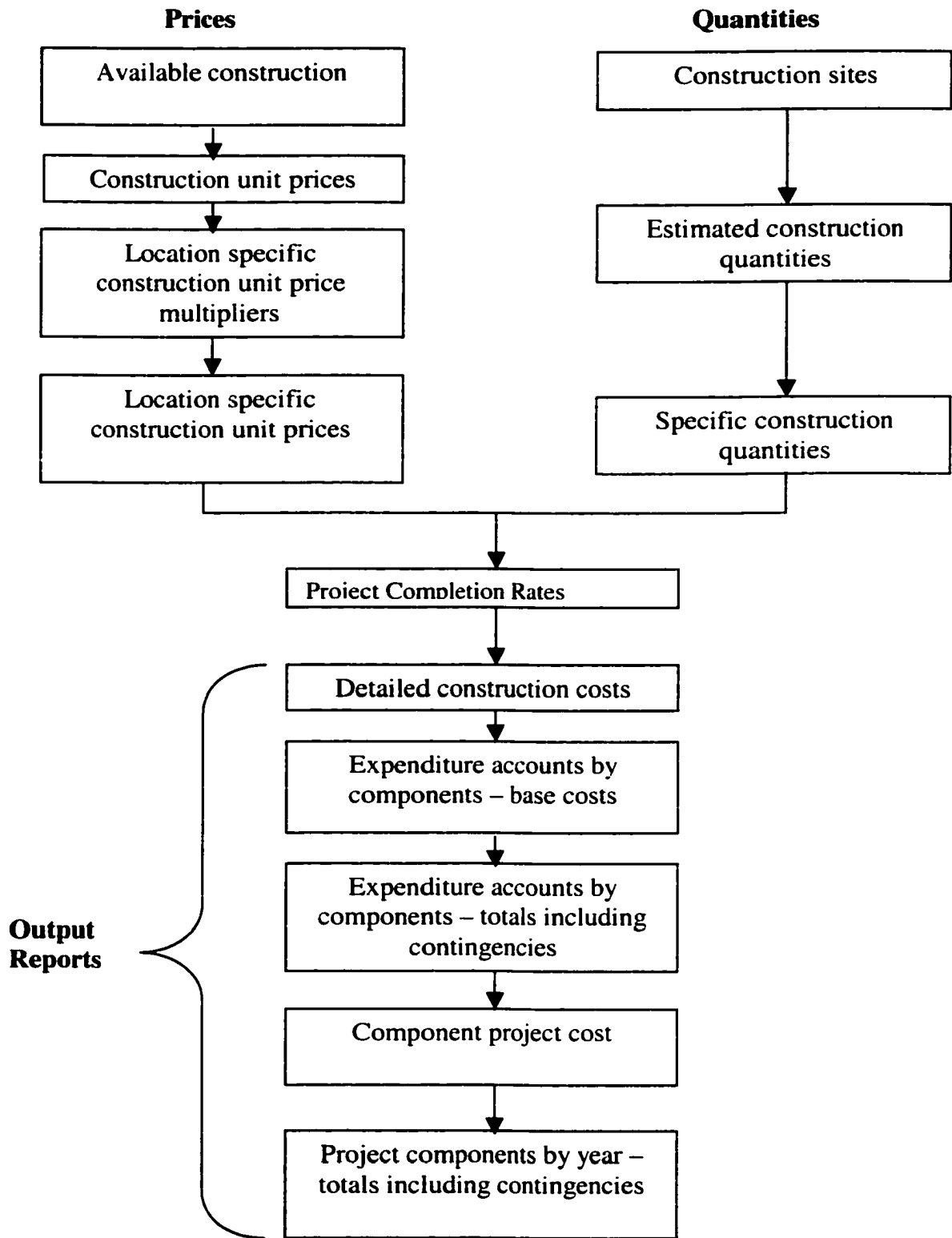


Figure 6.1 Flow Chart of Construction Cost Analysis.

The Vietnamese Government has official procedures to adjust general input prices to project location prices. General unit costs for a construction activity are adjusted to account for machines, materials, and labor required to complete each construction activity. Price adjustment factors devised by the Vietnamese were utilized, making refinements as necessary to generate specific unit costs. For the financial analysis, the financial costs for the project inputs were based on location specific unit costs as estimated by the Vietnamese Department of Dyke Management and Flood Control.

#### **6.4.2 Project Cost Tables**

The final step in the cost analysis is the construction of the various tables used to present the results of the cost analysis. Cost tables were developed to present cost analysis results in a tabular format similar in design to the COSTAB program. COSTAB is a project-costing program recommended by the Asian Development Bank for conducting the cost analysis of projects. General cost analysis results are presented in Chapter 7 and detailed cost tables will be presented in the Appendix Tables A1, A2, A3, and A4.

#### **6.5 Benefit Analysis of the Flood Protection Project**

The benefits from a dyke rehabilitation project are measured as the reduction in expected flood damage resulting from the implementation of the project. The estimated reduction in expected damage represents the willingness to pay of the beneficiaries of the flood protection project (Shabman, 1997). This section outlines the methods used to estimate the benefits from a flood protection project. Figure 6.2 shows the logical flow chart for performing the economic analysis of a flood protection project.

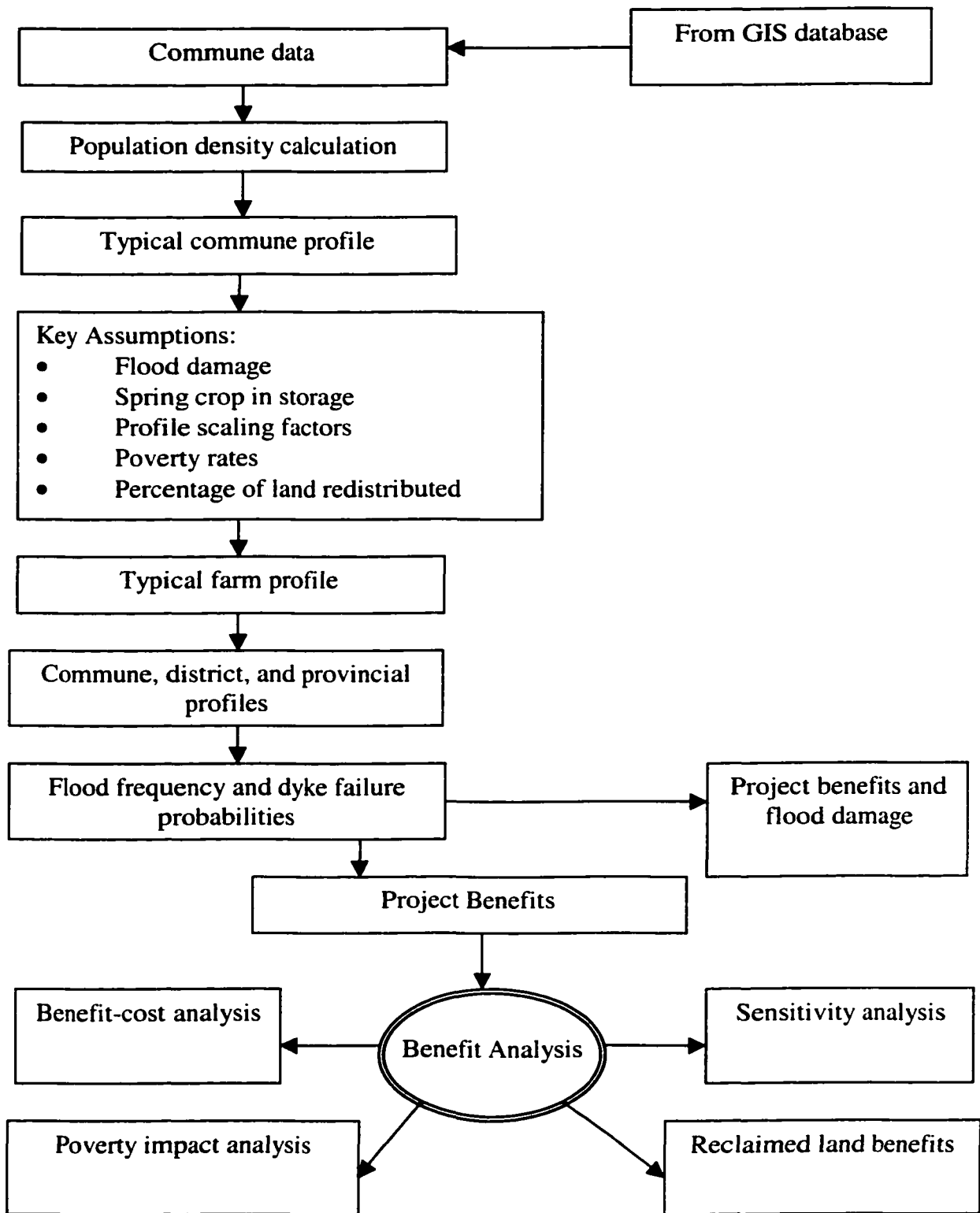


Figure 6.2 Flow Chart for Economic Benefit Analysis.

### ***6.5.1 Identification of Protected Area***

To estimate the expected damage from flooding, it is necessary to construct an economic profile of the area that a flood will affect. The project area is defined as the land area that can potentially be protected by the rehabilitated and existing dyke system. Within the protected area, relevant land use classifications were chosen and their corresponding land use areas calculated. Different flood scenarios were defined on a per hectare basis. In the case of road infrastructure, flood scenarios were defined on a per kilometer basis. In this manner, each flood scenario yielded unique values for flooded land areas based upon the different land use classifications.

#### ***6.5.1.1 Population Density Calculation***

In order to estimate the total population affected by a flood, a spatial interpretation of population will be developed. Population data in Vietnam is available on a commune level for both urban and rural areas. Using the data, an estimate of population density was made for both urban and rural areas. Based on this population density parameter, each flood scenario yielded a different population that is affected by a given flood scenario.

#### ***6.5.1.2 Construction of Typical Commune Profile***

The commune profile is constructed based on commune and household interviews and addresses the main flood protection benefits as stated previously. These sectors include agriculture, households, industry, commerce, and infrastructure. The sectors analyzed are those sectors representing the majority of production and assets susceptible to damage by flooding. Each economic sector was compiled at the commune political boundary level. The purpose of the commune profile is to provide a

base table of economic characteristics from which flood damage and, therefore, project benefits can be estimated. While, ideally economic data for each commune should be collected, financial and time constraints prohibited this activity. Interviews were conducted with commune government officials and village households to collect information on the economic sectors to be analyzed.

The agricultural profile was determined in the following manner. Since agricultural production varies throughout the year, the profile will incorporate the variations that would occur during the flood season. Variations in the agricultural profile included crops grown and previous crops still in storage at the time of flooding. Gross crop production values were calculated as the agricultural land area per commune multiplied by the average yield. This was then multiplied by the average local price for each crop. Livestock and poultry were similarly valued according to the local market price multiplied by the total number sold per unit of agricultural land area. To aid in the analysis, a farm production profile was constructed based on the typical commune profile and key parameters made regarding flood damage. The farm profile was constructed on a per hectare of agricultural land basis.

The housing profile included the number of houses per unit area in the study area, and household asset values. The number of households per unit area was derived from the population data pertaining to the land use categories of urban and rural populated areas. The estimated population densities for the rural and urban populated land use were used to calculate new populations that were then divided by the average number of people per household. This allowed the number of households to be calculated spatially. Commune and village interviews served as the source for data

concerning the value of assets contained in houses. This value was compared with previous estimations of household assets.

The industrial profile was calculated using official statistics for asset and production values of state, private, and foreign-owned industries. Damage that can occur to industry included assets lost or damaged by the flood and production losses resulting from an inability to operate because of a flood.

The commerce profile concerned smaller commercial operations, usually operated out of the ground floor of a person's house. Asset values were gathered from the commune interviews. Damage for this sector was calculated in a manner similar to that for the housing sector.

The infrastructure profile concerned those items which were identified as important and susceptible to flood losses during the commune interviews. Infrastructure damage may include damage to hospitals, water supply systems, power plants or substations, or transportation.

#### *6.5.1.3 Parameters for Estimating Flood Damage and Project Benefits*

A set of parameters regarding flood damage, crop storage, and poverty rates were determined based on the commune interviews. The parameters were based upon the experience of government officials with previous floods. The parameters are essential to estimating the flood damage. Parameters were checked with previous work done on flooding in Vietnam to check that they were reasonable.

#### *6.5.1.4 Flood Frequency and Dyke Failure Probabilities*

The calculation of flood frequencies and dyke failure probabilities is necessary to isolate the economic benefits of a flood protection project. The main output from a

flood protection project is the reduction in the probability of a flood occurring within the protected area. This reduction in flood probability is a joint probability of dyke failure probability and flood frequency probability. The difference in without-project protected area flood probabilities and with-project protected area flood probabilities creates a residual, or reduction, in expected damage from flood events. The reduction in expected flood damage is the benefit of the flood protection project.

Flood frequency analysis uses a given probability distribution to estimate the magnitude of flood discharge or stage at different reoccurrence intervals. There are numerous methods used to estimate flood frequencies, each with their own advantages and disadvantages. These advantages and disadvantages are generally based on a probability distribution's ability to reproduce extreme values, the quality of the flood data to meet statistical requirements of a particular distribution, the uncertainty of estimated parameters, the reasonableness of assumptions, and the effects of skew (Burrell, 2000). The Pearson Type-III distribution is the probability distribution utilized by the Department of Dyke Management and Flood Control.

For the current study, the river flood frequencies were not affected by the project (at the project location) so the without-project and with-project flood frequencies were identical. Project benefits are a result of a reduction of flood frequencies within the protected area, which is a result of a reduction in dyke failure probabilities. Because discrete river flood levels were used in the economic analysis, it was necessary to calculate relative flood frequencies for each particular flood event.

Dyke failure probabilities must be calculated for the range of flood levels that can impact the stability of the dyke structure for both the with-project and without-

project scenarios. For flood levels that are too low to impact the dyke structure, the probabilities do not need to be calculated. The dyke failure probabilities estimated for this project were based on the most appropriate method as judged by the project's hydrologic engineer.

Estimated expected flood damage, discussed in the next section, was multiplied by the joint probability of each river flood level and dyke failure to yield an expected damage level for each flood level. This process was repeated for both the without-project and with-project cases. Total economic benefits of the flood protection project were calculated by subtracting the with-project expected flood damage for a given flood level from the without-project expected flood damage for a given flood level and summing over all river flood event classes.

### ***6.5.2 Estimating Economic Damage***

Calculations of expected damage were made at the commune level. These commune level damage assessments were made by multiplying the relevant damage parameters for a particular flood with each economic sector in the commune profile. This yielded an expected damage estimate for a particular flood for each commune.

#### ***6.5.2.1 Expected Flood Damage Estimates***

The expected flood damage for a given the occurrence of a given flood scenario is calculated by combining the commune profile data, the expected damage parameters, and the land use data. The equation used to calculate expected damage simply sums the various estimations of damage for each of the different sectors. Expected flood damage for each commune is calculated with the following equation:

$$EAD_c = \alpha HHA + \eta(\beta[\theta(q_s p_s) + (q_f p_f)] + \sum \chi(Lp_L)) + \phi(mg + \gamma d) + \delta BT + k \sum z$$

EAD	= expected damage for commune c,
c	= commune c,
$\Phi$	= urban populated land area inundated,
$\eta$	= agricultural land in the inundated area,
$\alpha$	= percentage of household assets damaged,
HH	= number of households in inundated area,
A	= average asset value per household,
$\beta$	= percentage of agricultural crop damaged,
s	= spring season crops,
f	= fall season crops,
$\theta$	= percentage of spring crop in storage,
q	= crop yield per hectare,
p	= price per unit of output,
$\chi$	= percentage of livestock damaged,
L	= livestock head per agricultural land hectare,
m	= months of industrial production down time,
g	= monthly gross industrial output per hectare,
$\gamma$	= percentage of industrial assets damaged,
d	= asset value of industry,
$\delta$	= percentage of damage to commerce,
B	= number of shops in the inundated area,
T	= average asset value per shop,
k	= percent roads damaged, and,
z	= length of each type of road in inundated area.

This equation gives the expected damage for any given commune for a specified flood scenario in the Red River Delta of Vietnam. As stated above, the equation sums the damage estimates for each sector to arrive at the total commune damage expected for a given flood. Varying the estimated flood damage parameters will change the flood damage calculation. In this way, different flood scenarios can be tested. A breakdown of how flood damage for each of the various economic components in a commune is calculated is given in Table 6.1.

Table 6.1 Calculations of Flood Damage for Different Economic Components.

<p><b>Housing</b>  Value = (assets per household type)*(number of people per hectare/ people per household)*(percent lost)</p>
<p><b>January to May Agriculture (crop: paddy)</b>  Value = (agricultural land area)*(yield)*(price)*(percent stored in month <i>i</i>)*(percent lost)</p>
<p><b>May to October Agriculture (crop: paddy)</b>  Value = (agricultural land area)*(yield)*(price)*(percent lost)+(agricultural land area)*(yield)*(price)*(1- percent lost)</p>
<p><b>Livestock and Poultry</b>  Value = (Livestock per hectare)*(total area)*(average weight)*(live weight price)*(percent lost)</p>
<p><b>Industry</b>  Value = (monthly industrial output per hectare)*(urban populated area)*(months of downtime) + (industrial assets per hectare)*(urban populated area)*(percent lost)</p>
<p><b>Commerce</b>  Value = (percent of households)*(number of households)*(average asset value)*(percent lost)</p>
<p><b>Roads</b>  Value = (amount of roads for flooded area)* (repair cost per kilometer for each road type)*(percent damaged)</p>

### 6.5.3 Estimating Flood Protection Benefits as Property Damage Avoided

The economic benefits of a flood protection project are estimated as the property damage avoided because of the project. Property damage avoided is the value of the damage not incurred because a flood protection measure is implemented. Property damage avoided in a project area may be estimated with the following equation:

$$PDA = \sum_c \sum_i (\rho_i^{wo} \lambda_i^{wo} (EAD_c) - \rho_i^w \lambda_i^w (EAD_c))$$

where: PDA = property damage avoided,

wo = without-project parameter,

- $w$  = with-project parameter,  
 $\lambda_i$  = dyke failure probability,  
 $\rho_i$  = flood probability,  
 $i$  = different river flood levels.

