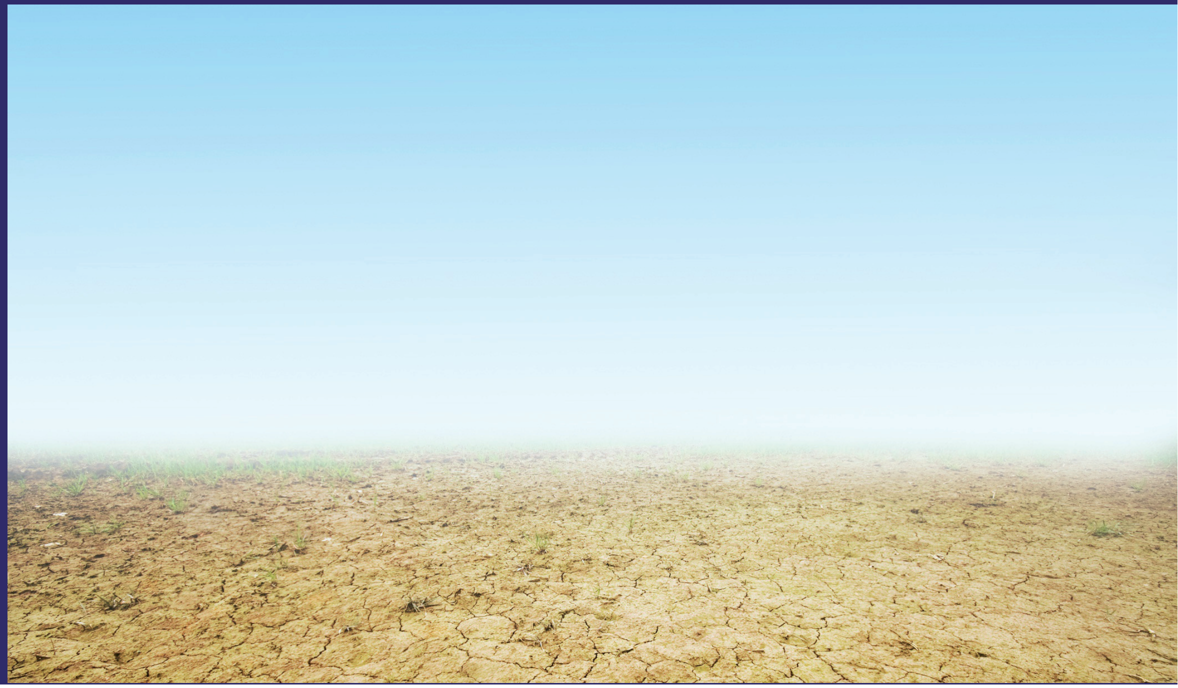
This book is about the comparision of costs and benefits of alternative dyke constructions (seasonal August dykes and permanent High dykes) for agricultural production in Vietnam's Mekong Delta, using a case study of three communes in flood-prone areas of An Giang province. The research's findings from this book show that the August dyke system provides the highest net agricultural benefits than either No dykes or High dykes in the areas of No dykes of the Mekong Delta was supported. The government policy should focus on exploiting of the flood benefits using August dykes and minimising the High dyke development in the region.



Van Kien Nguyen

An Economic Evaluation Of Flood Dike Construction In The Mekong Delta

Cost-Benefit Analysis Of Flood Protection Dike Construction In An Giang Province

Van Kien Nguyen

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Abbreviations

ADARD	An Giang Department of Agriculture and Rural Development
AGDS	An Giang Department of Statistics
AUD	Australian Dollar: 1 AUD = 12,000 VND
B	Benefit
C	Cost
CPBARD	Chau Phu Bureau of Agriculture and Rural Development
CPSYB	Chau Phu statistics year book
GDP	Gross Domestic Product
GO	Gross Value
GSOV	General Statistics Office of Vietnam
IUCN	The World Conservation Union
MRC	Mekong River Commission
NB	Net benefit
NPV	Net present value
OLV	O Long Vi commune
PV	Present value
TMT	Thanh My Tay commune
VEN	Vietnam Economic News
VND	Vietnam Dong
VNG	Vietnamese Government
VTT	Vinh Thanh Trung commune
WWF	World Wildlife Fund

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Finally, I am grateful for the support of my fellow students in the EMD program, Crawford School of Economics and Government, the Australian National University.

Abstract

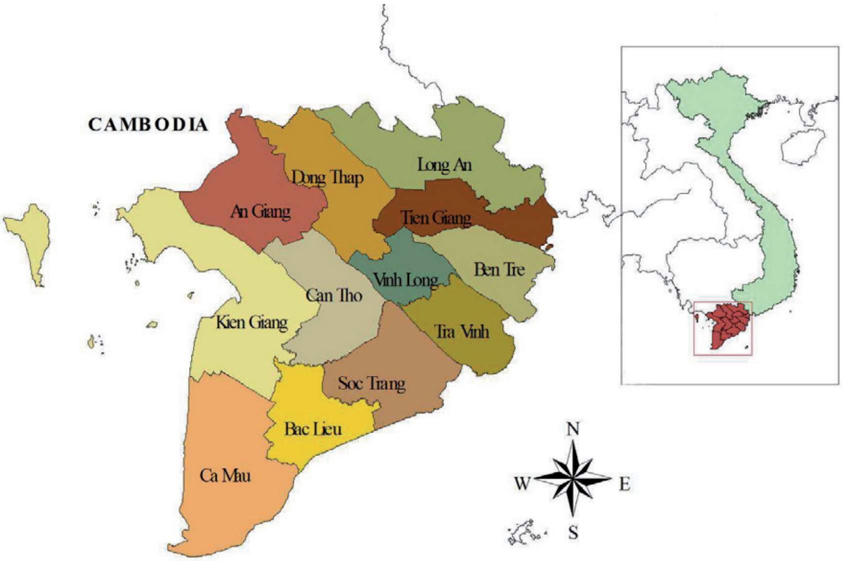
This research compared costs and benefits of alternative dyke constructions (seasonal August dykes and permanent High dykes) for agricultural production in Vietnam's Mekong Delta, using a case study of three communes in flood-prone areas of An Giang province. Market analysis was used to calculate the costs and benefits of agricultural production and costs of dyke investment. The research hypothesis that the August dyke system provides the highest net agricultural benefit than either No dykes or High dykes in the areas of No dykes of the Mekong Delta was supported. The government policy should focus on exploiting of the flood benefits using August dykes and minimising the High dyke development in the region. A study for estimating non-marketed benefits of High dyke construction are needed to provide the total economic benefits of High dykes.

Chapter 1 Introduction

1.1. Background

The Mekong Delta is a key fishery and agricultural production zone located on the southern coast of Vietnam (Figure 1). The Delta supports 17 million people and accounts for 20.8 per cent of the country's population (GSOV 2004). Most people live in rural areas (80 per cent) and work in the agricultural sector (GSOV 2004). The Delta includes 3.9 million hectares (ha) currently under cultivation (GSOV 2004), of which irrigated paddy fields comprise 2 million ha (Hori 2000), that are extremely important to the Vietnamese agricultural economy. Between 2001 and 2005, the Delta's annual economic growth was 13.9 per cent (VEN 2006). In particular, the export value rose from US $1.46 million in 2001 to US $2.89 million in 2005, of which 80 per cent came from agricultural production and seafood (VEN 2006). Since the Delta's economic growth has been increasing rapidly, it has become a major contributor to the country's economy.

Figure 1: Map of the Mekong Delta, Vietnam

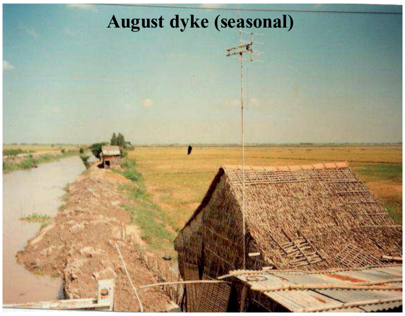


However, the annual flooding of the Delta is an obstacle to continued agricultural and rural development. Nearly one-half of the Delta's total area is continuously inundated for between four and six months during the flood season (Hori 2000, Gupta *et al*. nd). These floods result in many tangible and intangible costs. The tangible costs include direct damage to infrastructure, and disruption to commercial, residential and agricultural activity while the intangible costs consist of indirect damages such as human loss, ill health, inconvenience and loss of cultural significance (Gupta *et al.* nd). For example, the 1997 flood took the lives of many children, with the overall death toll reaching 607 (MRC 1999). In addition to the human loss, 173,606 houses were destroyed by the flood in 1997 (MRC 1999). The flood also caused the loss of 19,785 ha of rice, while 251,341 ha of rice were affected by decreased yields (MRC 1999). It is estimated that the 1997 flood damage amounted to 6,996 thousand million VND (about 900 million $AUD) (MRC 1999). These costs are a burden for both the government and the local people of the Mekong Delta region. Thus, regional economic development must take flood issues into consideration for sustainable development.

Despite these inevitable costs, floods in the Mekong Delta have also traditionally been known to bring benefits which contribute significantly to sustainable agriculture development in the region. Firstly, floods provide natural freshwater fish, other aquatic animals and aquatic vegetables for rural livelihoods. It is estimated that the average fish capture in the Delta is about 500 kg per household per year, which provides significant protein source for local people (Trong and Binh 2004, MRC 2002: 9). Secondly, floods deposit 150 million tonnes of sediment on paddy fields every flood season (Tien 2004). This helps to replenish the soil and maintain soil fertility for rice cultivation. Evidence shows that after every flood season, local rice farmers not only gain higher yields but also need to use less fertilizer because of the nutrient mud from sediment (Nga 1999, Anh *et al.* 2002, Tien 2004). Furthermore, floods have important biological functions; for example, floods help to recharge groundwater, clean farm residuals, and maintain biodiversity (Gren *et al.* 1995: 335, WWF 2004a: 3 and Cuny 1991: 333). Besides these substantial natural advantages, new livelihood approaches have also been exploiting potential flood benefits in the region. Since 2000, many new farming activities have been initiated in the An Giang province during the flood season including flood-based giant freshwater prawn culture, flood-based Snake-Head fish farming, and aquatic vegetable cultivation (ADARD 2002). The gross output (GO) values of new farming practices in An Giang province accounted for 22.18 per cent of total GO values of two main rice crops per year in 2004 (ADARD 2005). The GO values of flood-based farming practices in An Giang province were VND 1,561 billion, compared to the values of VND 7,041 billion for two main rice crops per year in 2004 (ADARD 2004). Hence, these benefits contribute to the rural economy and to the improvement of rural livelihoods.