All other variables are as defined previously. This equation is adapted from a textual description of the calculation of flood protection benefits (Young, 1996).

This equation expresses the benefits of the flood protection project by subtracting the expected damage with the project from the expected damage without the project. In other words, the equation gives the expected reduction in flood damage as a result of project implementation. When summed over all river flood levels, the calculated amount gives you the annual expected damages for a flood in a specific area. Summed over all communes, the equation yields the total annual benefits of the flood protection project. The annual amount is recalculated for each year in the project's life.

#### ***6.5.4 Cost-Benefit Analysis of the Flood Protection Project***

The two cost-benefit analysis decision criteria favored by the Asian Development Bank are the net present value (NPV) and the economic internal rate of return (EIRR). For the current study, no alternative projects were available for analysis. Therefore, the current analysis was limited to estimation of the cost-benefit parameters and results. However, the proposed method for analyzing poverty alleviation concerns was examined and compared with the poverty impact ratio recommended by the Asian Development Bank.

### 6.5.5 Sensitivity Analysis

The results of the economic and financial analysis are derived from a collection of estimated parameters and future predictions. The results necessarily involve some degree of uncertainty. Sensitivity analysis was performed to test the impacts of adverse effects on a project's outcome. The procedure involved changing one or more of the key parameters or variables and re-calculating the economic internal rate of return and net present value. Sensitivity analysis should be applied to items that are either quantitatively large relative to other items or characterized by a high degree of uncertainty. Sensitivity analysis helps to test the robustness of a given project in the face of uncertainty.

The Asian Development Bank recommends that the sensitivity analysis report sensitivity indicators for changes in key parameters. A sensitivity indicator shows the percentage change in the project's net present value or internal rate of return relative to a percentage change in a variable or combination of variables. The sensitivity indicator is calculated by the following equation for the net present value:

$$SI = \frac{\frac{NPV_b - NPV_1}{NPV_b}}{\frac{V_b - V_1}{V_b}},$$

and for the internal rate of return:

$$SI = \frac{\frac{IRR_b - IRR_1}{IRR_b - d}}{\frac{V_b - V_1}{V_b}}$$

where: *NPV* = net present value,

*IRR* = internal rate of return,

- V = variable being tested,
- d = discount or other benchmark rate,
- b = indicates base case,
- l = indicates tested case (Asian Development Bank, 1997).

The sensitivity indicator shows the effect that a change in a variable has on the net present value or the internal rate of return. If the sensitivity indicator has a large absolute value then changes in the variable in question will have a large impact on the net present value or internal rate of return.

Where a project demonstrates a high susceptibility to risk, measures to reduce the possibility of risk occurring should be incorporated into the project. Results of the sensitivity analysis are reported in a table along with results of the base case. Finally, an assessment of the likelihood of the changes occurring should be made.

## **6.6 Poverty Impact Analysis**

A poverty impact analysis is conducted to analyze a project's contribution toward the reduction of poverty. The Asian Development Bank aims for projects that are pro-poor in that they disproportionately benefit those living in poverty. This is a direct result of the Asian Development Bank's overarching goal of poverty alleviation. For any given level of aggregate net benefits, the poor must receive a proportion of total net benefits that is greater than the proportion of people living in poverty in the project area. In this manner, the implementation of a project will serve to increase equality of incomes in the project area.

For this study, the distribution of project costs and benefits is one element in determining a project's acceptability. This involves the analysis of who benefits from a

project and who pays for a project. For a public goods project such as flood protection, the emphasis of distributional analysis will be on how the benefits are shared. Of special significance to the Asian Development Bank are a project's impacts on the poor regarding poverty alleviation. The poor may be defined as that group of people living at or below a country's poverty line or some other socially acceptable measure. Generally, the poverty line is represented by some income level below which a certain standard of living is no longer possible to achieve and future existence is not ensured. To analyze poverty impacts, the Asian Development Bank uses the poverty impact ratio. The poverty impact ratio, however, analyzes net benefit distribution and not impacts on poverty.

#### ***6.6.1 Poverty Impact Ratio***

The poverty impact ratio shows the distribution of project net benefits accruing to the poor relative to total project net benefits. The concept behind it is that if net benefits fall at a greater proportion to the poor then the project is characterized as pro-poor. The poverty impact ratio is most effective when project net benefits can be distributed independently of income. In this way, a project can help raise poor incomes relatively more than non-poor incomes, which will have a poverty reducing impact. Thus, the poverty impact ratio maintains its effectiveness as an indicator of the distribution of project benefits, when distribution is a concern. Increasing the equality of income is an implied goal of the poverty impact ratio.

The poverty impact ratio was calculated for the case study in the following manner. The estimation of poverty impact involves the identification of the target group and the benefits accruing to them. In the present case, the target group is the

poor. In Vietnam, agriculture accounts for 66 percent of total employment, but 80 percent of those living in poverty (World Bank, 1999). Another 7 percent of the poor are accounted for as non-working or retired (World Bank, 1999). Furthermore, the agricultural sector can be largely represented by a relatively homogeneous, paddy producing farm model. Therefore, benefits accruing to the poor will be calculated by multiplying the provincial poverty rates with the estimated agricultural benefits for the typical farm model developed in the flood model. This amount will then be aggregated by the inundated area of the chosen flood scenario. Costs will be zero for the poor since there is currently no cost recovery scheme planned for this project. The ratio will be computed as this amount over the total estimated net benefits of the project. The poverty impact ratio will then be compared to the poverty incidence rates for the study area. If the poverty impact ratio is greater than the poverty incidence then the project has a greater proportional impact on the poor than the rest of the population

While industry represents only about 4.5 percent of rural employment, it accounts for 33 percent of national output (General Statistical Office, 1999); (World Bank, 1999). To show the impact of highly valued beneficiaries on the distribution of flood protection benefits, the poverty impact ratio was also calculated removing benefits accruing to industry. Removing industrial benefits was not presented as a method to calculate an acceptable poverty impact ratio, but to demonstrate the weakness of the poverty impact ratio in the current case.

For a flood protection project where benefits are tied directly to production and asset values, the poverty impact ratio will fail as an adequate indicator of project effectiveness regarding poverty alleviation. The poverty impact ratio will penalize a

flood protection project because benefits of reduced flood probabilities are distributed to all and valued by assets and production. This can be true despite the effectiveness of the project in alleviating poverty compared to alternative projects. The poverty impact ratio, therefore, does not analyze the impact of a project on poverty alleviation, but rather it indicates how benefits are distributed.

### ***6.6.2 Safety-first Criteria and Poverty Alleviation Impacts***

A safety-first valuation can overcome the weakness of the poverty impact ratio. A safety-first valuation can demonstrate the relative increase in value that a project has for a target group. In the current case, the target group is primarily poor farmers. It has been shown that the closer a farmer is to some critical minimal level of production or income, then the more likely they will be acting to maximize the probability of survival rather than profits (Miracle, 1968); (Todaro, 1996). The dual of this problem is that the farmer is acting to minimize the probability of disaster occurring. This is exactly the kind of benefit that a flood protection project provides. In regard to a minimization of disaster probability, a poverty impact ratio cannot say anything about project effectiveness regarding poverty alleviation. A project that helps the poor only a little but the non-poor none will receive a higher poverty impact ratio than a project that helps the poor substantially more, but more equally with the non-poor. If poverty alleviation is a project goal, then it is necessary to examine a project's impact on poverty.

Poverty presents certain problems when calculating the economic value of a project. As discussed above the farmer's objective may not be profit maximization, but survival maximization. Therefore, a farmer may choose an investment that minimizes

the choice of disaster occurring over an investment that has a higher expected return. This type of safety-first decision-making has been shown to reflect actual decision-making by farmers (Sands, 1989); (Upton, 1987).

Safety-first rules were first devised as a way of incorporating risk into the valuation of alternative investment options (Roy, 1952). A safety-first criterion is based on the idea that the decision maker judges the alternative strategies as to the probability they exceed a minimum threshold below which final income should not fall (Eeckhoudt and Gollier, 1995). The variance of possible outcomes for alternative investment options may result in final wealth falling below the critical level. Therefore, valuations of alternatives balance expected returns with the downward riskiness of a given alternative. The more risk-averse a person, the more heavily the downward riskiness will be weighted.

In the case of a flood protection project, a safety-first valuation rule can apply the actual benefits (lower flood probabilities) of the project directly to a risk based valuation of project benefits for the target group. In regard to poverty, this can be interpreted as minimizing negative fluctuations in incomes of the poor due to flooding. In this manner, the relative effectiveness of alternative projects to poverty alleviation can be ranked consistently with national development goals. In the present case, a safety-first criterion has the multiple benefits of reflecting farmer behavior, of incorporating the actual probabilistic effect of a flood protection project, and of lending guidance to a preference ordering.

The safety-first value was calculated in the following manner. First, the lower partial second moment was calculated with the following equation:

$$\sigma^{2-}(t) = \sum_z^t (t - x)^2 \rho$$

- where:  $t$  = the critical threshold,  
 $x$  = the final income,  
 $\rho$  = the probability of experiencing a particular outcome,  
 $z$  = the lowest possible outcome for  $x$  (Fishburn, 1977).

The lower partial second moment was calculated using the poverty line as the threshold and also using the expected income as the threshold. The difference in the two thresholds is that use of the poverty line threshold will result in large values for the riskiness of a project. This is caused by the relatively large deviation of possible outcomes from the poverty threshold level. This can be interpreted as the high cost that moving further below the poverty line carries for the farmers or society.

The probability of experiencing a particular outcome is identical to the probability of experiencing the event that would cause the particular outcome. That is, for the calculation of the lower partial moments, the probability of experiencing a particular outcome will be taken as the previously calculated joint flood frequency and dyke failure probabilities. This holds intuitive appeal in that the probabilities are based on established procedures that reflect the predicted physical impact of the project.

The safety-first values of the alternative projects was calculated by the following equation:

$$V(w_f) = E(w_f) - k\sigma^{2-}(t)$$

Where:  $V(w_f)$  = the value of final wealth adjusted for risk preference,

$E(w_f)$  = the expected value of final wealth for a given state of the world,

$k$  = a measure of risk preference,

$\sigma^2(t)$  = lower partial second moment (Eeckhoudt and Gollier, 1995).

This equation allows one to value alternatives by balancing risk and return. In this sense, the lower partial moment represents the cost of risk. The variable  $k$  represents the risk preference (weighting) that is applied to the negative variance associated with the expected outcome. For the analysis,  $k$  was set equal to one for reported results and varied for the sensitivity analysis.

The safety-first valuations gave an estimation of what each alternative is worth to an individual in the target group. When the threshold level was given as the poverty line, then those living below the poverty line had negative safety-first valuations. This was caused by the large deviation of possible outcomes from the threshold poverty level relative to the expected outcome. What this means is that the cost of risk is so high that the farmer would never choose to farm. The negative valuations can be interpreted as an indication of the desperation of the poor. If the incremental increases of alternatives are examined, they will be quite large and positive. This is consistent with the utility of poverty theory presented in Chapter 2, where the marginal utility of a necessary bundle was said to approach infinity when below the poverty line. While it cannot be said that the safety-first value is equated with utility, it can be shown that in some sense the incremental improvements from a reduction of risk below the poverty line far out-value the incremental increase in expected income.

Alternatively, use of the expected income with expected flood damage as the threshold resulted in positive safety-first valuations. This result was caused by the relatively small variance in possible outcomes compared to the expected outcome

(threshold). While both will allow for the ranking of alternative projects, the positive valuations may hold higher practical appeal directly related to the positive valuations. These values can be interpreted as values based more on straight production values with the desperation of poverty eliminated. In practical situations, the positive valuation from using the current income level may be easier to explain than a negative valuation from using the target level. The valuations derived when using the poverty threshold, however, will give a better indication of the incremental improvements from implementation of the project that are consistent with the incremental increases in utility one would expect in a poverty situation.

The calculated safety-first valuations were ranked in order of value to indicate preferences based on the project's impact on the target group. This approach is superior to the poverty impact ratio in that alternative projects can be ranked according to the magnitude of their impact on reducing the probability of negative income fluctuations for the poor, whereas the poverty impact ratio can only be used to rank alternative projects according to their relative distribution of benefits. The poverty impact ratio will rank a project that benefits the poor a little and the rich none higher than a project that helps the poor substantially and the rich some. In the current case of flood protection projects, this may lead to the rejection of projects that otherwise would be quite beneficial to the poor. That, of course, would be a move away from meeting the goal of poverty alleviation.

## **CHAPTER 7: RESULTS OF THE RESEARCH**

### **7.1 Introduction**

This chapter discusses the results obtained from utilizing the methods described in Chapter 6. This chapter describes the specific details of the proposed rehabilitation project, the calculated cost tables, the cost-benefit calculations, and the sensitivity analysis. Also presented are the results and comparisons of the alternative poverty impact analyses. It is shown that the proposed safety-first ranking criterion performs better for flood protection projects than the poverty impact ratio suggested by the Asian Development Bank for analyzing poverty impacts.

### **7.2 Basic Information for the Benefit and Cost Analyses**

The following section outlines information provided by the Asian Development Bank necessary for conducting the economic analysis of the flood protection project. All of the following economic parameters are adopted from previous work done for the Asian Development Bank (Asian Development Bank, 1999). Price contingencies were set equal to 10 percent of calculated base costs. The exchange rate at the time of this analysis was approximately VND 14,300 to US\$ 1. It was estimated that the Asian Development Bank would finance 80 percent of total costs, while the Government of Vietnam will finance the remaining 20 percent of total costs. The foreign exchange component was estimated to equal 5 percent of total costs. A summary of the basic parameters used for the economic analysis is presented in Table 7.1.

**Table 7.1 Summary of Basic Input into Economic and Financial Analysis.**

Cost sharing: Vietnam	20 percent
Cost sharing: Asian Development Bank	80 percent
Exchange rate (VND:US\$)	14,300
Foreign Exchange	5 percent
Physical contingencies	10 percent of base costs

### **7.3 Cost Analysis of the Flood Protection Project**

This section presents the details of the cost analysis. First, calculated input quantities and location specific input prices will be examined. A summary cost table is presented of the general cost analysis results. Detailed cost tables for the project are presented in Appendix Tables A1, A2, A3, and A4.

#### **7.3.1 Construction Quantities and Completion Rates**

Estimated quantities for each construction activity for the proposed dyke rehabilitation are given for each specific location in Table 7.2. A map of the construction locations, general activities, and quantities is given in Figure 7.1. Earth fill was classified as either using manual or machine methods. Excavation was classified as either “removal of vegetation” or “excavation.” The Vietnamese Department of Dyke Management and Flood Control expressed the opinion that the project could be completed within one year. Construction would occur after the end of a flood season (approximately October 15). It was predicted, therefore, that construction would be completed in the first year and benefits realized starting with the second year.

Table 7.2 Site Locations and Input Quantities for the Project.