Despite the acknowledged advantages of floods, since 2001 Vietnamese government policies have been directed towards reducing the costs of floods through dyke development projects (VNG 2001)[1]. Through these policies, two types of dyke constructions have been installed throughout the Delta by local governments and farmers. The first is a permanent 'High dyke' system (Figure 2) to stop floods completely, thus protecting local property and allowing the growing of an additional third rice crop during the flood season: the number of such High dyke areas in the region has increased rapidly (Tien 2005 and Hoi 2005). The second dyke construction is a temporary 'August dyke' system (Figure 2), which is used to protect the summer rice crop from floods in August but allows floodwaters into the paddy fields afterwards.

Figure 2: The August and High dyke constructions in the Mekong Delta



The construction of dykes clearly results in economic benefits in the Delta. High dykes, for example, protect the second rice crop from flood damage and increase rice production by allowing an additional rice crop to be cultivated during the flood season. For example, 80,340 ha out of 230,000 ha of agricultural lands of the An Giang province grew a third rice crop in high dyke areas in 2004 (ADARD 2005). As a result, 63,451 tonnes of rice were produced in 2004 estimated at a value of VND 143.9 billion (AUD 11.9 million) (ADARD 2005). The construction of High dykes has boosted the economic growth of the province in recent years. On the other hand, the benefits of the August dyke system consist of saving the second rice crop from flood damage while retaining the natural benefits of floods.

[1] In 2001, the Prime Minister issued Decision No. 1548/QD-TTg relating to investments in the raising of housing foundations and the construction of residential clusters/dykes in flood-prone areas of the Mekong Delta.

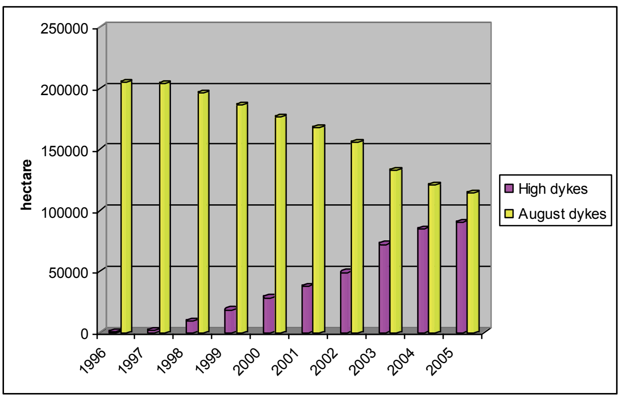
1.2. Research issues

There is widespread concern about the impacts of structural measures for flood management. Drawing from experiences in European countries, the World Wildlife Fund (WWF 2004a: 17) argue that the higher the dyke, the greater the volume of water that is held back, and therefore the greater the level of risk to human life and property in the event of a dyke failure. In response, Germany has proposed removing some dykes and flood defenses (WWF 2002: 4) and has recognized that the catastrophic impacts of past floods in Europe are the result of past and current mistakes. WWF (2002:4), therefore, suggests that the sustainable management of river basins in a country such as Germany requires the conservation of floodplains and wetlands as ecological flood controllers. In Bangladesh, Islam (2001:791) argues that the ‘cordon approach’ to flood management, which is to build constructions along entire riversides on all main rivers, will result in floodplains being deprived of the nurturing effects of inundation: this approach would consume much capital investment and leave a debt burden to the country. In India, Gupta *et al*. (2003: 119) found that, from 1971 to 1996, structural measures of flood protection, such as dykes, were inadequate in controlling losses and reducing vulnerability.

Additionally, there are arguments to support the retention of flood in agricultural areas. For example, in Nigeria, Kimmage and Adams (1992) conclude that the benefits of agricultural production are much greater than the direct benefits from a proposed irrigation development project to divert waters away from floodplains: such projects consume a huge amount of capital but result in very poor economic performance.

In the Mekong Delta, the structural measures against floods have been developed rapidly with an increasing area of internal dyke installation. An Giang is one of seven flood-prone provinces in the Delta and has the longest history of internal dyke construction, commencing in 1998 (Nha 2006: 17). Initially, 204,238 ha of paddy fields and residential areas were protected using August dykes with only 732 ha of paddy fields controlled by High dykes (Nha 2006) (Figure 3). More recently, however, the area with August dykes has decreased to 114,450 ha in 2005 with a corresponding and rapid increase in the area of High dykes, reaching 90,520 ha in 2005 (ADARD 2005). The main reasons for the increase in the area with High dykes are the full flood control and the opportunity for a third rice crop during the flood season. As argued in Section 1.2., the greater the number of High dykes, the potentially higher the costs for society as have been seen in Germany, Bangladesh and India (WWF 2004b, Islam 2001, Gupta *et al.* 2003).