	Excavation (m <sup>3</sup> )	Earth fill (m <sup>3</sup> )	Grass planting (m <sup>3</sup> )	Pond filling (m <sup>3</sup> )
<b>I. Left dyke of Duong River</b>				
1. K0.300 - K1.500 Left Duong	-	-	-	40,770
2. K4.800 - K5.400 Left Duong	-	-	-	40,350
3. K6.000 - K7.500 Left Duong	10,120	42,888	50,187	-
4. K13.600 - K15.000 Left Duong	7,673	41,469	38,243	-
5. K17.000 - K17.800 Left Duong	-	-	-	41,915
6. K25.500 - K28.500 Left Duong	25,128	145,814	122,493	-
7. K46.000 - K51.000 Left Duong	33,738	217,759	168,336	-
<b>II. Right dyke of Duong River</b>				
8. K0.550 - K3.700 Right Duong	-	-	-	105,126
9. K21.600 - K24.000 Right Duong	-	-	-	161,000
10. K28.000 - K29.500 Right Duong	-	-	-	147,475
11. K31.500 - K38.400 Right Duong	206,669	50,177	248,666	201,210
12. K41.000 - K48.000 Right Duong	50,338	257,984	246,361	543,515

Source: Department of Dyke Management and Flood Control, Ministry of Agriculture and Rural Development, Vietnam

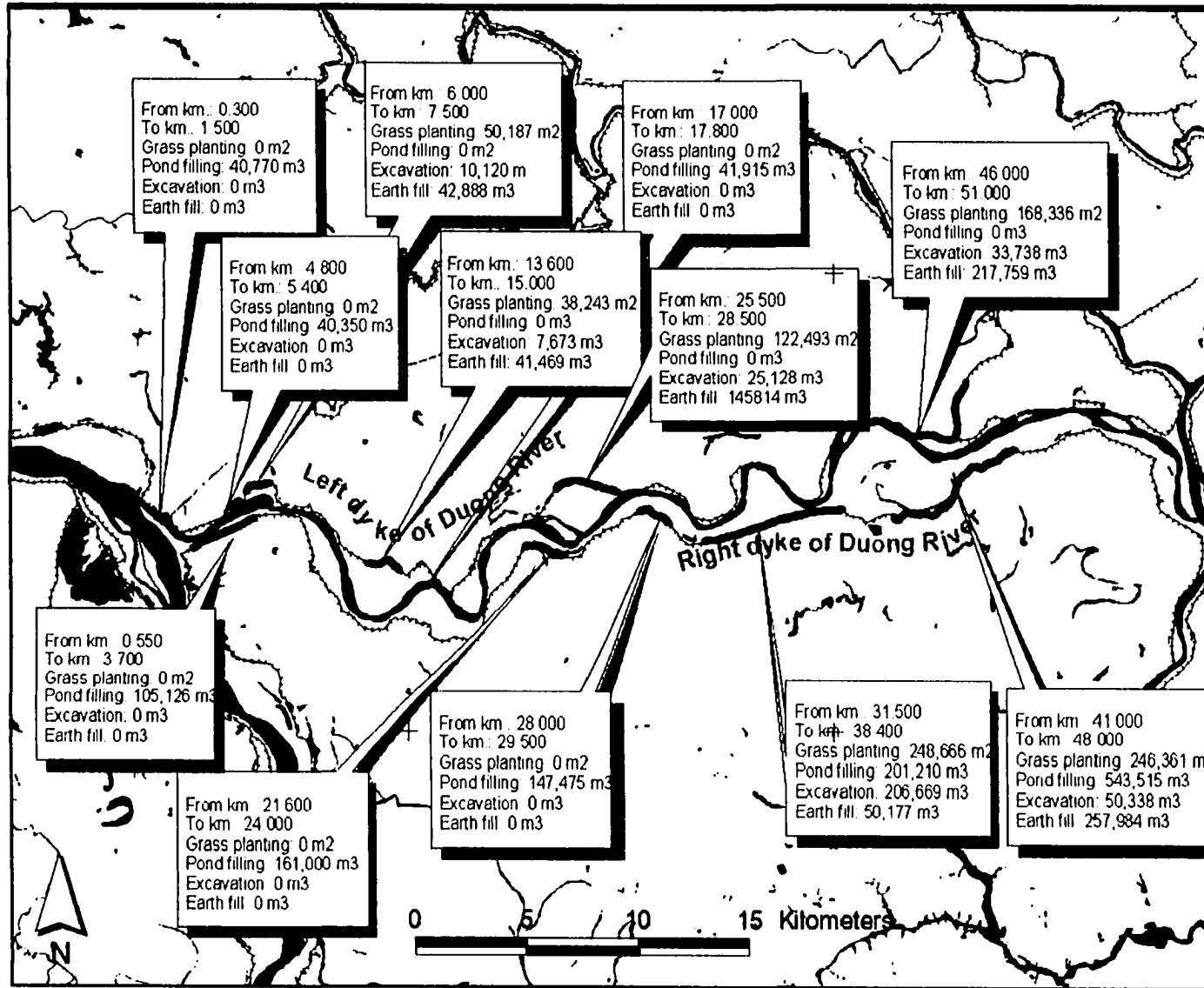


Figure 7.1 Construction Locations, Activities, and Quantities.

### 7.3.2 Results of the Cost Analysis

The results of the cost analysis for the proposed project are presented in this section. Financial costs for the project inputs were based on location specific unit costs as estimated by the Vietnamese Department of Dyke Management and Flood Control. Since the Vietnamese Dong is not believed to be significantly distorted in value, economic costs were set equal to financial costs (Asian Development Bank, 1999).

Summary costs for the project are presented below in Table 7.3. Based on a US\$ 2 million cost limit stated in a related Asian Development Bank Aide Memoir (2000), costs exceed the project selection criteria by US\$ 1.1 million (excluding price contingencies). However, the US\$ 2 million cost limit is based upon preliminary cost estimates. In order for the project to be economically viable, it must also be financially feasible. The remainder of the economic analysis is presented on the assumption that adequate funding for a US\$ 3 million project can be secured.

Table 7.3 Summary Cost Table for the Duong River Dyke Rehabilitation Project.

	(1,000,000 VND)			(US\$)		
	Local	Foreign	Total	Local	Foreign	Total
Rehabilitation of Dyke	37,900	2,000	39,900	\$2,650,000	\$140,000	\$2,790,000
<b>Total baseline costs</b>	37,900	2,000	39,900	\$2,650,000	\$140,000	\$2,790,000
Physical Contingencies	3,800	200	4,000	\$266,000	\$14,000	\$280,000
Price Contingencies	1,000	27	1,027	\$70,000	\$2,000	\$72,000
<b>Total project costs</b>	42,700	2,227	44,927	\$2,986,000	\$156,000	\$3,142,000

No cost recovery plan for the project is currently in place. However, the project may hold significant cost savings in terms of avoided costs for emergency flood relief actions, post flood relief programs, and future dyke maintenance to repair floodwater damage. These potential cost savings, however, are not investigated here. This yields a more conservative net benefit estimation in the economic analysis of the project.

#### **7.4 Results of the Benefit Analysis**

There are considerable benefits arising from this flood protection project. Economic benefits from this flood protection project were calculated using the property damage avoided approach. As described in Chapter 6, benefits considered for this project included agricultural production, household assets (excluding the house structure), industrial assets and production, commerce, and major roads and highways. Additionally, by including benefits to agriculture, poverty alleviation concerns can be addressed.

##### **7.4.1 Identification of Protected Area and Beneficiaries**

The project will benefit all economic activities and people protected by the Duong River Dyke System. That is, anyone residing within the protected area will be able to enjoy the benefits of lower flood probabilities. The project area as defined for this study is divided into two sections by the Duong River. The southern section of the protected area is delineated by the Duong River to the north, the Red River to the west, the Thai Binh River to the east, and the Luoc River to the south. The northern section of the protected area was defined by the Duong River to the south, the Cau River covering most of the northern and eastern border, and the western boundaries of Dong Anh District and Yen Phong District. A map of the protected area is shown in Figure

7.2. The area was defined based on the Duong River Dykes and dykes on other rivers that formed a well-defined protected area.

The resulting area protected by the Duong River Dyke System includes parts of Ha Noi City and the provinces of Hai Duong, Hung Yen, and Bac Ninh. The area includes a total of 484 communes, townships, and wards. The total area of the protected area is 292,100 hectares based upon data contained in the UNDP Disaster management unit's GIS database. The total population of the project area is equal to approximately 3.5 million people.

Ideally, flood depth, duration, and area of inundation vary for different river flood levels examined during the analysis. This procedure entails a significant amount of effort to determine the different flood scenarios. The difficulty in estimating different flood scenarios was exacerbated in the current study by the acute lack of required data in Vietnam. For this study, a "most likely" flood scenario was estimated and that scenario was applied to all river flood levels. This approach was followed previously by Lustig in his flood studies in Vietnam (Lustig, 1993a; Lustig, 1993b)). To test the sensitivity of the economic analysis to this approach, three separate flood scenarios will be analyzed based solely on changes in the area of inundation.

The three flood scenarios to be investigated are based on two historic flood events and a most likely 1-in-100 year flood event with simultaneous right and left bank dyke breaks at Thuong Cat. Two flood scenarios are based on the historic floods of 1945 and 1971. Flood damage estimations will be calculated for reoccurrences of the historic floods of 1945 and 1971. Another scenario will be 100 percent inundation for

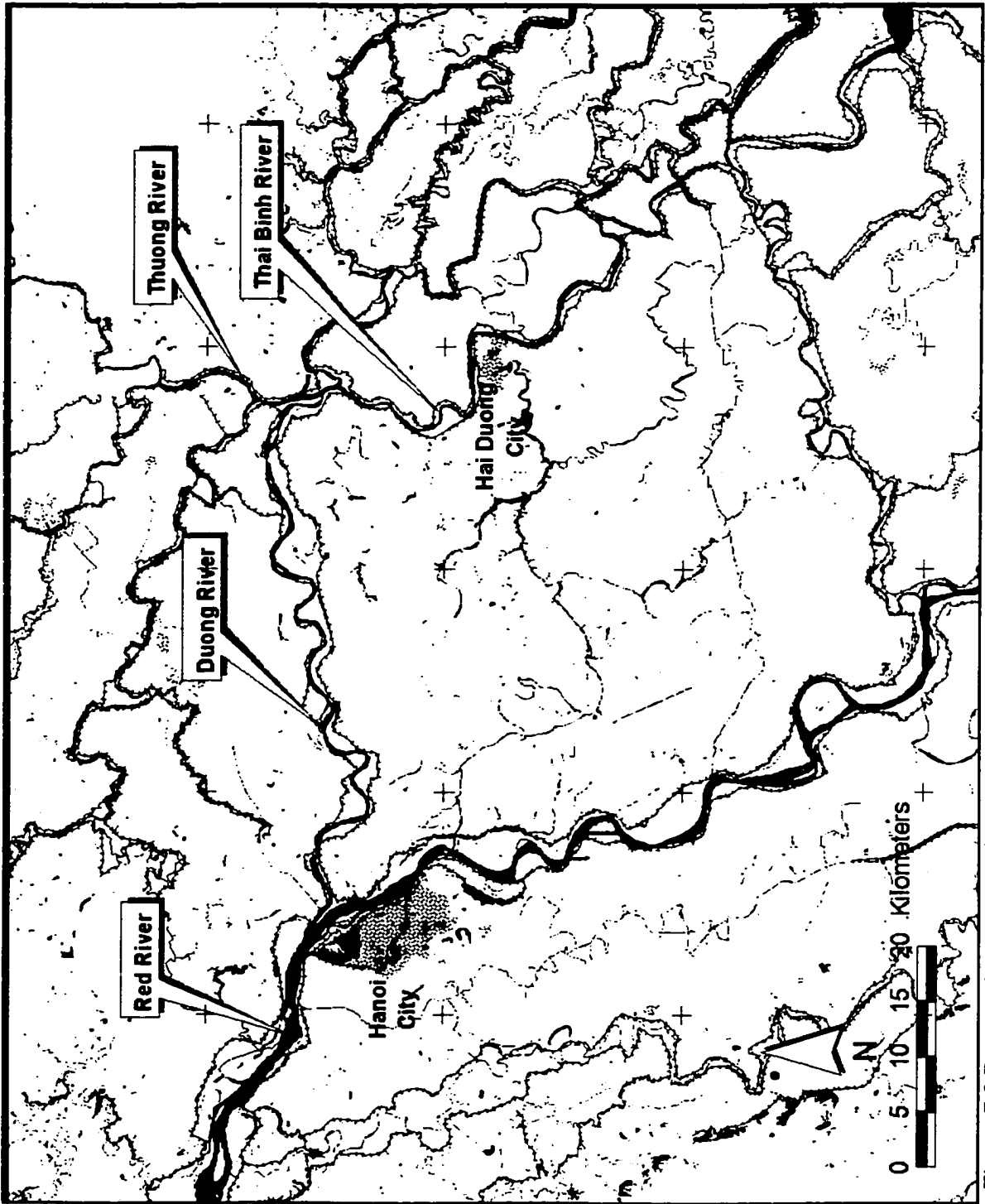


Figure 7.2 Protected Area as Defined by Rivers and Dyke System Locations.

all areas lower than 10 meters in height, although the damages will be assessed for a flood lower than this level. Officials in the Department of Dyke Management and Flood Control noted that for the historic flood of 1971 the flood depth was 3.5 meters in the project area. A comparison of inundated areas for the different flood scenarios is shown in Figure 7.3. The 10-meter height was chosen because of limitations of the topographic information in the GIS database. If better information had been available, then more accurate inundation mappings could have been made.

The flooded land areas for each flood scenario were entered into the GIS database. Each scenario was then imported into the economic analysis model as various land use areas to calculate flood damage and project benefits of the flood protection project. The data and model were defined at the commune level.

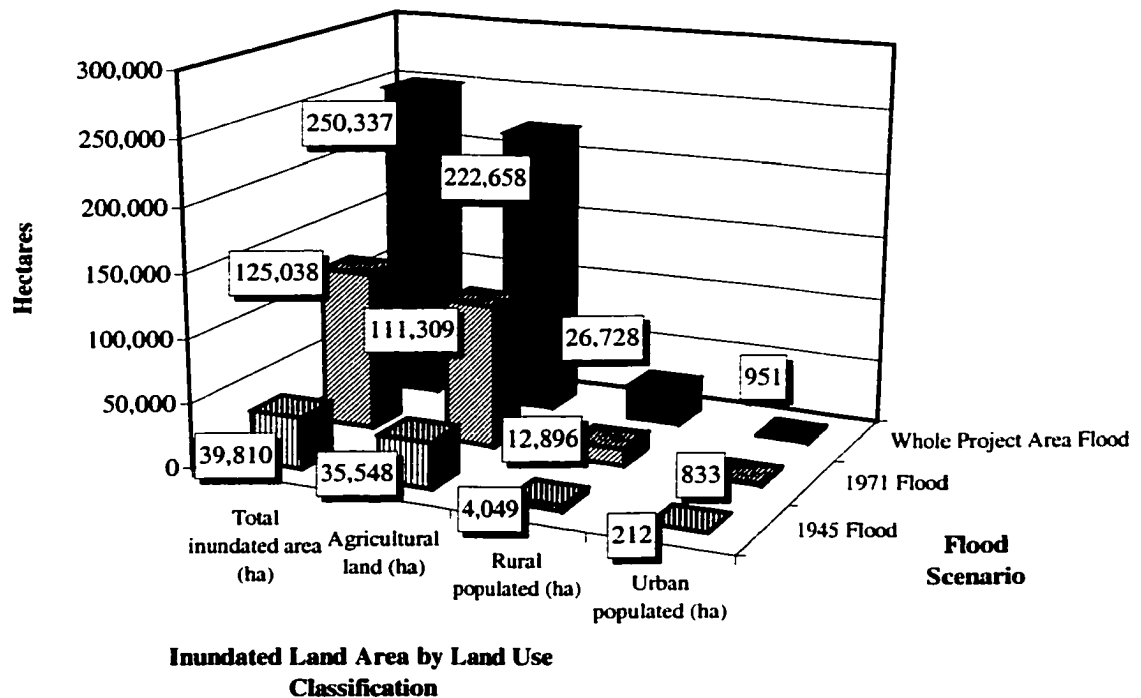


Figure 7.3 Inundated Areas for the Flood Scenarios Used in the Benefit Analysis.

#### **7.4.2 *Population Density Calculation***

In order to estimate the total population affected by a flood, a procedure was devised to add a spatial dimension to the commune population values. Data on land area for urban and rural populated areas were available from the GIS database. Based on population data from the 1999 Statistical Yearbook for Ha Noi Province, it was estimated that urban populated areas have a population density roughly 10 times that of rural populated areas (General Statistical Office, 2000). Rural population density was then calculated as the total commune population divided by the sum of rural populated land area plus 10 times the urban populated area.

#### **7.4.3 *Construction of Typical Commune Profile***

The protected area profile was developed based on land use data and population data. Additionally, two interviews were conducted with commune government officials and village households to collect information on the economic structure at the commune level. The interviews were used to define a typical commune in the region, which was then used to build the sector profiles for each commune in the protected area. The interviews were conducted primarily to gather numeric commune level data. The interviews also were conducted to gather information necessary to build the model of flood damage based on the officials historical knowledge of previous floods.

Annual commune agricultural activities were based on a paddy-paddy-maize rotation. Animal production choices included cattle, pigs, and poultry. Animal cull rates were averaged for the communes interviewed. Livestock activities were normalized on a per hectare basis for agricultural land. Based on interviews, non-agricultural income was estimated to equal 20 percent of agricultural income. Since the

crop primarily damaged by flooding in the Red River Delta is the summer paddy crop, crops other than paddy were not considered in the flood damage analysis.

During commune interviews, the question was asked “would farmers change their cropping patterns if additional flood protection was provided?” The commune officials interviewed felt that crop diversification depended not only on increased flood protection but on several factors including credit availability and knowledge on how to grow new crops. It was, therefore, concluded that crop diversification is not likely to be a result of a flood protection project, and was not considered in the analysis.

Prices received by the farmers for crops and livestock are location specific and require no adjustments. Crop budgets for each crop option were gathered during the commune interviews. Crop budgets were compared with previous crop budgets developed for agricultural studies in the Red River Delta and found to be consistent.

The housing profile was developed based on the number of houses per unit area in the study area, and household asset values. The number of households per unit area was derived from the population data pertaining to urban and rural populated areas. Population densities were estimated for rural and urban populated land use categories, populations were estimated which were then divided by the average number of people per household. This allowed the number of households to be calculated spatially.

Household asset values were estimated by the government official interviewed during the study. In addition, an assessment was made on how susceptible these assets were to flooding. Flood damage was predicted to be mainly limited to the first floor and estimated single story asset values were applied to all households.

The industrial profile was developed using official statistics for asset values of state, private, and foreign-owned industries. Giang Bien Commune was the only commune interviewed that had any industrial production. Compared with official aggregate statistics, the asset values gathered from interview were judged too low to represent the protected area accurately. Therefore, industrial output and asset value estimates were made based on data in the *1998 Vietnam Statistical Yearbook* and in the *1998 Results of Survey on Industry* (General Statistical Office, 1999). Since, the interviews indicated that most industrial production is urban, industrial production was limited to urban populated land areas. Since floods temporarily interfere with productive activities, output data was divided by twelve to derive monthly production values. This implies no seasonal fluctuations in production. If more detailed data had been available, seasonal production fluctuations could also have been addressed.

The commerce profile concerns smaller commercial operations, usually operated out of the ground floor or a person's house. The number of commerce enterprises was estimated to equal 3 percent of total households. The average asset value was obtained from the interviews with commune officials.

The infrastructure profile addressed only major roads and highways in the protected area. The estimated cost for repairing paved roads was derived from an article in the *Vietnam News*, which indicated that the cost for repairing paved roads for flood damage average about VND 60 million/km (VNS, 2000). The cost for repairing dirt roads was estimated to be VND 2 million/km. A summary table of the typical commune in the area protected by the Duong River Dyke Rehabilitation Project is given in Table 7.4.

Table 7.4 Estimated Typical Commune Profile in the Project Area.