Figure 3 : The areas with August and High dykes in the An Giang province from 1996 to 2005

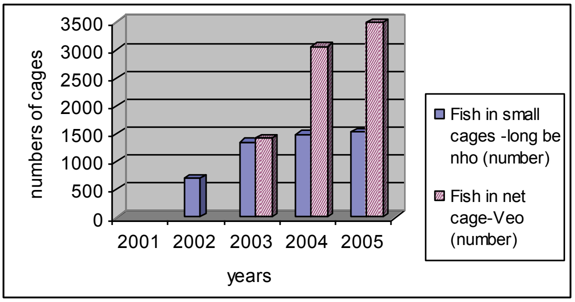


Source: An Giang Department of Agriculture and Rural Development (2005)

According to Nha (2006), the soil fertility has declined in the High dyke areas of Cho Moi district in An Giang province. Significantly, Nha (2006: 92-99) also found that the amount of nitrogen fertilizer used for the first rice crop has increased by 15, 14 and 15 kg per ha respectively after two, four and six years of high dyke construction in the Cho Moi district. In contrast, the August dyke system has not shown an increase in the use of fertilizer for the first rice crop, because the soil is replenished by sediment in the floodwater (Nha 2006: 92-99). Therefore, the environmental impacts of dykes must be taken into account in the region's long-term agricultural development planning.

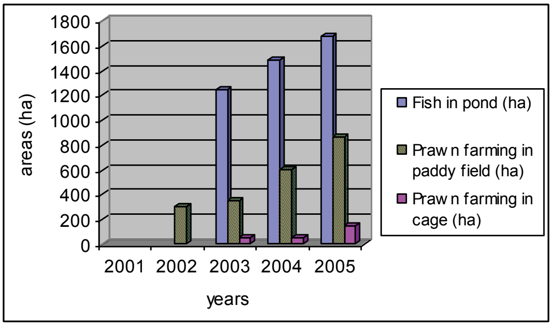
The evaluation of dyke construction alternatives is thus critically important to the region's sustainable agricultural development. Indeed, a new understanding of how to exploit flood benefits has occurred in recent times. Local farmers have changed their point of view, from floods being a disaster to their being an ally (VNN 2002). For example, floods have become important resources for regional aquaculture development. Using the benefits of floods in areas with both No dyke and August dyke systems, the cultivation of flood-based fish and giant freshwater prawn was introduced in 2002 and the magnitude of these activities has subsequently increased (Figures 4 and 5). These types of new farming practices have contributed significantly to the rural economy. The opportunity costs of dyke development projects may indeed prove significant if these kinds of flood benefits are to be taken into consideration in the decision-making process for dyke construction.

Figure 4: Fish farming in net cages 'veo' in An Giang province from 2001 to 2005



Source: An Giang Department of Agriculture and Rural Development (2005)

Figure 5: Fish and freshwater prawn farming in An Giang province from 2001 to 2005



Source: An Giang Department of Agriculture and Rural Development (2005)

Although dykes currently generate substantial economic benefits to local communities, both dyke alternatives have investment and opportunity costs. The investment costs of dykes can be obtained from actual expenditure on investment and maintenance. However, the opportunity costs of both dykes have not been explored. From a long-term perspective, all the costs must be taken into account when comparing dyke alternatives. Yet, if opportunity costs are not taken into account, the economic returns to dyke development projects may be over-estimated. The question which then arises is which dyke construction alternative provides the greatest net economic benefits to agricultural production in the region. To answer this crucial question, a cost and benefit analysis of the alternative dyke options was carried out, to provide information to decision-makers which could improve government policies for flood management in the Mekong Delta.

1.3. Research objectives

This research aims to fill the information gap about economic costs and benefits of the dyke construction in the Mekong Delta. The partial valuation approach was used to estimate the economic benefits and costs of dykes, and opportunity costs of the High dykes were measured using the economic values of flood-based farming activities. The economic benefits of dykes are direct use values, such as agricultural production, so a market-based approach was used to calculate the values of these benefits. The hypothesis tested was that in the Mekong Delta of Vietnam without any dykes, the construction of August dykes provides the highest net agricultural benefits than either No dykes or High dykes.

- The main objective of this study, therefore, was to compare costs and benefits of dyke construction alternatives in the Mekong Delta, with sub-objectives being.
- To estimate the costs of dyke constructions and opportunity costs of dykes;
- To estimate the economic values of farming alternatives in the area of No dykes, August dykes and High dykes; and
- To compare costs and benefits of farming alternatives in the August dykes and High dykes to the No dykes

1.4. Structure of this report

This report is divided into six major chapters. Chapter one has introduced the background and the research issues arising from the dilemma of floods and dykes in the Mekong Delta. Chapter Two provides the theoretical framework for the research, including definitions of terms, and discussion of ecological functions and economic values of floods, and property rights (public good, public bad and common pool resource). Chapter Three explains the process of developing the research question and the hypothesis, with the research method described in Chapter Four. Chapter Five presents and discusses the results. Finally, the discussion and conclusion are presented in Chapter Six.

Chapter 2 Theoretical Framework

2.1. Functions and economic value of floods

2.1.1 Ecological functions of floods

Floods have a crucial function in socio-economic development (Figure 6), as they sustain and replenish ecological functions for the economy (WWF 2004a: 2).