Item	Unit	Value
Population	people/ha	11.00
Pop growth rate	percent	0.0145
1 story house	unit/ha	2.55
2 story house	unit/ha	0.13
Assets 1 story house	million VND/unit	13.50
Assets 2 story house	million VND/unit	25.00
People per house	people/household	5
Agricultural income	million VND/person/yr	1.65
Non-farm income	percent of agricultural production	0.20
Roads	km/ha	0.01
Road repair cost (paved)	million VND/km	60.00
Road repair cost (dirt)	million VND/km	2.00
Average farm size	ha/household	0.27
Spring paddy land	ha/ha of agricultural land	0.29
Winter paddy land	ha/ha of agricultural land	0.29
Cereal land (corn)	ha/ha of agricultural land	0.20
Paddy productivity	t/ha	5.08
Paddy price	million VND/t	1.70
Corn productivity	t/ha	2.64
Corn price	million VND/t	2.20
Production costs (paddy)	million VND/ha	4.40
Production costs (corn)	million VND/ha	1.90
Cow	head/ha	0.66
Cow cull rate	percent/year	1.00
Cow price liveweight	VND/kg	10000.00
Pig	head/ha	6.75
Pig cull rate	percent/year	1.00
Pig price liveweight	VND/kg	9000.00
Poultry	head/ha	33.33
Poultry cull rate	percent/yr	1.00
Poultry price liveweight	VND/kg	13000.00
Industrial production	million VND/ha/month	0.33
Industrial assets	million VND/ha	6500.00
Commerce (small shops)	percent of households	0.03
Average commerce assets	million VND	5.00

Source: interviews with commune government officials in Bac Ninh Province and Hanoi City. Industrial parameters estimated from data in the Hanoi City and Hai Duong Statistical Yearbooks.

#### **7.4.4 Parameters for Flood Damage Analysis**

Several parameters were developed for the analysis of the flood protection project. Parameters were based primarily upon interview results, but also on preliminary findings of other studies conducted in the Red River Delta of Vietnam. For example commune officials were asked, “if a 1 meter flood occurred what percentage of the summer crop would be lost.” In this way, estimates of percentages lost for each sector were developed.

##### **7.4.4.1 Flood Damage Parameters**

Two floods were considered; one flood at 1/3 meter flood depth and one flood at 1 meter flood depth. Based on commune officials’ knowledge of the local conditions and previous responses to flooding, the officials estimated how much damage would be experienced by each sector under the two flood scenarios. Averages were calculated and applied universally to the entire project area as summarized in Table 7.5.

Table 7.5 Parameters of Flood Damage for Flood Height of 1/3 Meter and 1 Meter.

<b>Flood Damage for Different Flood Levels</b>	<b>1/3 m</b>	<b>1 m</b>
Crop loss in percent	50%	100%
Livestock loss in percent	20%	45%
Housing asset loss in percent	10%	25%
Industrial loss in percent	25%	50%
Downtime for industrial production (months)	3	4
Asset loss for shops in percent	15%	28%
Roads destroyed in percent	35%	48%

### *Damage to Agriculture*

Local officials estimated that damage to agriculture would be 50 percent of the crop for a 1/3 meter deep flood and 100 percent for a 1 meter deep flood. The percent of crop loss is multiplied by the value of the summer crop and the value of the spring crop still in storage to derive damage estimates to crops. The parameter for percent of livestock and poultry lost for each flood scenario was multiplied by the value of livestock and poultry production to calculate the flood damage.

### *Damage to Housing*

Damage to housing included only the asset values of belongings in the house and not the house structure itself. During previous flood events, people in the Red River Delta moved their belongings including livestock on to the dyke or higher ground in order to protect their belongings from flood damage. Priority was placed on saving high value items leaving lower value and bulky items susceptible to flood damage. Estimates for damage to household assets for each flood were estimated to be between 10 and 25 percent for a 1/3 meter and 1 meter flood, respectively.

### *Damage to Industry*

Industry suffers damage in two respects: damage to assets and damage as a result of production down time. Only Giang Bien commune had any industrial activities. The Giang Bien officials estimated that for a flood of 1/3 meter industrial losses would equal 25 percent of asset values and 3 months of lost production. For a 1-meter flood, industry would suffer a loss of 50 percent of their assets and 4 months of production down time.

### *Damage to Commerce*

Commune officials related that owners of shops would be efficient at protecting their goods from being damaged by flooding. Officials in Giang Bien thought that shop owners would experience no losses, while officials in Tri Phuong judged damages would be 30 percent for a 1/3 meter flood and 50 to 60 percent for a 1 meter flood.

### *Damage to Infrastructure*

Damage to infrastructure only examined costs incurred in order to repair roads damaged by flooding. Damage to roads were included in the benefits calculation at the suggestion of the commune officials in Giang Bien commune who related that road damage would represent a major loss from flooding. The percent of damage to roads was estimated for each flood scenario and multiplied by the repair cost to derive damage estimates. Damages arising from the temporary interruption of transportation, however, were not included in the calculations.

#### *7.4.4.2 Crop Storage Parameters*

Since most farm households store some portion of their crop for home consumption, an analysis table was created to estimate how much of the spring crop is still in storage for each month of the flood season. These estimates were drawn from commune interviews. Based on the wide range of responses received, two scenarios were created: a low storage scenario (35 percent of the Spring crop is stored in May) and a high storage scenario (85 percent of the Spring crop is stored in May). In this manner, the economic damage and benefits could be varied by the month the model flood occurred during the flood season for the different estimated crop storage percentages.

#### 7.4.4.3 Sectoral Scaling Factors for Aggregation

Industrial output per hectare of urban area was estimated using data from Ha Noi City and Hai Duong Province, which are the two most industrial Provincial areas in the Delta. Unfortunately, industrial data for Hung Yen and Bac Ninh Provinces were not available. While estimating industrial profiles for each province, tests were performed to see if it was acceptable to extrapolate estimated industrial profiles to the province level. In order to account for the high degree of industrial production concentrated in Ha Noi City and in Hai Duong Province, scaling factors were developed to adjust the typical industrial profiles. This was necessary so that the typical commune profile did not overestimate the amount of industrial production. The industrial scaling factors for the four provinces are reported in Table 7.6 below.

Table 7.6 Estimated Scaling Factors for Industrial Production and Assets.

<b>Province</b>	<b>Scaling Factors for Industrial Production</b>
Hanoi	1.0
Hai Duong	1.1
Hung Yen	0.4
Bac Ninh	0.55

Source: Estimations by the author using industrial statistical data contained in Hanoi City and Bac Ninh Province Statistical Yearbooks (Hanoi Statistical Office, 2000);(Hai Duong Statistical Office, 1998).

Industrial gross output was estimated per hectare of urban populated area and then multiplied by the adjustment factor. Model results were checked against available

official data to check the consistency of the estimations. Testing demonstrated that the scaling factors worked well in estimating industrial production in the four provinces.

#### *7.4.4.4 Poverty Rates in the Project Area*

Provincial poverty rates were obtained from the World Bank (Baulch, 2000). The poverty data were developed for a provincial poverty mapping project in Vietnam. The project is a collaboration between the World Bank, the Vietnamese General Statistical Office, and the International Food Policy Research Institute. Poverty figures were given in percentages of poor households and percentages of poor people. The figures adopted for the current study are for percentage of poor people in each province.

#### *7.4.5 Typical Farm Profile*

The typical farm production profile was based on a paddy-paddy-maize cropping pattern along with the raising of livestock. To account for the lack of crop diversity, the winter cropping area was set equal to the area of the spring paddy crop. Non-farm income was estimated to equal 20 percent of the income from agricultural activities. Expected damage if a flood were to occur was estimated based on the flood water level and crop storage scenarios.

Financial damage considered only the impact on monetary income for the farm. Economic damage considered the economic value of damage incurred. The resulting farm profile was constructed on a per hectare of agricultural land basis and is presented in Table 7.7. Damage values presented in the table were based on the 1/3 meter flood depth and 1 meter flood depth damage parameters. Estimated damage exceeds net income for the spring and summer paddy crop because damage estimates do not

consider the sunk costs of crop production. This means that the farmer will experience a loss for the crop.

#### **7.4.6 Flood Frequency and Dyke Failure Probabilities**

Flood frequencies and dyke failure probabilities were estimated in order to calculate the economic benefits of the flood protection project. Benefits from the project are realized from the reduction in the probability of a dyke failing for a given flood stage. The following sections review and report the results from the estimations undertaken during the course of this project feasibility study.

**Table 7.7 Estimated Profile of a Typical Farm Production in the Project Area and Expected Damage for a Flood 1/3 m Deep and for a Flood 1 m Deep.**

<b>Typical Farm Income</b>	<b>Total Annual Income (1,000 VND)</b>	<b>Spring Paddy (1,000 VND)</b>	<b>Summer Paddy (1,000 VND)</b>	<b>Winter Crop (1,000 VND)</b>	<b>Pig (1,000 VND)</b>	<b>Cow (1,000 VND)</b>	<b>Poultry (1,000 VND)</b>
Net income per ha	17,332	45	2,636	3,908	4,253	2,640	650
Non-farm income	3,466						
Total average net income per ha	20,798						
Financial damage per ha (1/3 meter flood)	5,827	0	4,318	0	851	528	130
Economic damage per ha (1/3 meter flood)	7,752	2,029	4,318	0	790	528	87
Financial damage per ha (1 meter flood)	12,031	0	8,636	0	1,914	1,188	293
Economic damage per ha (1 meter flood)	15,855	4,059	8,636	0	1,777	1,188	195

#### 7.4.6.1 Flood Frequency Estimates

Flood frequency probabilities were calculated by the Vietnamese Institute of Water Resources Planning in the Ministry of Agriculture and Rural Development Department of Dyke Management and Flood Control (DDMFC, 2000). The Institute of Water Resources Planning utilized a Pearson Type-III distribution when estimating flood frequencies. For the current study, the flood frequencies were be affected by the project so estimating the without-project and with-project frequencies was not necessary. The estimated flood frequency probabilities for the Duong River at Thuong Cat are presented in Table 7.8.

Table 7.8 Flood Frequency Estimates for the Duong River at Thuong Cat.

<b>Probability in percent</b>	<b>Cumulative probability</b>	<b>Return interval (years)</b>	<b>River flood height (m)</b>
0.01	0.0001	10000	17.4
0.10	0.001	1000	15.8
0.20	0.002	500	15.3
0.33	0.003	300	15.0
0.50	0.005	200	14.7
1.00	0.010	100	14.2
2.00	0.020	50	13.6
3.00	0.030	33	13.3
5.00	0.050	20	12.9
10.00	0.100	10	12.4
20.00	0.200	5.0	11.7
25.00	0.250	4.0	11.5
30.00	0.300	3.3	11.4
40.00	0.400	2.5	11.1
50.00	0.500	2.0	10.8

Source: Department of Dyke Management and Flood Control (2000). "Hydrological and Hydraulic Analysis for Duong River System" Hanoi.

#### *7.4.6.2 Dyke Failure Probabilities*

Dyke failure probabilities were estimated for the Duong River dyke system in the following manner. First, since it is impossible to predict the exact location or extent of a dyke failure, a critical area of the dyke system was chosen as representative of the whole dyke system. The section chosen for this project is located at Thuong Cat on the Duong River. Thuong Cat was chosen for two reasons. First, Thuong Cat is the location of the primary gauging station for the Duong River. Second, Thuong Cat is located near critical sections of the Dyke System that will be included in the project. Officials at the Department of Dyke Management and Flood Control identified that a dyke break at this section of the dyke system would result in the inundation of 100 percent of the project area for a 1-in-100 year flood flow. This inundation scenario is for a simultaneous left and right bank dyke failures. Dyke failure probabilities were calculated for the same flood levels for which flood probabilities were calculated.

Information on the dyke structure on the Duong River at Thuong Cat was obtained from the Center for Dyke Engineering. The design plan showed that the river would reach the toe of the dyke at a river flood level of 11.9 m. Current dyke design standards show that at a river flood level of 13.8 meters, the dyke will experience an overflow condition and an estimated complete failure. If the project is implemented, then the height of the dyke will be raised to 14.3 meters. Dyke failure probabilities were taken from other studies, normalized, and averaged. These average normalized failure probabilities were then applied to the Thuong Cat dyke section to get the dyke failure probabilities (Burrell, 2000).

Since discrete dyke elevations are used, dyke failure probabilities must be adjusted to reflect a certain event class. For instance, a dyke height of 12 meters will represent the relative dyke failure frequency for a flood event between 11.5 meters and 12.5 meters (assuming a 1 meter interval between examined dyke heights). A plot of the estimated cumulative dyke failure probabilities are given along with the design specifications for dyke height both without-project and with-project in Figure 7.4. To account for the degree of uncertainty involved with the estimation of dyke failure probabilities, additional with-project dyke failure probabilities were estimated by adjusting the with-project dyke failure probabilities up by 30 percent and by 60 percent of the originally calculated difference. In this way, the sensitivity of the economic analysis to errors in the dyke failure probabilities can be tested.

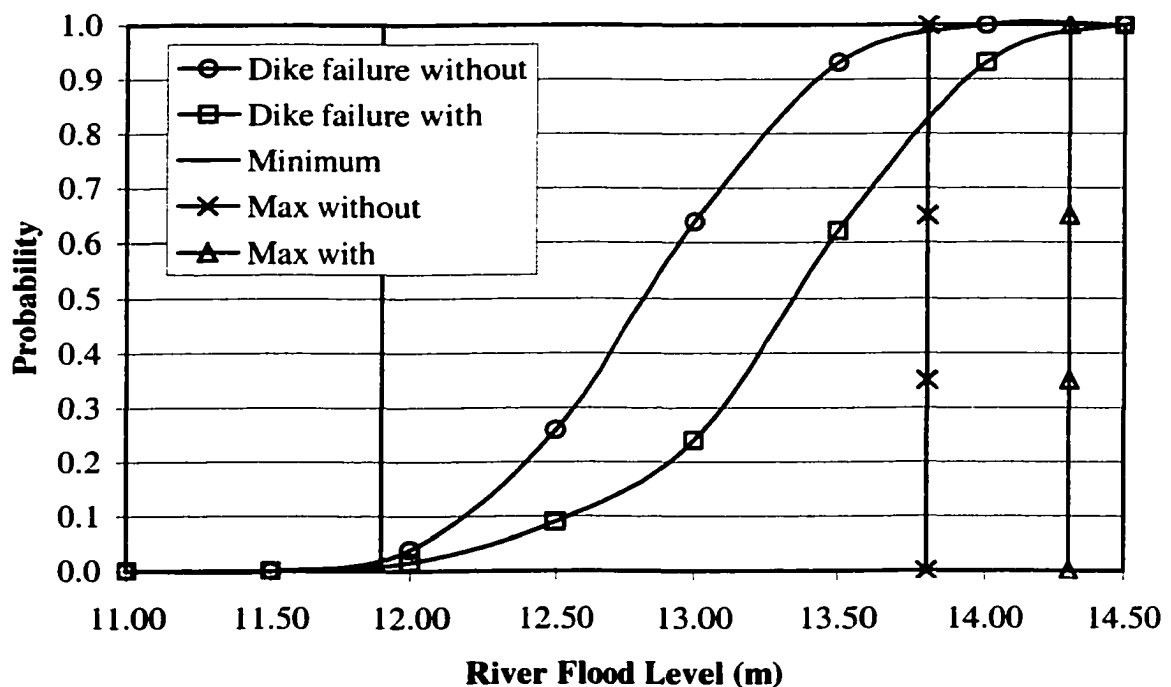


Figure 7.4 Cumulative Dyke Failure Probabilities Without-project and With-project.

Joint probabilities were calculated by multiplying the relative flood frequencies with the corresponding relative dyke failure probabilities for each river flood level. To compensate for the size of the chosen interval between flood heights, it was necessary to calculate the density of each event class. This was accomplished by dividing the relative joint frequency for each event class by the interval size. The relative cumulative flood frequencies, relative cumulative dyke failure probabilities, and joint densities are presented in Table 7.9.

Table 7.9 Flood Frequency and Dyke Failure Joint Probabilities for the Duong River.

River flood level (m)	Flood frequency without project	Flood frequency with project	Relative dyke failure frequency without project	Relative dyke failure frequency with project	Joint density without project	Joint density with project
11.7	.8	.8	-	-	-	-
12.0	.0477	.0477	.0384	.0151	.0061	.0024
12.3	.0412	.0412	.1125	.0452	.0155	.0062
12.6	.0335	.0335	.1765	.0454	.0197	.0051
12.9	.0255	.0255	.2331	.0804	.0198	.0068
13.2	.0181	.0181	.2186	.192	.0132	.0116
13.5	.0118	.0118	.1518	.2433	.006	.0096
13.8	.0071	.0071	.0691	.214	.0016	.0051
14.1	.0041	.0041	-	.1273	-	.0017
14.4	.0026	.0026	-	.0372	-	.0003
14.7	.0022	.0022	-	-	-	-

Source: Calculations by the author using flood frequencies estimated by the Department of Dyke Management and Flood Control and dyke failure probabilities estimated by Jim Burrell, project hydraulic engineer.

#### 7.4.7 Estimating Economic Flood Damage

The project area was affected greatly by the historic floods that of 1945 and 1971 when several dyke failures occurred in the project area shown in Figure 7.5.