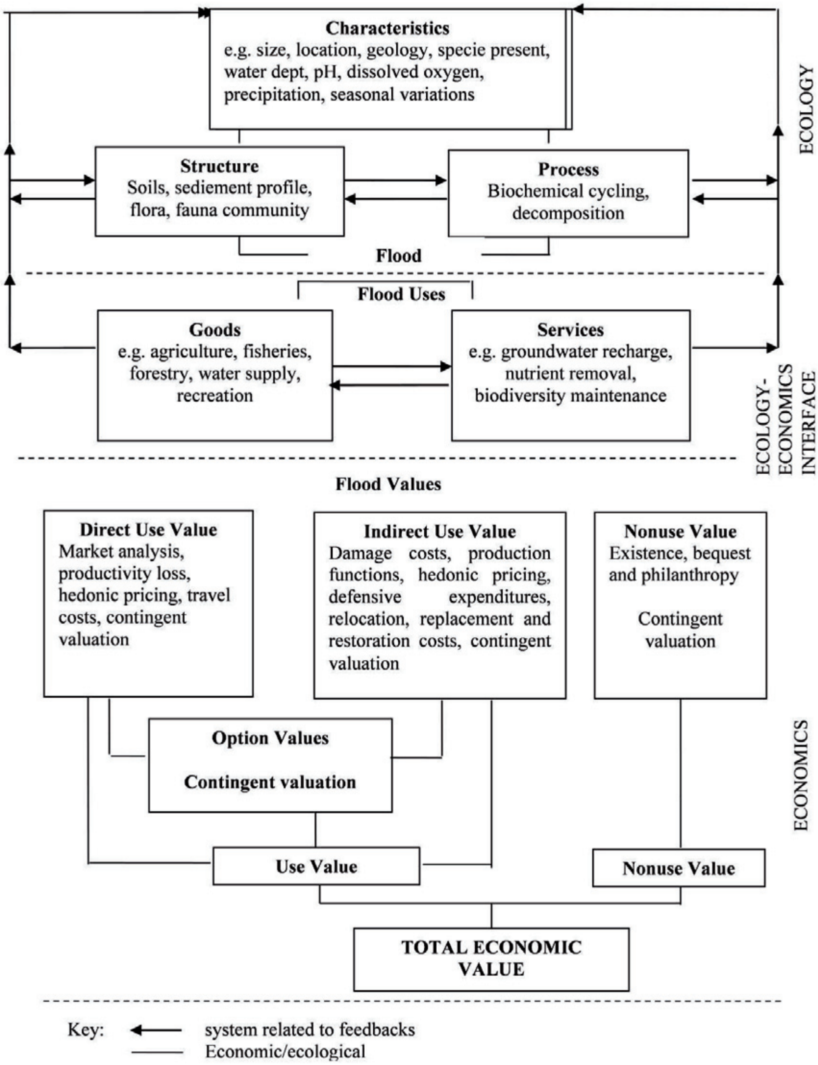
> 'In linking with the river and its floodplains, floodwaters transport nutrients, organisms and genes that are important for fish fauna and waterfowl population'
>
> **Source:** WWF (2004a)

Floodplains also freely provide nutrient retention, rich biodiversity, support for sustainable agriculture, forestry and fishery, groundwater recharge and tourism (WWF 2004a:3, Islam 2001:789-90, Cuny 1991: 333). In the Mekong Delta, tonnes of sediment are deposited in the paddy fields after every flood season (Nga 1999, Anh *et al.* 2002, Tien 2004). This crucial benefit from floodplain services is a major contributor to the Delta's sustainable rice cultivation (Tien 2004).

2.1.2 Economic values of floods

Information on total economic value can be gained from economic valuations, defined as 'an attempt to assign quantitative and monetary values to goods and environmental services, whether or not market prices are available to assist us' (Lambert 2003:1). Tietenberg (2004: 32) classifies total economic value of resources into three main components: use values, option values and non-use values. These values cannot be excluded in the Mekong's floodplains, so any intervention into this resource should be considered as the sum total economic value of floodplains.

Figure 6: Connections between flood functions, use and non-use values



Adapted from Tunner *et al*. (2000), WWF (2004a), WWF (2004b)

Total economic value of the Mekong floodplains can thus include use values, option values and nonuse values (Table 1). Use values can be divided into direct and indirect use values (Babier 1993: 23). Direct use values are based on conscious use of environmental assets in consumption and production activities such as fish capture, prawn farming and Neptunia growing in the region. Indirect use values are based on the contributions of natural resources to human life support (Wills 1997: 147). The indirect support of these values provides economic activities by natural flood functions or regulatory environmental services such as nutrient retention. Option values reflect the value people place on a future ability to use the environment (Tietenberg 2004: 32). Non-use values involve no tangible current interaction i.e. no production, consumption or life support linkage between environmental assets and the people who benefit from it (Wills 1997: 147). Estimates of the economic value of floodplains are therefore vital if planners are to have even the slightest chance of balancing the environmental impacts of different development options (Kimmage and Adams 1992: 3).

Table 1: Total economic values of floods

Use values			**Non-use values**
Direct use values	**Indirect use values**	**Option values**	
Fish Agriculture Aquaculture Water transport Wildlife harvesting	Nutrition retention Ground water recharge Natural pest control	Potential future uses (direct and indirect uses) Future value of information	Biodiversity Cultural heritage

Sources: WWF (2004a), WWF (2004b) and Anh *et al.* (2002)

2.2. Floods as a 'public good' and a 'public bad'

Bennett and Block (1991: 281) consider public goods as 'goods which are essentially non-excludable but which are also non-rival in consumption i.e. the consumption by one person does not affect the availability of the goods to others and are particularly troublesome to allocate through any private property right'. Floods are non-excludable because individuals cannot stop floods properly. Floods are also non-rival because if one person uses floods it does not affect the available floodwaters for other farmers in the region, particular with flood-based farming practices.

Olson (1965: 41) classifies public goods into two groups, 'exclusive' and 'inclusive' public goods. With exclusive public goods, groups try to minimize the number of members, while the opposite is true for inclusive public goods (Ostrom 2003: 242). In this context, floods are inclusive public goods: the greater the number of farmers involved in flood management, the more farmers shared the costs of providing a public good 'flood management' for all beneficiaries. As Ostrom (2003: 242) notes, 'increasing the number of participants frequently brings additional resources that could be drawn on to provide a benefit that will be enjoyed by all'.

In contrast to other public goods, however, a flood is also a 'public bad'[2] because it provides undesirable costs to society. Floods have caused many human fatalities, destroyed property and brought a burden to the local communities in the Mekong Delta (Tien 2004). The provision of dykes for flood management can be a 'public good' for some people, but dykes can also be a 'public bad' for others. Thus, some farmers in communes where dykes have been constructed cannot exclude a dyke construction action, even thought this intervention may be not beneficial for them in the long run (pers.comm. Bennett 2006). In particular, some farmers believe that the construction of High dykes may diminish the fish stock, eliminate sediment, increases pest damage on

[2] http://en.wikipedia.org/wiki/Public_bad

rice and lead to a reduction in rice yields in long term, yet, they must accept the high dyke construction because they are only a minority in the community and their points of view are rejected by the economic perspectives of the community (pers. comm. Dung 2006).

2.3. Dyke constructions and a community decision-making

Since floods are both public good and bad, individual farmers cannot deal with this problem. Community decision-making is required to minimize flood costs and maximize flood benefits so that it can provide socially optimal outcomes. Therefore, a community decision-making process considers High dykes as a social improvement over August dykes as a result of an increase in areas with High dykes in recent years. To make an appropriate decision, information about costs and benefits of No dykes, August dykes and High dykes is required. The assessment of the use of August dykes or High dykes compared with No dykes needs a cost and benefit analysis of those dyke types.

Chapter 3 Research Questions and Hypotheses

3.1. Research questions

Chapter one revealed the problems of dyke construction for flood management worldwide and the rapid increase in high dyke constructions in the Mekong Delta. Chapter two explained the theoretical framework of a 'public good', a 'public bad', common pool resources, and the economic value of floods. Individual farmers cannot afford to install dykes to control floods because it is costly and risky. However, there are economies of scale in dealing with floods, which means collective actions can be carried out at lower construction costs than individual actions. Therefore, there is a need to coordinate individual actions so that they do not have externality effects on others (pers. comm. Bennett 2006). Group of farmers can afford to install dykes. The collective actions of the community in building dykes also generate the costs because of the special characteristics of floods as a 'public good' and a 'public bad'. Hence, what levels of intervention from the local farmers regarding the construction of August or High dykes are appropriate for flood management to provide the greatest net agricultural economic return to local farmers in the region? Providing information on costs and benefits of dyke development projects is crucial for making the best choice.

So far, no study has evaluated the costs and benefits of alternative dyke construction in the region by using information on dyke construction costs and opportunity costs of the High dykes such as flood-based farming practices and rice farming. While construction costs may be obtained from the actual expenditure on dyke development projects, information on farming alternatives is not so readily available. To estimate the opportunity costs of dykes, therefore, studies on the economic values of farming alternatives must be used. In consideration of these values, the main objective of this research has focused on the direct use values of farming system alternatives in the area of No dykes, August dykes and High dykes in the Delta. A partial valuation of agricultural benefits is required when dyke development projects may result in an alteration of floodplain benefits.

This study, therefore sought to address the crucial question:
Which dyke construction alternative (August or high dyke) provides the greatest net economic benefits to farmers in areas of No dykes in the Mekong delta, Vietnam?

To clarify this research question, several sub-questions were also considered.

- What are the costs and agricultural benefits of No dykes (the status quo)?
- What are the costs and agricultural benefits of the August dykes compared with No dykes?
- What are the costs and agricultural benefits of the High dykes compared with No dykes?
- In each case, do the benefits outweigh the costs?
- Do the net benefits of the August dykes outweigh the net benefits of No dykes?
- Do the net benefits of the High dykes outweigh the net benefits of No dykes?

3.2. Hypotheses

To answer these questions in the context of agricultural development in the region, this study tested the following hypothesis.

In areas of the Mekong Delta (Vietnam) without any dykes, the construction of August dykes provides higher net agricultural economic benefits than either No dykes or the construction of High dykes.

The hypothesis considers that the August dykes not only mitigate flood damage to the second rice crop but also allow exploitation of flood-based farming. Although High dykes do generate an additional rice crop, they also prevent any opportunity for flood-based farming and interrupt natural flood benefits, such as fishery capture and sediment deposition. Therefore, the following sub–hypotheses were also tested:

- The net agricultural benefits of the August dykes are positive compared to No dykes.
- The net agricultural benefits of the High dykes are negative compared to No dykes.