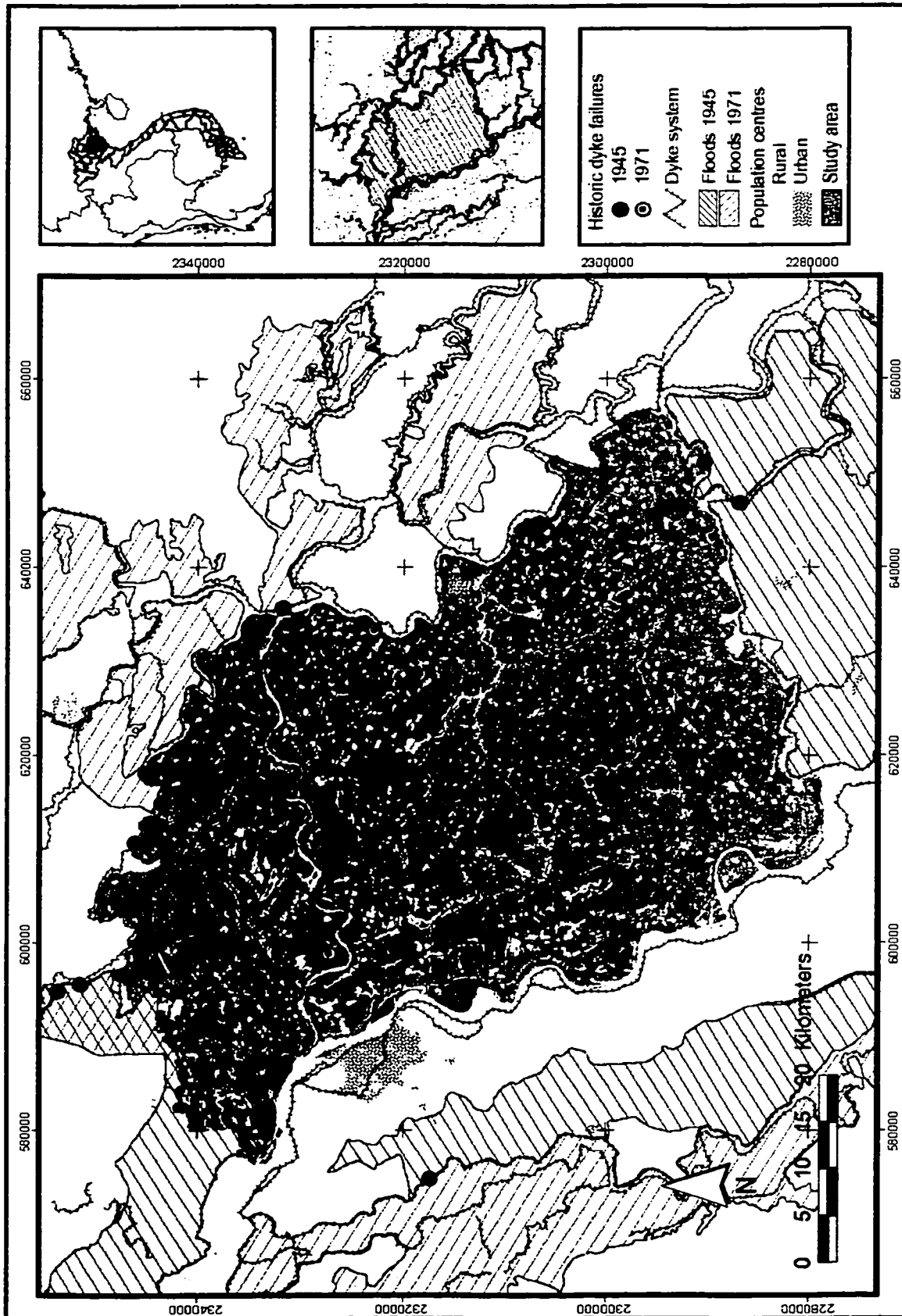


Figure 7.5 Historic Floods of 1945 and 1971 in the Project Area.

Estimates of flood damage for each historic flood, if it were to occur today, were calculated to test the economic model. Additionally, damage was estimated for a flood covering the entire project area. The three flood scenarios were based on a flood occurring in August. Damage estimates for the three flood scenarios based on a 1 meter deep flood are presented in Table 7.10 and damage estimates for a 1/3 meter deep flood are presented in Table 7.11.

Table 7.10 Damage Estimates for the Historic Floods of 1945 and 1971 and a Flood Covering the Whole Project Area Based on Year 2000 Prices and a 1 Meter Depth Flood.

Flood losses for 1 meter deep flood	1945	1971	Whole project area	1945	1971	Whole project area
	(Million VND)			(Million US\$)		
Crop losses	451,000	1,413,000	2,827,000	\$32	\$99	\$198
Livestock losses	116,000	363,000	725,000	\$8	\$25	\$51
Housing losses	332,000	1,031,000	2,043,000	\$23	\$72	\$143
Commerce losses	4,000	12,000	24,000	\$0	\$1	\$2
Highways	24,000	38,000	66,000	\$2	\$3	\$5
Major roads	0	1,000	1,000	\$0.00	\$0.07	\$0.07
Industrial assets damage	689,000	2,707,000	3,090,000	\$48	\$189	\$216
Industrial output losses	213,000	1,019,000	1,190,000	\$15	\$71	\$83
<b>Total</b>	<b>1,830,000</b>	<b>6,584,000</b>	<b>9,966,000</b>	<b>\$128</b>	<b>\$460</b>	<b>\$697</b>

Table 7.11 Damage Estimates for the Historic Floods of 1945 and 1971 and a Flood Covering the Whole Project Area Based on Year 2000 Prices and a 1/3 Meter Depth Flood.

Flood losses for a 1/3 meter deep flood	1945	1971	Whole project area	1945	1971	Whole project area
	(Million VND)			(Million US\$)		
Crop losses	226,000	707,000	1,413,000	\$16	\$49	\$99
Livestock losses	51,000	161,000	322,000	\$4	\$11	\$23
Housing losses	133,000	412,000	817,000	\$9	\$29	\$57
Commerce losses	2,000	7,000	13,000	\$0	\$0	\$1
Highways	18,000	28,000	49,000	\$1	\$2	\$3
Major roads	0	0	1,000	\$0.00	\$0.00	\$0.07
Industrial assets damage	345,000	1,354,000	1,545,000	\$24	\$95	\$108
Industrial output losses	160,000	764,000	892,000	\$11	\$53	\$62
<b>Total</b>	<b>934,000</b>	<b>3,433,000</b>	<b>5,053,000</b>	<b>\$65</b>	<b>\$240</b>	<b>\$353</b>

As reported in the *1998 Vietnam Statistical Yearbook*, the Gross Domestic Product (GDP) for Vietnam was VND 361,500 billion measured in 1998 prices (General Statistical Office, 1999). Flood damage in the project area from a repeat of the 1945 flood assuming a 1 meter deep flood would equal 0.5 percent of the total national GDP. Flood damage from a repeat of the 1971 flood assuming a 1 m deep flood would equal 1.8 percent of the total national GDP. This indicates the serious threat that flooding poses for Vietnam, especially considering that the above estimated damage is

only for the project area and does not include the total flooded area in the Red River Delta for the two historic floods analyzed.

#### **7.4.8 Estimation of Project Benefits**

Project benefits were estimated for both a 1/3 meter deep flood and a 1 meter deep flood for the 1945, 1971, and whole project area flood scenarios. The results of the benefit estimation are presented in Table 7.12. Poverty project benefits are those benefits accruing to the segment of the agricultural sector predicted to be living below the poverty line. Agricultural benefits are the total benefits accruing to the agricultural sector. “Project benefits – no industry” are all project benefits less the benefits accruing to industry. Finally, “project benefits – no road benefits” are all project benefits less those accounted for by a reduction in expected road repair costs.

Table 7.12 Project Benefits for Different Flood Scenarios (million VND).

<b>Flood Scenario</b>	<b>Flood Depth</b>	<b>Total Project Benefits</b>	<b>Poverty project benefits</b>	<b>Agricultural project benefits</b>	<b>Project benefits - no industry included</b>	<b>Project benefits - no road benefits included</b>
1945 Flood	1/3 meter	24,300	4,500	7,200	11,200	23,800
1971 Flood		89,200	14,300	22,500	34,200	88,500
Whole project area		131,300	29,200	45,100	67,900	130,000
1945 Flood	1 meter	47,500	10,000	14,700	24,100	46,900
1971 Flood		171,000	31,400	46,100	74,200	170,000
Whole project area		258,900	64,000	92,300	147,700	257,200

#### ***7.4.9 Cost-Benefit Analysis of the Flood Protection Project***

A major component involved in the decision-making process concerns the results of the cost-benefit analysis. The economic internal rate of return and the net present value of the project were analyzed for the 1945 historic flood with a 1/3 meter flood depth scenario. The 1945 flood scenario gives the most conservative estimation of economic benefits. The length of the analysis was set at 30 years. The discount rate for the net present value calculation was taken to be 12 percent, which is the minimum economic internal rate of return acceptable to the Asian Development Bank. Annual expected benefits are identical for each year in the study. This is the result of the exclusion of inflation rates in the study. General price changes, however, should be excluded from the economic analysis. Further, forecasts of project area economic development were excluded because forecasts were unavailable. The results are presented in Table 7.13. The project is acceptable with a net present value of VND 181 billion (US\$ 12.7 million) and an economic internal rate of return of 69 percent.

#### ***7.4.10 Sensitivity Analysis***

Sensitivity analyses were conducted to check the robustness of the results. Results are presented in Table 7.14. The sensitivity analysis indicated that economic desirability of the project is robust. Since industry was the highest value sector analyzed in terms of expected damage and benefits, calculations of the net present value and economic internal rate of return excluding industrial effects were made. This calculation yielded a net present value of VND 62 billion (US\$ 4,300,000) and an economic internal rate of return of 32 percent. These results continued to indicate an economically favorable project. In the extreme case where project costs are increased

Table 7.13 Results of the Cost-benefit Analysis (VND) Using the 1945 Flood with a 1/3 Meter Flood Depth Scenario.

Year	Project Costs (VND)	Expected Flood Protection Benefits (VND)	Expected Net Benefits (VND)	Expected Net Discounted Benefits (VND)
2001	44,931,000,000	-	-44,931,000,000	-44,931,000,000
2002	-	30,870,000,000	30,870,000,000	27,563,000,000
2003	-	30,870,000,000	30,870,000,000	24,609,000,000
2004	-	30,870,000,000	30,870,000,000	21,973,000,000
2005	-	30,870,000,000	30,870,000,000	19,618,000,000
2006	-	30,870,000,000	30,870,000,000	17,516,000,000
2007	-	30,870,000,000	30,870,000,000	15,640,000,000
2008	-	30,870,000,000	30,870,000,000	13,964,000,000
2009	-	30,870,000,000	30,870,000,000	12,468,000,000
2010	-	30,870,000,000	30,870,000,000	11,132,000,000
2011	-	30,870,000,000	30,870,000,000	9,939,000,000
2012	-	30,870,000,000	30,870,000,000	8,874,000,000
2013	-	30,870,000,000	30,870,000,000	7,924,000,000
2014	-	30,870,000,000	30,870,000,000	7,075,000,000
2015	-	30,870,000,000	30,870,000,000	6,317,000,000
2016	-	30,870,000,000	30,870,000,000	5,640,000,000
2017	-	30,870,000,000	30,870,000,000	5,036,000,000
2018	-	30,870,000,000	30,870,000,000	4,496,000,000
2019	-	30,870,000,000	30,870,000,000	4,014,000,000
2020	-	30,870,000,000	30,870,000,000	3,584,000,000
2021	-	30,870,000,000	30,870,000,000	3,200,000,000
2022	-	30,870,000,000	30,870,000,000	2,857,000,000
2023	-	30,870,000,000	30,870,000,000	2,551,000,000
2024	-	30,870,000,000	30,870,000,000	2,278,000,000
2025	-	30,870,000,000	30,870,000,000	2,034,000,000
2026	-	30,870,000,000	30,870,000,000	1,816,000,000
2027	-	30,870,000,000	30,870,000,000	1,621,000,000
2028	-	30,870,000,000	30,870,000,000	1,448,000,000
2029	-	30,870,000,000	30,870,000,000	1,293,000,000
2030	-	30,870,000,000	30,870,000,000	1,154,000,000
<b>Discount Rate 12.0%</b>			<b>EIRR</b>	<b>69%</b>
<b>Estimated losses for 1945 flood scenario:</b>			<b>NPV (VND)</b>	<b>180,984,000,000</b>
<b>(VND) 934,000,000,000</b>			<b>NPV (US\$)</b>	<b>12,745,000</b>
<b>(US\$) 66,000,000</b>				

by 50 percent and benefits reduced by 50 percent, the net present value is VND 50 billion (US\$ 3,500,000) and the economic internal rate of return is 23 percent. Given the difficulty involved with estimating economic benefits of a flood protection project, this favorable result lends support to the general results of the economic analysis.

Sensitivity indicators for these calculations are given in italics below the economic internal rate of return and net present value. Sensitivity indicators give the percentage change in the net present value for a percentage change in a variable or the percentage change in the EIRR above 12 percent for a percentage change in a variable. All of the sensitivity indicators are relatively small, indicating that results of the economic analysis are relatively insensitive to changes in project benefits or costs.

To test the sensitivity of the analysis results to changes in the dyke failure probabilities, additional calculations were performed using smaller predicted improvements for the dyke rehabilitation efforts. Two additional sets of with-project dyke failure probabilities were estimated by reducing the predicted improvement of the with-project dyke failure probabilities by 30 percent and by 60 percent of the original estimate. When the predicted with-project dyke failure probabilities improvement was reduced by 30 percent, the economic internal rate of return fell to 48 percent and the net present value fell to VND 115 billion. When the predicted with-project dyke failure probabilities improvement was reduced up by 60 percent, the economic internal rate of return fell to 27 percent and the net present value fell to VND 48 billion. The dyke failure probability sensitivity tests indicate that project acceptability is rather robust regarding variations in the dyke failure probability calculations.

Table 7.14 Sensitivity Analysis of the Economic Analysis for the 1945 Flood Scenario.

(NPV in billion VND)		Base Case	Change in Total Project Costs or Total Project Benefits			
			20%	10%	-10%	-20%
	<b>EIRR</b>	69%				
	<b>NPV</b>	181				
<b>Project costs</b>	<b>EIRR</b>		57%	62%	76%	86%
	<i>sensitivity indicator</i>		-1.01	-1.10	-1.35	-1.51
	<b>NPV</b>		173	177	185	189
	<i>sensitivity indicator</i>		-0.22	-0.22	-0.22	-0.22
<b>Project benefits</b>	<b>EIRR</b>		82%	76%	62%	55%
	<i>sensitivity indicator</i>		1.21	1.21	1.21	1.21
	<b>NPV</b>		225	203	159	137
	<i>sensitivity indicator</i>		1.22	1.22	1.22	1.22
<b>Discount Rate</b>	12.00%					
<b>Sensitivity of results to changes in key parameters:</b>						
		<b>EIRR</b>	<b>NPV</b>			
No industrial benefits included		32%	62			
No road benefits included		67%	177			
Pond Filling costs +15%		60%	160			
Earth Filling (manual) costs +15%		64%	172			
Project benefits +10% and costs -10%:		84%	207			
Project benefits -10% and costs +10%:		56%	155			
Project benefits -50% and costs +50%:		23%	50			
Delay in benefits 1 year		47%	156			
Delay in benefits 2 years		37%	134			
Dyke failure probability improvement reduced 30 percent		48%	115			
Dyke failure probability improvement reduced 60 percent		27%	48			

## **7.5 Sustainability of Project Effects**

The project involves a one-time construction effort requiring no future additional maintenance above the level of annual maintenance already being conducted. However, realizing the economic benefits of this project requires that the dyke system throughout the adjacent areas be maintained. If maintenance of other dyke sections is neglected, then project benefits may be short lived. Given Vietnam's economic expansion, the donor community's interest in flood protection, and the government's awareness of the importance of maintaining the dyke system, this should not be a problem if current dyke maintenance trends continue.

A potential problem arises from the fact that upstream dyke improvements may have an adverse impact on downstream flood potential. In order to avoid these problems, it is necessary to address this problem from a basin-wide approach. However, one of the criteria put forth by the Asian Development Bank is that all projects be part of a river basin plan. The economic analysis can easily be extended to include downstream effects if additional hydrologic analysis is conducted to discover what these effects are.

## **7.6 Poverty Impact Analysis**

Inclusion of the proposed project under the *Third Red River Water Resources Sector Project* requires that the project have a favorable impact on poverty alleviation (Asian Development Bank, 2000). The proposed project has a positive impact on expected incomes through reduced expected flood damage as shown in column E of Table 7.15. Another requirement for inclusion of a project is that the poverty rate in the

project area exceeds 33 percent as measured by the World Bank (Asian Development Bank, 2000). The poverty rates as shown in Table 7.15 indicate that the project is favorable to the Asian Development Bank in terms of rural poverty rates in the project area, where the lowest rural poverty rate is 35 percent for Hanoi Province. Only the total poverty rate for Hanoi City falls below the Asian Development Bank's criteria at 16.8 percent. However, this project includes only two districts from Ha Noi City. Unfortunately, district level poverty rates were unavailable for Ha Noi. The relatively low number of poor population impacted corresponds to the conservative flood scenario used in the analysis.

The Asian Development Bank also considers a project to have favorable impacts on poverty if the project benefits the poor at a greater degree than the more well off. This effect is measured by the poverty impact ratio (PIR), which was computed and is presented in Table 7.15. Poverty impact ratios were calculated using both total project benefits and project benefits less industrial benefits. The poverty impact ratio was then compared to the poverty rates in the project area. The minimum total poverty rate of 35 percent does not compare favorable with the calculated poverty impact ratio of 22. However, when industrial benefits are removed, then the poverty impact ratio compares favorable to the poverty rates at 35 to 67. Since, flood protection project benefits are measured in terms of protected assets and production, an acceptable poverty impact ratio can be estimated by removing large beneficiaries, such as in this case industrial production and assets. However, the removal of certain sectors is arbitrary and cannot be justified. The calculation was done only to demonstrate the weakness of the poverty impact ratio in the present case.