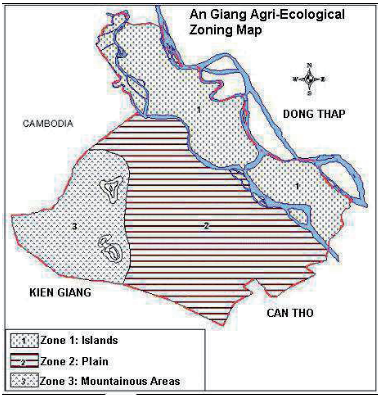
Chapter 4 Research Methods

4.1. Research site selection

An Giang province was selected as a case study because it is located in a flood-prone area of the Mekong Delta and represents a variety of flood management approaches (No dykes, August dykes and High dykes). In 2005, the total area with dykes covered more than 204,970 ha, of which 90,520 ha were constructed using High dykes, whereas about 114,450 ha were established with August dykes (ADARD 2005).

An Giang province has a total of eleven districts and towns, divided into three agro-ecological zones: Island districts (Zone 1), Plains (Zone 2) and Mountainous areas (Zone 3) (Figure 7). Of these, the first two Zones are often inundated for four to six months of the year, while the mountainous zone is unaffected by floods. Within flood-prone areas of the province, Zone 2 comprises a high proportion of land areas (five out of eleven districts) and represents the most flood-prone areas of the Delta.

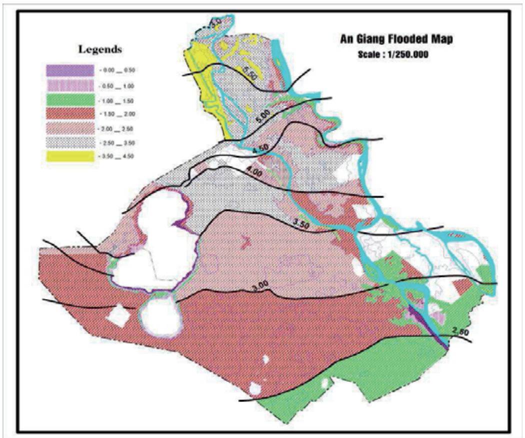
Figure 7: The agri-ecological zoning map of An Giang province



Source: An Giang Department of Land Management (2000)

In Zone 2, three communes in the Chau Phu district (Vinh Thanh Trung (VTT), O Long Vi (OLV) and Thanh My Tay (TMT) were chosen for this study, as they had all three dyke alternatives and represented the large flood-prone areas in terms of biophysical and social economic conditions in the region (Figure 8).

Figure 8: The An Giang inundated map and the study sites



Source: An Giang Department of Agriculture and Rural Development (2000)

4.2. Overview of the study sites

4.2.1 The Vinh Thanh Trung commune of the Chau Phu district

The Vinh Thanh Trung (VTT) commune is situated in the Chau Phu district and lies along the west side of the Mekong River. According to the An Giang master land use plan for 2010, this commune was classified as being in agro-ecological Zone 2 (Plains), which is the large flooded plain area within the province. The biophysical and socio-economic conditions of the commune are described in Table 2.

Table 2: The natural- socio-economic conditions of the Vinh Thanh Trung commune

Geographical name	Zone 2 (five districts located in the West of Mekong river: Long Xuyen, Chau Doc, Chau Thanh, Thoai Son and Chau Phu)
Location	Chau Phu district
Total natural land area	2,649 ha
Agricultural land	2,115 ha
Total population	30,299 people
Population density	1,144 person km-2
Households	6,129
Soil condition	Alluvial soil
Hydrological conditions	Floods in dept: 1.5 ÷ 2.0 m
Flood season	From July to November
Dyke construction	August dykes: 2000 ha, constructed in 1996 High dykes: 650 ha, constructed in 2002
Land use and flood-based farming practices	Three rice crops: 650 ha in the High dyke areas Two rice crops: 2000 ha in August dykes areas One rice crop + one flood-based giant freshwater prawn in net fences (41 ha) in August dykes Two rice crops + one flood-based giant freshwater prawn in net fences in August dykes Two rice crops+ *Neptunia-Oleraceae* (18 ha) Snake Head fish farming in net cages in August dykes Fishery captures

Sources: Chau Phu statistical year book (CPSYB) (2004) and VTT (2003, 2004, 2005)

4.2.2 The O Long Vi commune of the Chau Phu district

The O Long Vi (OLV) commune is located in a remote area of the Chau Phu district, in the Zone 2, its biophysical and socio-economic features are sufficiently described in Table 3. The land use system of the commune is mainly based on rice farming and flood-based farming practices in No dyke areas such as giant freshwater prawn farming in the net fences on the paddy fields during the flood season, *Neptunia-Oleraceae* growing and Snake Head fish farming in net cages which are extremely important for rural livelihoods during the six months of floods. Furthermore, fishery capture is the main income source for the majority of local people during the flood season (Tien 2005).