Table 7.15 Poverty Impact Analysis for the Project Using the 1945 Flood Scenario.

<b>Province/City</b>	<b>Urban Poverty Rate (% population)</b>	<b>Rural Poverty Rate (% population)</b>	<b>Total Poverty Rate (% Population)</b>
Ha Noi	2.94	35.47	16.82
Hai Duong	11.3	40.41	36.45
Hung Yen	23.53	47.74	45.72
Bac Ninh	19.69	47.18	44.65
Estimated Urban Poor Population Effected			5,900
Estimated Rural Poor Population Effected			187,300
<b>Poverty Impact Ratio (with industrial benefits)</b>			22.84
<b>Poverty Impact Ratio (no industrial benefits)</b>			67.08

A primary goal of this flood protection project is the reduction in negative income fluctuations among the poor. To analyze this impact, a safety-first criterion was used as an alternative approach to analyzing the project's impact on poverty. The safety-first value is not equated with a certainty equivalent. The certainty equivalent yields a measure of income (or some other variable) that, if acquired with certainty, yields an identical level of utility as the expected outcome of a gamble. The gamble is assumed to have a higher expected value but a variance greater than zero (Brent, 1998).

A safety-first valuation positively relates expected returns to the valuation of the project, while it negatively relates the negative variations of expected outcomes. Some analysts have equated this type of valuation with utility (Brent, 1998). The

interpretation used here of a safety-first valuation, however, is more consistent with the interpretation given by Roy (1952) in that a safety-first valuation assigns points to alternative resource allocations, so that it is neither a money value nor utility measure. Rather, the safety-first valuation offers a preference scale of alternative resource allocations for an individual farmer.

If, as in this case, it is assumed that the target group is homogeneous in their risk preference, then the safety first values can be used to indicate a social preference ordering (for the farmer subset). The assumption of homogeneity requires that all farmers hold the same risk preference parameter across all incomes. The safety-first value can then be used to get an idea of the relative magnitude of the increase in benefits attributable to the reduction in the probability of disaster. As will be shown, those furthest below the threshold will experience the greatest increase in value because of the project. Those with expected incomes above the threshold will no longer factor in the negative variations and will have relatively small increases in their safety-first values. However, one must use caution in interpreting the safety-first values and remember that it is only a point-based preference ordering

The safety-first valuations were originally designed so that one could maximize expected return while minimizing the probability of a disaster occurring. Roy (1952) explicitly stated that he used safety-first solely to discover the implications of a certain type of behavior. He felt that people rarely judged alternative assets solely based on the assets upside potential, but investment decisions were also significantly affected by the chance that the final outcome would fall below some critical threshold level. Current

research focus has shifted to the ways in which uncertainty are managed to stabilize household consumption and away from subjective risk preferences (Ellis, 1998).

The critical threshold for the project was considered as the official Vietnamese poverty line measured at VND 100,000 per person per month. Four farm models were evaluated to measure the project's impact on agricultural incomes. The farm models were developed for the Gia Thuan Irrigation Project Feasibility Study (Asian Development Bank, 1999). Each farm size (small, medium, and large) represents approximately one-third of all farms in the Gia Thuan Irrigation Project area, which includes part of the Duong River Project area.

The project has a positive impact on expected agricultural incomes, albeit somewhat small (average of about VND 60,000 per household annually). The safety-first ranking criteria, unlike the poverty impact ratio, shows a favorable indication for the project, with all farm models ranking the with-project scenario higher (safety-first ranking of 1) than the without-project scenario (safety-first ranking of 2) as shown in Table 7.16. This result holds at a risk preference value of one, which indicates unity weighted risk aversion.

As explained in Chapter 6, two critical thresholds were used for calculation of the safety-first valuations. The first critical threshold is the expected per capita income resulting without the project. The second critical, and more relevant, threshold is the per capita income used to designate the poverty line in Vietnam. The safety-first rankings reported in Table 7.16 result from use of the expected income level threshold to calculate safety-first values. The poverty level threshold, however, is the threshold level that is used for the one analyzed for the poverty impact sensitivity analysis.

Table 7.16 Impact of Project on Farm Income for Different Farm Sizes

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>		<b>E</b>	<b>F</b>
	Farm Size (ha) /a	Estimated annual farm income without flood (VND)	Maximum Expected Flood Damage (VND)	Income comparison		Safety- First Ranking	
				Monthly per capita income without flood (VND)	Monthly per capita income with flood (VND)		
<b>Small Farm A</b>							
Without-project	0.17	3,535,700	990,600	58,900	57,600	2	
With-project	0.17	3,535,700	980,700	58,900	58,100	1	
<b>Small Farm B /b</b>							
Without-project	0.17	2,871,400	990,600	47,900	46,500	2	
With-project	0.17	2,871,400	980,700	47,900	47,100	1	
<b>Medium Farm</b>							
Without-project	0.27	5,511,600	1,544,200	91,900	89,800	2	
With-project	0.27	5,511,600	1,528,700	91,900	90,600	1	
<b>Large Farm</b>							
Without-project	0.40	8,319,400	2,330,800	138,700	135,500	2	
With-project	0.40	8,319,400	2,307,500	138,700	136,800	1	

/a Source: ADB (1999) Gia Thuan Irrigation And Drainage Rehabilitation Project Feasibility Study (calculated only for Bach Ninh Province).

/b Note: Small farm B is distinguished from small farm A in that farm B grows no winter crop.

The computed safety-first valuations using expected income as the threshold for each alternative show that the with-project alternative has a higher safety-first value for all of the four farm models as presented in Table 7.17. For the average farm size, the increase in annual safety-first value per household is approximately 913,000. The per hectare safety-first valuation is higher for the small farm A (4,095,000) than for the medium farm (4,065,000), but lower for the large farm (4,155,000). The small farm B, the poorest farm, has the lowest per-hectare valuation (3,319,000) of all the other farms. This is caused by the dominant effect of the reduction in annual income based on small farm B's cropping pattern. The results given here are inconsistent with the proposed utility theory indicating that expected income is not the appropriate threshold to use in order to derive a preference ordering consistent with the utility theory. Instead, it is appropriate to use the poverty line as the critical threshold to analyze investment decisions in regard to impacts on poverty.

The safety-first valuations using the poverty level of VND 100,000 per capita per month as the critical threshold are shown in Table 7.18. The large farm model, which is initially above the poverty line, is the only model with a positive safety-first valuation of the project. It is also identical to the valuation using expected income as the threshold. This is because the lower partial moment is not calculated above the threshold level. The incremental increases in valuations on a per hectare basis are much higher for the poorest farm than for the richest. While the large farm increases its valuation of the project by 6,293 per hectare per year, the poorest farm (small farm B) has an incremental value increase of 6.4 billion. Thus, the small farm experiences a greater increase in their safety-first valuation from an implementation of the project.

**Table 7.17 Safety-First Values for Different Farms Sizes With and Without the Project using expected income as the threshold.**

	Farm size (ha) /b	Monthly per capita safety-first value	Annual per capita safety-first value	Per ha safety-first value
<b>Small Farm A</b>				
Without-project	0.17	52,954	635,451	3,737,948
With-project	0.17	58,026	696,310	4,095,941
<b>Small Farm B</b>				
Without-project	0.17	41,954	503,451	2,961,478
With-project	0.17	47,026	564,310	3,319,470
<b>Medium Farm</b>				
Without-project	0.27	77,452	929,421	3,507,248
With-project	0.27	89,776	1,077,311	4,065,325
<b>Large Farm</b>				
Without-project	0.40	138,302	1,659,630	4,149,075
With-project	0.40	138,512	1,662,147	4,155,367

Utilization of the safety-first criterion results in approval of a project that holds great incremental safety-first value for the target group. This project, however, is rejected under the poverty impact ratio criteria. The safety-first technique has also given guidance as to the preferred alternative based on the impact the project has on national and project goals regarding reduction in negative income fluctuations.

A difficulty with the safety-first approach lies in the identification of the proper risk parameter,  $k$ . A positive value of  $k$  indicates risk aversion with higher values of  $k$

related to higher degrees of risk aversion. In order to estimate a value of the risk parameter, a parametric approach can be utilized. Different parameters can be varied in order to trace out a frontier. Once a frontier is determined, it can be solved for the proper  $k$  based on the existing conditions of the other parameters.

Table 7.18 Safety-First Values for Different Farms Sizes With and Without the Project using the poverty line as the threshold.

	Assumed Farm Size (ha) /b	Monthly Safety-First Value	Annual Safety-First Value	Annual Per ha Safety-First Value	Incremental Increase in Value
<b>Small Farm A</b>					
Without-project	0.17	-134,000,000	-1,679,000,000	-9,879,000,000	4,026,000,000
With-project	0.17	-82,900,000	-995,000,000	-5,852,000,000	
<b>Small Farm B</b>					
Without-project	0.17	-224,000,000	-2,692,000,000	-15,836,000,000	6,441,000,000
With-project	0.17	-133,000,000	-1,597,000,000	-9,395,000,000	
<b>Medium Farm</b>					
Without-project	0.27	-5,800,000	-69,900,000	-263,700,000	115,700,000
With-project	0.27	-3,300,000	-39,000,000	-147,900,000	
<b>Large Farm</b>					
Without-project	0.40	138,302	1,659,630	4,149,075	6,293
With-project	0.40	138,512	1,662,147	4,155,367	

Results of the sensitivity analysis of the safety-first rule to the risk parameter,  $k$ , for small farm A are presented in Table 7.19. The figures in Table 7.19 show that as

risk-aversion grows, the lower the safety-first value is for the project. This is because of the increasing importance (or weighting) the negative variance receives. The third column, though, shows the incremental increase in safety-first value of the project over the without-project safety-first value.

Table 7.19 Sensitivity of Safety-First Values to the Risk Parameter.

Risk preference parameter (k)	Per capita safety-first value	Incremental change in safety-first value
0.0	58,820	89
0.1	-8,237,805	5,704,235
1.0	-82,907,434	57,041,543
2.0	-165,873,687	114,082,996
3.0	-248,839,941	171,124,450
4.0	-331,806,195	228,165,904

The results of the sensitivity analysis of the safety-first values to variations in the threshold level are shown in Table 7.20. The results demonstrate that safety-first values lose value at an increasing rate as the expected outcome falls further below the critical level. Once expected outcome rises above the critical threshold level, however, the safety-first value simply reflects the expected outcome in its calculation. This is caused because the lower partial moment is not computed for possible outcomes above the threshold level. Therefore, it can be interpreted that the downward risk is no longer a concern of the decision maker. In this manner, the safety-first rule can also be

interpreted as reflecting changes in attitude toward risk as income climbs. As the decision maker moves above the threshold level, downward risk is no longer incorporated into the valuations used to order alternative project.

Table 7.20 Sensitivity of Safety-First Values to the Threshold Level.

Critical Threshold (VND)	Per capita safety-first value	Incremental change in safety-first value
25,000	58,820	89
50,000	58,820	89
75,000	-12,800,000	9,000,000
100,000	-82,900,000	57,000,000
200,000	-885,000,000	476,000,000

The sensitivity analysis of both the poverty impact ratio and the safety-first rule are presented in Table 7.21. Several key parameters were varied to explore the two approaches. These parameters included the critical threshold level and the risk preference parameter. Additionally, the amount of benefits received by the poor relative to the other income groups was increased.

The sensitivity analysis revealed that there was only one case where the poverty impact ratio and the safety-first valuation yielded identical results. This is when the benefits for the poor are doubled while benefits received by the other economic sectors are held constant. In this case, however, the income of the poor is boosted to the level where they are no longer considered poor.

**Table 7.21 Sensitivity Comparison of Poverty Impact Ratio and Safety-First.**

Critical threshold (VND)	Risk preference parameter ( <i>k</i> )	Expected benefits to the poor (X's increase)	Poverty impact ratio (Critical: 35.5%)	Incremental change in safety-first value	Approval by poverty impact ratio	Approval by safety-first criterion
50,000	1	1	22.84	89	no	yes
75,000	1	1	22.84	9,000,000	no	yes
100,000	1	1	22.84	57,000,000	no	yes
200,000	1	1	22.84	476,000,000	no	yes
100,000	1	2	37.19	9,400,000	yes	yes
100,000	2	1	22.84	114,000,000	no	yes
100,000	0	1	22.84	89	no	yes

The first four rows of Table 7.21 show that the further below the poverty line a farmer's income is, the greater is their incremental change in safety-first value for the project. One final point of note concerns the case when poverty is eliminated. When all possible outcomes are above the poverty line, that is, poverty is eliminated, and the poverty level is used as the critical threshold level, then the safety-first rule yields values that are identical to a zero weight being given to risk.

The sensitivity of the net present value calculation to the choice of discount rate was also tested. Results for the sensitivity tests for choice of discount rate are presented in Table 7.22. The results in the table indicate that the net present value will continue to indicate a favorable project up to a discount rate of somewhere between 65 percent and

70 percent. Therefore, the project recommendations drawn from the net present value can be said to be no sensitive to the discount rate.

Table 7.22 Sensitivity of Net Present Value to the Discount Rate.

Discount rate	Net Present Value of Project (US\$)
10%	\$15,531,000
12%	\$12,656,000
50%	\$784,000
65%	\$109,000
100%	-\$492,000

The sensitivity analysis indicates that the poverty impact ratio will never given an acceptable rating for a flood protection project using the current modeling techniques. This result is caused by the fact that flood protection benefits are valued by production and assets and that damage estimates are estimated without variation to different flood heights. This directly contradicts the high value that poor farmers acting according to safety-first rules would give the project.

A criticism with the results is that the increase in expected income attributable to the project is relatively small. This is because project benefits depend on the occurrence of a low probability event. This criticism is, of course, true. Ultimately, the answer to this problem must be left to the policy maker. The results, however, of the analysis show that the flood protection project is an economically desirable project based on the potential Pareto criterion. Additionally, results show that the project has a

positive impact regarding a reduction in negative income fluctuations among the poor. If safety-first behavior is accepted as a valid reflection of actual farmer behavior then any reduction in the probability of disaster occurring is valued more than the expected benefits it creates for the farmer. This is a result of the risk adversity of the farmers.

## **CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS**

This study examined the practical application of welfare economic theory to cost-benefit analysis. Cost-benefit analysis uses the potential Pareto criterion to guide resource allocations to maximize the welfare of society. Traditionally, the resource allocation optimization problem has been approached from an economic efficiency standpoint. Under standard cost-benefit analysis, economic efficiency is defined as the greatest increase in the aggregate level of net benefits regardless of the distribution of benefits. The alternative project that is the most preferred is the one with the highest net present value. Therefore, the efficiency criterion is flawed if distributional issues are important to society. The efficiency criterion subsumes that the current income distribution is acceptable and gives equal weighting to all benefits and costs. Therefore, adherence to the efficiency criterion may result in resource allocation decisions that create undesirable effects, such as exacerbating poverty.

From a theoretical standpoint, the problem arises from the measurement of social welfare. It is generally held that social welfare should be a function of the welfare of society's individuals. The most thoroughly explored idea for measuring a person's welfare is that of utility. Utility is a theoretical concept that provides a representation of a person's well-being or welfare. In order to be useful, utility would have to be measurable, cardinal, and comparable. Unfortunately, it has been shown that utility is only ordinally measurable and not interpersonally comparable. In response to

these findings, welfare economics began to focus on the valuation of benefits received from a resource allocation as a proxy for welfare measurements.

Another problem arises from the aggregation of individual preferences. It is a general accepted assumption that individuals act to maximize their utility. It is also generally assumed that society makes resource allocation decisions to maximize society's utility. It follows that the social welfare function should be a function of individual utilities. The search for an aggregation rule included Arrow's social choice rule, which found that it was impossible to formulate a social choice function if certain conditions were adhered to which were considered part of a reasonable society. The search for an aggregation rule also included Bergson's social choice function, which could aggregate individual utilities, but would change for any change in individual utilities. Unfortunately, since utility is not measurable, cardinal, or interpersonally comparable, it remained impossible to aggregate individual utilities. Therefore, the aggregation of individual welfare has moved to the utilization of the aggregate measures of benefit valuations as a measure of social welfare.

Cost-benefit analysis is the practical embodiment of this search. Cost-benefit analysis is a tool used to evaluate alternative resource allocations in order to determine optimal allocations. Traditionally, the optimal criterion has been the efficiency in resource use. Defined under the idea of Pareto optimality, this means that resources are used optimally when no reallocations exist where at least one person can gain without causing another to lose. Since most policy choices cause at least some people to lose, the idea of potential Pareto improvements was introduced. This allows the gainers to

hypothetically compensate the losers and still realize a net gain. The result is a positive aggregate measure of net benefits.

Cost-benefit analysis aggregates individual preferences by summing the valuations of net benefits received from a resource allocation into a net present value. The socially preferred option is the allocation that yields the highest net benefits. This approach is implicitly based on the idea that the distribution of benefits is not important to society. It implies the idea that the marginal utility of income is identical for all people. However, this idea is contrary to utility theory, which theoretically holds that the marginal utility of income is higher for the poor.

In order to accommodate poverty concerns several different approaches have been suggested. One approach to including poverty into cost-benefit analysis is to weight the benefits accruing to the poor more heavily than the benefits accruing to the rich. This allows targeting in favor of the poor, yet maintains the appealing single index ranking of projects. Unfortunately, this method has proved both arbitrary in construction and difficult in implementation.

Problems with the weighting approach center on an inherent arbitrariness as to the development of the weights. There is a lack of any empirical basis for the establishment of the weights. This has led to a general lack of comfort with explicitly stating the value judgments underlying a weighting system. Therefore, most economic analyses tend to favor the traditional unweighted approach where value judgments regarding the weights do not need to be stated explicitly. The traditional approach, however, does in fact embody the value judgment that the current distribution of income is acceptable and benefit weights do not need to be utilized.

Other approaches address the issue from a multi-dimensional standpoint. Poverty concerns are analyzed separately from the cost-benefit analysis, such as with the poverty impact ratio recommended by the Asian Development Bank. The poverty impact ratio, as recommended by the Asian Development Bank attempts to measure project net benefits accruing to the poor and compare them with overall net benefits. If the poverty impact ratio exceeds some benchmark rate, then the project is acceptable regarding impact on poverty alleviation goals.

This study examined a proposed dyke rehabilitation project for the Duong River in the Red River Delta of Vietnam. A major objective of the project is to contribute to poverty alleviation through a reduction in vulnerability to flooding. The economic sectors analyzed are those productive activities or asset holdings that are susceptible to flood damage. This study focused on industry, agriculture, housing, road infrastructure, and commerce.

This study has shown that the traditional cost-benefit analysis techniques fall short when poverty alleviation is an objective. First, cost-benefit analysis fails to adequately address divergence in incomes, especially in the case of poverty. The marginal utility of income for people varies by income level. It has been shown that the marginal utility of income for those in poverty approaches infinity. Therefore, on an individual basis a person living in poverty will apply every additional unit of income obtained to the purchase of a necessary bundle of consumption goods in an attempt to escape poverty. Thus, it will normally prove beneficial to implement projects that help the poor escape poverty even though the willingness to pay measures are relatively low.

However, in the current project poverty alleviation is the main objective of the project. The Asian Development Bank recommends the use of a poverty impact ratio to examine a project's impact on poverty. The poverty impact ratio falls short for the current case. This shortcoming is a result of the method by which flood protection benefits are estimated as discussed above. Use of the poverty impact ratio in flood protection projects will be biased against the poor as well. According to the poverty impact ratio, a project that benefits the poor greatly and the rich some will be outweighed by a project that benefits the poor only a little and the rich none. This is inconsistent with the poverty alleviation objective.

This study shows that a safety-first valuation criterion can provide a way to effectively rank alternative flood protection projects according to their impact on the poor. The safety-first valuation shows incremental increases that far exceed the incremental increases in income. This is consistent with the idea that below poverty the marginal utility exceeds the marginal willingness to pay. The safety-first approach is acceptable in the current situation because the target group is relatively homogenous in productive activities. This approach could become impractical in cases of developing countries where livelihoods are far more varied.

Safety-first valuations were originally proposed as a method to incorporate risk concerns when the primary concern was downward fluctuations in wealth below some critical threshold. This is precisely what the current project is designed to accomplish. The safety-first valuation incorporates the change in probability of disaster occurring as produced by the project. It further incorporates the main concern, which is the poverty line. Because the expected outcome is already substantially below the poverty line, the

variance of potential negative income fluctuations outweighs the expected outcome producing negative valuations. However, the incremental increases in safety-first valuations are much larger than the incremental increases in expected income. This result is consistent with the concept of utility below the poverty line.

For the case study examined in this paper, the traditional cost-benefit analysis indicates a favorable project if the specifics of funding can be finalized. The current cost estimates exceed the project selection criteria by over US\$ 1 million. Given the enormous potential benefits of this project it may be prudent to relax the project cost limitations, rather than compromise the integrity of the rehabilitation by limiting construction activities to an arbitrary construction cost limit.

The property damage avoided method used for calculating the economic benefits of a flood protection project is limited in the current case. A lack of data did not allow for the inclusion of flood scenarios that varied with river height. Therefore, flood damage, and thus project benefits, will be overestimated. Incorporation of a more accurate flood model will improve the preciseness of the results. In order to compensate for this problem, a conservative flood scenario was used in the estimation of the economic benefits.

The poverty impact analysis, however, does not meet the Asian Development Bank's poverty impact ratio criterion. This result is caused by the way flood protection benefits are calculated and Vietnam's existing poverty situation. Benefits to the poor are quickly outweighed by benefits accruing to the more highly valued industrial sector.

The safety-first valuations demonstrated a marked increase in the valuation of the project benefits caused by the explicit incorporation of risk into the estimation.

Utilized as a separate ranking criterion, the safety-first valuation indicated a significant impact on poverty alleviation and a favorable project. This method is limited to those situations where the output is probabilistic, the target group is rather homogeneous in behavior, and traditional benefit estimation techniques are based on asset and production values when poverty alleviation is a concern. Therefore, the project demonstrates clear support of Vietnam's development strategy and the Asian Development Bank's goal of poverty alleviation. The proposed project will help to alleviate poverty in the project area by reducing expected negative income fluctuations due to flooding.

Estimation of an accurate value for the risk parameter was presented as one problem with the safety-first approach. In this sense, it is similar to a benefit-weighting scheme in that the assignment of a risk parameter can be arbitrary. One approach to rectifying this problem is to pursue a parametric approach in an attempt to discover an accurate representation of this variable. In the case were different values for the risk parameter change investment decisions, different parameters can be varied and analyzed based on actual decision behavior. In this way, an accurate representation of existing risk-aversion can be determined and incorporated into future studies.

It is recommended that the safety-first valuation method be utilized in situations when poverty alleviation is a concern for flood protection projects. The change in flood probabilities will normally be calculated for the hydrologic and hydraulic analyses, so the with and without project probabilities are known. The valuations are calculated for those projects that first meet the traditional economic analysis requirements of a positive net present value and an acceptable internal rate of return. This will guarantee

a project that is economically viable. The safety-first valuations can then be used to rank projects based on their expected impact on the social goal of poverty alleviation. Future research may want to examine similar valuation techniques to find a method that produces positive valuations of project benefits. This would result in a method that is even more thoroughly consistent with the utility of those in poverty.

Future research could investigate the impact that a flood has regarding the length of time it takes a farmer to recover to pre-flood conditions. This research could give another dimension to the potential impact of a flood protection project on poverty alleviation. A second possible area of future research could focus on the theory of utility for those living in poverty developed here. Especially important would be a thorough development of the conditions and their implications for market equilibrium.

## REFERENCES

- Albala-Bertrand, J. M. (1993). *Political Economy of Large Natural Disasters: with Special Reference to Developing Countries*. Clarendon Press, Oxford.
- Anand, P. (2000). "Decisions vs. Willingness-to-Pay in Social Choice." *Environmental Values* 9: 419-430.
- Arrow, K. J. (1951). *Social Choice and Individual Values*. Wiley, New York.
- Asian Development Bank (1997). *Guidelines for the Economic Analysis of Projects*. Asian Development Bank, Manila.
- Asian Development Bank (1999). *Fighting Poverty in Asia and the Pacific: The Poverty Reduction Strategy*. Asian Development Bank, Manila.
- Asian Development Bank (1999). *Gia Thuan Irrigation Rehabilitation Subprojects*. Asian Development Bank, Hanoi.
- Asian Development Bank (1999). *Profile of the Water Resources of the Red River Basin*. Asian Development Bank, Hanoi.
- Asian Development Bank (2000). *Aide Memoir: Pre-Appraisal of the Proposed Second Red River Basin Sector Project*, Hanoi.
- Baulch, B. (2000). E-mail to Marshall L. Silver, September 26, 2000.
- Bentham, J. (1791). *Principles of Morals and Legislation*. Doubleday, London.
- Bentkover, J. D., V. T. Covello, et al., Eds. (1986). *Benefits Assessment: The State of the Art*. D. Reidel Publishing Company, Dordrecht.
- Bergson, A. (1938). "A Reformulation of Certain Aspects of Welfare Economics." *Quarterly Journal of Economics* 52(2): 310-334.
- Bigman, D. (1996). "Safety-First Criteria and Their Measures of Risk." *American Journal of Agricultural Economics* 78(February): 225-235.
- Binnie & Partners (1994). *Red River Delta Master Plan: Background Report 1: Hydrology and Meteorology, Volume 1*. World Bank, Hanoi.

- Binnie & Partners (1994). *Red River Delta Master Plan: Volume 2: The Present Situation*. World Bank, Hanoi.
- Blue, E. N. and L. Tweeten (1997). "The Estimation of Marginal Utility of Income for Application to Agricultural Policy Analysis." *Agricultural Economics* 16: 155-169.
- Boadway, R. W. (1974). "The Welfare Foundations of Cost-Benefit Analysis." *The Economic Journal* December: 926-939.
- Boadway, R. W. and N. Bruce (1984). *Welfare Economics*. Basil Blackwell, New York.
- Boisvert, R. N. (1972). *Choice in Risk Situations: A Comparison and Evaluation of Alternative Criteria*. Ithaca, Cornell University.
- Bonner, J. (1986). *Introduction to the Theory of Social Choice*. Johns Hopkins University Press, Baltimore.
- Brent, R. J. (1990). *Project Appraisal for Developing Countries*. New York University Press, New York.
- Brent, R. J. (1998). *Cost-Benefit Analysis for Developing Countries*. Edward Elgar, Cheltenham.
- Buchanan, J. A. (1954). "Social Choice, Democracy, and Free Markets." *Journal of Political Economy* 62(2): 114.
- Burrell, J. (2000). E-mail to author, December 13, 2000.
- Buss, T. F. and L. C. Yancer (1999). "Cost-Benefit Analysis: A Normative Perspective." *Economic Development Quarterly* 13(1): 29-37.
- Clements, P. (1993). "An Approach to Poverty Alleviation for Large Development Agencies." *World Development* 21(10): 1633-1646.
- Coles, J. L. and P. J. Hammond (1995). "Walrasian Equilibrium without Survival: Existence, Efficiency, and Remedial Policy." *Choice, Welfare, and Development: A Festschrift in Honour of Amartya K. Sen*. K. Basu, P. Pattanaik and K. Suzumura. Clarendon Press, Oxford.
- Cooter, R. and P. Rappoport (1984). "Where the Ordinalists Wrong About Welfare Economics." *Journal of Economic Literature* 22(June): 507-530.
- Dasgupta, P., P. Hammond, et al. (1979). "The Implementation of Social Choice Rules: Some General Results on Incentive Compatibility." *The Review of Economic Studies* 46(2): 185-216.

Davies, J. E. (1994). "Giffen Goods, the Survival Imperative, and the Irish Potato Culture." *Journal of Political Economy* 102(3): 547-565.

DDMFC (2000). *Hydrological and Hydraulic Analysis for Duong River System*. Ministry of Agriculture and Rural Development, Hanoi.

Driscoll, P., B. Dietz, et al. (1994). "Welfare Analysis When Budget Constraints are Nonlinear: The Case of Flood Hazard Reduction." *Journal of Environmental Economics and Management* 26: 181-199.

Eckstein, O. (1958). *Water-Resource Development: The Economics of Project Evaluation*. Harvard University Press, Cambridge.

Edgeworth, F. Y. (1881). *Mathematical Physics*. Kegan Paul, London.

Eeckhoudt, L. and C. Gollier (1995). *Risk: Evaluation, Management and Sharing*. Harvester, New York.

El-Jabi, N. and J. Rouselle (1987). "A Flood Damage Model for Flood Plain Studies." *Water Resources Bulletin* 23(2): 179-187.

Ellis, F. (1998). *Peasant Economics: Farm Households and Agrarian Development*. Cambridge University Press, Cambridge.

Fishburn, P. C. (1977). "Mean-Risk Analysis with Risk Associated with Below-Target Returns." *The American Economic Review* 67(2): 116-126.

Fisher, F. M. (1956). "Income Distribution, Value Judgments, and Welfare." *Quarterly Journal of Economics* 70(3): 380-424.

Food and Agriculture Organization (1992). *Vietnam: Watershed Management and Ethnic Minorities: Main Report*. Hanoi, Food and Agriculture Organization.

Freeman III, A. M. (1974). "On Estimating Air Pollution Control Benefits from Land Value Studies." *Journal of Environmental Economics and Management* 1: 74-83.

General Statistical Office (1999). *Results of Survey on Industry 1998*. General Statistical Office, Hanoi.

General Statistical Office (1999). *Socio-Economic Statistic Data of 61 Provinces and Cities in Vietnam*. Statistical Publishing House, Hanoi.

General Statistical Office (1999). *The Socio-Economic Survey of Households: 1994-1997*. Statistical Publishing House, Hanoi.

General Statistical Office (1999). *Statistical Yearbook 1998*. Statistical Publishing House, Hanoi.

General Statistical Office (2000). *Hanoi Statistical Yearbook 1999*. Statistical Publishing House, Hanoi.

Gillroy, J. M. (1992). "The Ethical Poverty of Cost-Benefit Methods: Autonomy, Efficiency, and Public Policy Choice." *Policy Sciences* 25: 83-102.

Hai Duong Statistical Office (1998). *Statistical Yearbook 1997 Hai Duong Province*.

Hanke, S. H. (1981). "On the Feasibility of Benefit-Cost Analysis." *Public Policy* 29(2): 147-157.

Hanoi Statistical Office (2000). *Statistical Yearbook 1999*. Hanoi Statistical Office, Hanoi.

Harberger, A. C. (1972). *Project Evaluation: Collected Papers*. Markham Publishing Company, Chicago.

Harsanyi, J. C. (1953). "Cardinal Utility in Welfare Economics and in the Theory of Risk-taking." *The Journal of Political Economy* 61(5): 434-435.

Harsanyi, J. C. (1969). "Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparisons of Utility." *Readings in Welfare Economics*. K. J. Arrow and T. Scitovsky. Richard D. Irwin, Inc., Homewood. 12.

Herzog, H. W. and A. M. Schlottmann (1990). "Valuing Risk in the Workplace: Market Price, Willingness to Pay, and the Optimal Provision of Safety." *The Review of Economics and Statistics* 72(3): 463-470.

Hicks, J. R. and R. G. D. Allen (1934). "A Reconsideration of the Theory of Value: Part I." *Economica* 1: 52-76.

Hicks, J. R. and R. G. D. Allen (1934). "A Reconsideration of the Theory of Value: Part II - A Mathematical Theory of Individual Demand Functions." *Economica* 1: 196-219.

Hirshleifer, J. (1983). "From Weakest-link to Best-shot: The Voluntary Provision of Public Goods." *Public Choice* 41: 371-386.

Kataoka, S. (1963). "A Stochastic Programming Model." *Econometrica* 31(1-2): 181-196.

Kim, J. S. (1989). "An Application of the Lexicographic Model of Choice to Flood Loss Management in the Republic of Korea." : Ph.D. Dissertation, Colorado State University.

- Knight, F. H. (1957). *Risk, Uncertainty and Profit*. Kelley and Millman, Inc., New York.
- Lal, D. (1974). *Methods of Project Analysis: A Review*. World Bank, Baltimore.
- Lewis, G. W. and D. T. Ulph (1988). "Poverty, Inequality and Welfare." *The Economic Journal* 98(390): 117-131.
- Lind, R. C., K. J. Arrow, et al. (1982). *Discounting for Time and Risk in Energy Policy*. Resources for the Future, Inc., Washington, D.C.
- Little, I. M. D. (1952). "Social Choice and Individual Values." *Journal of Political Economics* 60: 422-432.
- Little, I. M. D. and J. A. Mirrlees (1974). *Project Appraisal and Planning for Developing Countries*. Basic Books, Inc., New York.
- Londero, E. (1996). *Benefits and Beneficiaries: An Introduction to Estimating Distributional Effects in Cost-Benefit Analysis*. Inter-American Development Bank, Washington, D.C.
- Lustig, T. (1992). *A Method of Rapid Assessment of the Economic Benefits of Strategies for Mitigating Floods with Limited Data: the Case of North and Central Vietnam*. UNDP, Hanoi, Vietnam.
- Lustig, T. (1993a). *Evaluation of the Benefits of Emergency Rehabilitation of Ha Noi Dyke*. Asian Development Bank, Hanoi.
- Lustig, T. (1993b). *Economic Benefits of Strategies for Mitigating Floods in North and Central Vietnam*. United Nations Development Program, Hanoi.
- Mandler, M. (2000). "Interpersonal Comparisons of Utility and the Policy Paralysis Problem." *Social Choice and Welfare* 17: 95-115.
- Markowitz, H. (1952). "Portfolio Selection." *The Journal of Finance* 7(1).
- Marshall, A. (1948). *Principles of Economics*. The Macmillan Company, New York.
- McGregor, P. (1998). "Famine: A Simple General Equilibrium Model." *Oxford Economic Papers* 50: 623-643.
- McGuire, M. C. and H. Arron (1969). "Efficiency and Equity in the Optimal Supply of a Public Good." *The Review of Economics and Statistics* 51(1): 31-39.
- Miracle, M. P. (1968). "Subsistence Agriculture: Analytical Problems and Alternative Concepts." *American Journal of Agricultural Economics* 50(May): 292-310.

- Mishan, E. J. (1974). "Flexibility and Consistency in Project Evaluation." *Economica* 41(161): 81-96.
- Mishan, E. J. (1980). "How Valid are Economic Evaluations of Allocative Changes?" *Journal of Economic Issues* 14(1): 143-161.
- Mummy, G. E. and S. H. Hanke (1975). "Public Investment Criteria for Underpriced Public Products." *The American Economic Review* 65(4): 712-720.
- Nicholson, W. (1995). *Microeconomic Theory: Basic Principles and Extensions*. Harcourt Brace College Publishers, Fort Worth.
- Pearce, D. W., Ed. (1994). *The MIT Dictionary of Modern Economics*. The MIT Press, Cambridge.
- Pearce, D. W. and C. A. Nash (1981). *The Social Appraisal of Projects: A Text in Cost-Benefit Analysis*. The Macmillan Press, Ltd., London.
- Perman, R., Y. Ma, et al. (1996). *Natural Resource and Environmental Economics*. The MIT Press, Cambridge.
- Pigou, A. C. (1951). "Some Aspects of Welfare Economics." *The American Economic Review* 41(3): 287-302.
- Rashid, S. (1980). "The Policy of Laissez-Faire During Scarcities." *The Economic Journal* 90(September): 493-503.
- Rawls, J. (1971). *A Theory of Justice*. Harvard University Press, Cambridge.
- Ray, D. (1998). *Development Economics*. Princeton University Press, Princeton.
- Rizzi, D. (1990). "Discontinuous Preferences and Ethical Poverty Indices." *Economic Notes* 3: 321-341.
- Roberts, F. S., Ed. (1979). *Measurement Theory with Applications to Decision Making, Utility, and the Social Sciences*. Encyclopedia of Mathematics and its Applications. Addison-Wesley Publishing Company, Reading.
- Rothenberg, J. (1953). "Conditions for a Social Welfare Function." *Journal of Political Economy* 61(5): 389-405.
- Roy, A. D. (1952). "Safety First and the Holding of Assets." *Econometrica* 20(3): 431-449.

- Samuelson, P. (1954). "The Pure Theory of Public Expenditure." *The Review of Economics and Statistics* 36: 387-389.
- Samuelson, P. A. (1973). *Economics*. McGraw-Hill, New York.
- Sands, B. (1989). "Agricultural Decision-Making under Uncertainty: The Case of the Shanxi Farmers, 1931-1936." *Explorations in Economic History* 26: 339-359.
- Sassone, P. G. and W. A. Schaffer (1978). *Cost-Benefit Analysis: A Handbook*. Academic Press, Inc., San Diego.
- Scandizzo, P. L. and O. K. Knudsen (1980). "The Evaluation of the Benefits of Basic Need Policies." *American Journal of Agricultural Economics* February: 46-57.
- Schmid, A. A. (1989). *Benefit-Cost Analysis: A Political Economy Approach*. Westview Press, Boulder.
- Sen, A. (1970). "The Impossibility of a Paretian Liberal." *Journal of Political Economy* 78(January/February): 152-157.
- Sen, A. (1982). *Choice, Welfare and Measurement*. The MIT Press, Cambridge.
- Sen, A. (1995). "Rationality and Social Choice." *The American Economic Review* 85(1): 1-24.
- Shabman, L. (1997). "Making Benefit Estimation Useful: Lessons From Flood Control Experience." *Water Resources Update* Autumn(109): 19-24.
- Shanmugam, K. R. (2000). "Valuations of Life and Injury Risks." *Environmental and Resource Economics* 16: 379-389.
- Sharma, P. N. (1992). "Status and Future Needs for Forest Watershed Management in Vietnam." *Applied Engineering in Agriculture* 8(7): 461-469.
- Squire, L. and H. G. v. d. Tak (1975). *Economic Analysis of Projects*. Johns Hopkins University Press, Baltimore.
- Stevens, J. B. (1993). *The Economics of Collective Choice*. Westview Press, Boulder.
- Sugden, R. (1993). "Welfare, Resources, and Capabilities: A Review of Inequality Reexamined by Amrtya Sen." *Journal of Economic Literature* 31(4): 1947-62.
- Telser, L. G. (1955). "Safety First and Hedging." *The Review of Economic Studies* 23(1): 1-16.
- Tinbergen, J. (1964). *Central Planning*. Yale University Press, New Haven.

- Todaro, M. P. (1996). *Economic Development*. Addison-Wesley Publishing Company, Reading.
- U.S. Army Corps of Engineers (1996). "Federal Perspective for Flood-Damage-Reduction Studies." *Water Resources Handbook*. L. W. Mays. McGraw-Hill, New York.
- U.S. Water Resources Council (1983). *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*.
- UNDP/DMU (1999). Disaster Management Unit. 1999.
- UNIDO (1978). *Guide to Practical Project Appraisal: Social Benefit-Cost Analysis in Developing Countries*. United Nations, New York.
- Upton, M. (1987). *African Farm Management*. Cambridge University Press, Cambridge.
- Varian, H. R. (1992). *Microeconomic Analysis*. W. W. Norton & Company, New York.
- Veilleux, C. (1994/95). "Viet Nam's Forest: Historical Perspective on a Major Issue for Sustainable Development." *Journal of Business Administration* 22 & 23: 51-67.
- VNS (2000). "Life Limps Back to Normal in Flood-ravaged Provinces." *Vietnam News* 1 November 2000: 3.
- World Bank (1995). *Vietnam Environmental Program and Policy Priorities for a Socialist Economy in Transition*. World Bank, Washington, D.C.
- World Bank (1995). Vietnam Water Resources Sector Review: Working Paper 6. Hanoi, World Bank.
- World Bank (1999). *Vietnam Development Report 2000 Attacking Poverty: Country Economic Memorandum*. World Bank, Washington, D.C.
- World Bank, Asian Development Bank, et al. (1996). Viet Nam Water Resources Sector Review, World Bank, Asian Development Bank, FAO, UNDP, NGO, Water Resources Group in Viet Nam and the Government of Viet Nam.
- Young, R. A. (1996). *Measuring Economic Benefits for Water Investments and Policies*. World Bank, Washington, D.C.
- Young, R. A. (1996). "Water Economics." *Water Resources Handbook*. L. W. Mays. McGraw-Hill, New York.

**APPENDIX: DETAILED COST TABLES**

Table A1 Detailed Construction Costs

Vietnam  
 Sample Flood Protection Feasibility Study  
 Table 1. Duong River Dike Rehabilitation

Detailed Costs	Unit	Quantities				Unit Cost (VND)				Base Cost (VND)				Parameters (in %)			
		2001	2002	2003	2004	Total	2001	2002	2003	2004	Total	Physical Contingency Rate	Foreign Exchange	Gross Tax Rate			
<b>A. Civil Works</b>																	
<b>1. K0.300 - K1.500 Left Duong</b>																	
Pond filling	m3	40,770	-	-	-	40,770	13,242	539,876,340	-	-	-	-	539,876,340	10.0	5.0	10.0	
<b>Subtotal K0.300 - K1.500 Left Duong</b>																	
<b>2. K4.800 - K5.400 Left Duong</b>																	
Pond filling	m3	40,350	-	-	-	40,350	13,242	534,314,700	-	-	-	-	534,314,700	10.0	5.0	10.0	
<b>Subtotal K4.800 - K5.400 Left Duong</b>																	
<b>3. K6.000 - K7.500 Left Duong</b>																	
Earth Excavation	m3	10,120	-	-	-	10,120	11,003	111,350,609	-	-	-	-	111,350,609	10.0	5.0	10.0	
Earth Fill (by Machine)	m3	21,444	-	-	-	21,444	13,242	283,961,448	-	-	-	-	283,961,448	10.0	5.0	10.0	
Earth Fill (manual)	m3	21,444	-	-	-	21,444	20,299	435,285,147	-	-	-	-	435,285,147	10.0	5.0	10.0	
Grass Planting	m2	50,187	-	-	-	50,187	2,200	110,432,632	-	-	-	-	110,432,632	10.0	5.0	10.0	
Removal of Vegetation	m3	14,296	-	-	-	14,296	4,085	58,397,889	-	-	-	-	58,397,889	10.0	5.0	10.0	
<b>Subtotal K6.000 - K7.500 Left Duong</b>																	
<b>4. K13.600 - K15.000 Left Duong</b>																	
Earth Excavation	m3	7,673	-	-	-	7,673	11,003	84,426,208	-	-	-	-	84,426,208	10.0	5.0	10.0	
Earth Fill (by Machine)	m3	20,735	-	-	-	20,735	13,242	274,566,249	-	-	-	-	274,566,249	10.0	5.0	10.0	
Earth Fill (manual)	m3	20,735	-	-	-	20,735	20,299	420,883,225	-	-	-	-	420,883,225	10.0	5.0	10.0	
Grass Planting	m2	38,243	-	-	-	38,243	2,200	84,150,779	-	-	-	-	84,150,779	10.0	5.0	10.0	
Removal of Vegetation	m3	13,823	-	-	-	13,823	4,085	56,465,726	-	-	-	-	56,465,726	10.0	5.0	10.0	
<b>Subtotal K13.600 - K15.000 Left Duong</b>																	
<b>5. K17.000 - K17.800 Left Duong</b>																	
Pond filling	m3	41,915	-	-	-	41,915	13,242	555,038,430	-	-	-	-	555,038,430	10.0	5.0	10.0	
<b>Subtotal K17.000 - K17.800 Left Duong</b>																	
<b>6. K25.500 - K28.500 Left Duong</b>																	
Earth Excavation	m3	25,128	-	-	-	25,128	11,003	276,484,002	-	-	-	-	276,484,002	10.0	5.0	10.0	
Earth Fill (by Machine)	m3	72,907	-	-	-	72,907	13,242	965,434,494	-	-	-	-	965,434,494	10.0	5.0	10.0	
Earth Fill (manual)	m3	72,907	-	-	-	72,907	20,299	1,479,916,724	-	-	-	-	1,479,916,724	10.0	5.0	10.0	
Grass Planting	m2	122,493	-	-	-	122,493	2,200	269,536,421	-	-	-	-	269,536,421	10.0	5.0	10.0	
Removal of Vegetation	m3	48,605	-	-	-	48,605	4,085	198,545,741	-	-	-	-	198,545,741	10.0	5.0	10.0	
<b>Subtotal K25.500 - K28.500 Left Duong</b>																	
<b>7. K46.000 - K51.000 Left Duong</b>																	
Earth Excavation	m3	33,738	-	-	-	33,738	11,003	371,220,044	-	-	-	-	371,220,044	10.0	5.0	10.0	
Earth Fill (by Machine)	m3	108,880	-	-	-	108,880	13,242	1,441,782,339	-	-	-	-	1,441,782,339	10.0	5.0	10.0	
Earth Fill (manual)	m3	108,880	-	-	-	108,880	20,299	2,210,111,415	-	-	-	-	2,210,111,415	10.0	5.0	10.0	
Grass Planting	m2	168,336	-	-	-	168,336	2,200	370,410,414	-	-	-	-	370,410,414	10.0	5.0	10.0	
Removal of Vegetation	m3	72,586	-	-	-	72,586	4,085	296,508,716	-	-	-	-	296,508,716	10.0	5.0	10.0	
<b>Subtotal K46.000 - K51.000 Left Duong</b>																	
<b>8. K0.550 - K3.700 Right Duong</b>																	
Pond filling	m3	105,126	-	-	-	105,126	13,242	1,392,078,492	-	-	-	-	1,392,078,492	10.0	5.0	10.0	
<b>Subtotal K0.550 - K3.700 Right Duong</b>																	

**Table A1 (Continued) Detailed Construction Costs**

	Unit	Quantities					Unit Cost (VND)	Base Cost (VND)					Parameters (In %)		
		2001	2002	2003	2004	Total		2001	2002	2003	2004	Total	Physical Contingency Rate	Foreign Exchange	Gross Tax Rate
<b>9. K21.600 - K24.000 Right Duong</b>															
Pond filling	m3	161,000	-	-	-	161,000	13,242	2,131,962,000	-	-	-	2,131,962,000	10.0	5.0	10.0
<b>Subtotal K21.600 - K24.000 Right Duong</b>								2,131,962,000	-	-	-	2,131,962,000			
<b>10. K28.000 - K29.500 Right Duong</b>															
Pond filling	m3	147,475	-	-	-	147,475	13,242	1,952,863,950	-	-	-	1,952,863,950	10.0	5.0	10.0
<b>Subtotal K28.000 - K29.500 Right Duong</b>								1,952,863,950	-	-	-	1,952,863,950			
<b>11. K31.500 - K38.400 Right Duong</b>															
Earth Excavation	m3	206,669	-	-	-	206,669	11,003	2,273,984,088	-	-	-	2,273,984,088	10.0	5.0	10.0
Earth Fill (by Machine)	m3	25,089	-	-	-	25,089	13,242	332,221,917	-	-	-	332,221,917	10.0	5.0	10.0
Earth Fill (manual)	m3	25,089	-	-	-	25,089	20,299	509,263,729	-	-	-	509,263,729	10.0	5.0	10.0
Grass Planting	m2	248,666	-	-	-	248,666	2,200	547,170,398	-	-	-	547,170,398	10.0	5.0	10.0
Pond filling	m3	201,210	-	-	-	201,210	13,242	2,664,422,820	-	-	-	2,664,422,820	10.0	5.0	10.0
Removal of Vegetation	m3	16,726	-	-	-	16,726	4,085	68,322,861	-	-	-	68,322,861	10.0	5.0	10.0
<b>Subtotal K31.500 - K38.400 Right Duong</b>								6,395,385,814	-	-	-	6,395,385,814			
<b>12. K41.000 - K48.000 Right Duong</b>															
Earth Excavation	m3	50,338	-	-	-	50,338	11,003	553,870,252	-	-	-	553,870,252	10.0	5.0	10.0
Earth Fill (by Machine)	m3	128,992	-	-	-	128,992	13,242	1,708,112,064	-	-	-	1,708,112,064	10.0	5.0	10.0
Earth Fill (manual)	m3	128,992	-	-	-	128,992	20,299	2,618,368,854	-	-	-	2,618,368,854	10.0	5.0	10.0
Grass Planting	m2	246,361	-	-	-	246,361	2,200	542,098,423	-	-	-	542,098,423	10.0	5.0	10.0
Pond filling	m3	543,515	-	-	-	543,515	13,242	7,197,225,630	-	-	-	7,197,225,630	10.0	5.0	10.0
Removal of Vegetation	m3	85,995	-	-	-	85,995	4,085	351,280,565	-	-	-	351,280,565	10.0	5.0	10.0
<b>Subtotal K41.000 - K48.000 Right Duong</b>								12,970,955,787	-	-	-	12,970,955,787			
<b>Subtotal Civil Works</b>								36,272,345,732	-	-	-	36,272,345,732	10.0	5.0	
<b>B. Other Costs</b>															
I. Project Planning, Supervision															
Implementation and Appraisal /a	amount							3,627,234,573	-	-	-	3,627,234,573	10.0	5.0	10.0
<b>Total</b>								39,899,580,305	-	-	-	39,899,580,305			

/a Assumed to equal 10 percent of Civil Works costs

Table A2 Expenditure Accounts by Components - Base Costs

Vietnam

Sample Flood Protection Feasibility Study

**Expenditure Accounts by Components - Base Costs**  
(VND)

	<b>Rehabilitation of Duong River</b>		<b>Physical Contingencies</b>	
	<b>Dike</b>	<b>Total</b>	<b>%</b>	<b>Amount</b>
<b>I. Investment Costs</b>				
<b>A. Civil Works</b>				
Earth Excavation	3,671,335,202	3,671,335,202	10.0	367,133,520
Earth Fill (by machine)	5,006,078,511	5,006,078,511	10.0	500,607,851
Earth Fill (manual)	7,673,829,093	7,673,829,093	10.0	767,382,909
Grass Planting	1,923,799,066	1,923,799,066	10.0	192,379,907
Pond filling	16,967,782,362	16,967,782,362	10.0	1,696,778,236
Removal of Vegetation	1,029,521,497	1,029,521,497	10.0	102,952,150
<b>Subtotal Civil Works</b>	<b>36,272,345,732</b>	<b>36,272,345,732</b>	<b>10.0</b>	<b>3,627,234,573</b>
<b>B. Other Costs</b>	<b>3,627,234,573</b>	<b>3,627,234,573</b>	<b>10.0</b>	<b>362,723,457</b>
<b>Total BASELINE COSTS</b>	<b>39,899,580,305</b>	<b>39,899,580,305</b>	<b>10.0</b>	<b>3,989,958,030</b>
Physical Contingencies	3,989,958,030	3,989,958,030	-	-
Price Contingencies	1,041,950,546	1,041,950,546	9.1	94,817,500
<b>Total PROJECT COSTS</b>	<b>44,931,488,882</b>	<b>44,931,488,882</b>	<b>9.1</b>	<b>4,088,765,488</b>
Taxes	4,493,148,888	4,493,148,888	9.1	408,876,549
Foreign Exchange	2,246,574,444	2,246,574,444	9.1	204,438,274

Table A3 Expenditure Accounts by Components - Totals Including Contingencies

Vietnam Sample Flood Protection Feasibility Study Expenditure Accounts by Components - Totals Including Contingencies (VND)		Rehabilitation of Duong River Dike	Total
<b>I. Investment Costs</b>			
<b>A. Civil Works</b>			
Earth Excavation		4,134,343,157	4,134,343,157
Earth Fill (by machine)		5,637,416,716	5,637,416,716
Earth Fill (manual)		8,641,608,858	8,641,608,858
Grass Planting		2,166,417,684	2,166,417,684
Pond filling		19,107,662,755	19,107,662,755
Removal of Vegetation		1,159,358,904	1,159,358,904
<b>Subtotal Civil Works</b>		<b>40,846,808,074</b>	<b>40,846,808,074</b>
<b>B. Other Costs</b>		<b>4,084,680,807</b>	<b>4,500,069,359</b>
<b>Total PROJECT COSTS</b>		<b>44,931,488,882</b>	<b>45,346,877,433</b>
Taxes		4,493,148,888	4,493,148,888
Foreign Exchange		2,246,574,444	2,246,574,444

Table A4 Project Components by Year - Totals Including Contingencies

Vietnam Sample Flood Protection Feasibility Study Project Components by Year -- Totals Including Contingencies (VND)		Totals Including Contingencies			
		2001	2002	2003	2004
Rehabilitation of Duong River Dike		44,931,488,882	-	-	-
<b>Total PROJECT COSTS</b>		<b>44,931,488,882</b>	<b>-</b>	<b>-</b>	<b>-</b>
(US\$)		Totals Including Contingencies			
		2001	2002	2003	2004
Rehabilitation of Duong River Dike		\$3,142,062	-	-	-
<b>Total PROJECT COSTS</b>		<b>\$3,142,062</b>	<b>-</b>	<b>-</b>	<b>-</b>