Table 3: The natural and socio-economic conditions of the O Long Vi commune

Geographical name	Zone 2 (five districts located in the West of Mekong river: Long Xuyen, Chau Doc, Chau Thanh, Thoai Son and Chau Phu)
Total natural land area	7,065 ha
Agricultural land	6,580 ha
Total population	10,462 people
Population density	148 person km-2
Soil condition	Slight-medium acid sulfate soil
Hydrological conditions	Floods in depth: 1.7 ÷ 2.5 m
Flood season	From July to November
Dyke construction	No dykes:6,200 ha High dykes: 300 ha, constructed in 2004
Land use and flood-based farming practices	Three rice crops: 300 ha in High dyke areas Two rice crops:6,200 ha in No dyke areas Two rice + flood-based Neptunia-Oleraceae in No dyke areas One rice crop + flood-based giant freshwater prawn farming in net fences in No dyke areas Snake Head fish farming in the net cages in No dyke areas Fishery captures

Source: CPSYB (2004) and OLV (2003, 2004, 2005)

4.2.3 The Thanh My Tay commune of the Chau Phu district

The Thanh My Tay (TMT) commune, located in the Chau Phu district, was chosen to represent August dykes in the region. Rice is the main crop in the commune with the rotation of two crops per year (TMT 2006). During the inundated period, natural fish are freely accessed by the local fishermen and parts of the land areas are cultivated using flood-based farming practices such as giant freshwater prawn in net fences on the paddy fields, Snake Head fish in net cages, and *Neptunia-Oleraceae* growing in paddy fields (TMT 2006). The natural-socio-economic conditions of the commune are illustrated in Table 4.

Table 4: The natural and socio-economic conditions of the Thanh My Tay commune

Geographical name	Zone one (five districts located in the West of Mekong river: Long Xuyen, Chau Doc, Chau Thanh, Thoai Son and Chau Phu)
Total natural land area	3,289 ha
Agricultural land	2,929 ha
Total population	20,966 people
Population density	637 person km-2
Soil condition	Slight – medium acid sulfate soil
Hydrological conditions	Floods in dept: 1.7 ÷ 2.5 m
Flood season	From July to November
Dyke construction	August dykes
Land use and flood-based farming practices	Two rice crops: 2,893 ha Two rice crops + flood-based giant freshwater prawn farming in net fences Two rice crops + *Neptunia-Oleraceae*: 60 ha Snake Head fish farming in net cages Fish capture

Source: Chau Phu statistical year book (2004) and TMT (2003, 2004, 2005)

4.3. Data collection

This study accessed a wide range of secondary data, including published and unpublished documents from government agencies, research institutes and universities in Vietnam, with different valuation methods and actual outcomes (Table 5). Primary data on costs of dyke construction, flood damage, and areas of dykes was also collected through informal interviews with government officials (six staff) and tow prawn farmers at communal, district and provincial levels. The costs and benefits of farming alternatives such as rice, flood-based giant freshwater prawn, Snake Head fish, and *Neptunia-Oleraceae* farming were collected from previous studies and commune and district reports in An Giang provinces.

Table 5: Data types and sources, valuation methods and outcomes

Benefit and cost	Data Sources	Valuation Methods	Unit of Measurement
No dykes (Status quo)			
Rice damage costs (tones of rice /hectare)	Interview with communal staff	Damage avoided Loss producer surplus	VND 1,000/hectare
Farming benefits	Government reports, other studies	Market analysis	VND 1,000/hectare
August dykes compared to No dykes			
Cost of dyke construction and maintenance	Interview communal staff	Market analysis	VND 1,000/hectare
Extra farming benefits	Government reports, other studies	Market analysis	VND 1,000/hectare
Environmental costs (fish loss)	From Nha (2006), district's reports	Market analysis, Productivity change/Benefit transfer	VND1,000/household/year
High dykes compared to No dykes			
Cost of dyke construction and maintenance	Interview communal staff	Market analysis	VND 1,000/hectare
Change in farming alternatives	Government reports, other studies	Market analysis, Productivity change/Benefit transfer	VND 1,000/hectare
Environmental costs (fish loss, increase in fertilizer use)	From other studies		VND 1,000 /hectare/household

4.4. Data analysis

4.4.1 Techniques for valuing environmental goods and services

4.4.1.1. Types of valuation techniques

Two main types of valuation techniques are available to estimate environmental goods and services including market and non-market approaches (Tietenberg 2004). They can be applied in various economic valuation studies, although both have their advantages and disadvantages (Thang 2001). Applying these valuation techniques requires understanding of the economic concept of willingness to pay (WTP) which is the basis for economic valuations for any good and services (Babier *et al.* 1997:110). Floodplains in the Mekong Delta have both use and non-use values, so it is essential to use both approaches for valuing the goods and services of floods.

4.4.1.2. Market approach–valuing the use values

Supply-demand laws: The first approach is to value the flood benefits from market prices of flood services, based on supply-demand laws. This is the simplest method and most applicable way of calculating wetland benefits (IUCN 2003). It is also used to estimate the direct use values, especially floodplain agricultural production (Kimmage and Adams: 1992). This method assumes that no distortion of price mechanism exists in the market such as government interventions on exchange rates, subsidies, price ceiling, taxes and monopoly conditions, and that market prices will reflect the willingness to pay for goods and services (Babier 1997: 110). The limitation of this method is that the consumer surplus does not get included, as a result of the failure to take into account the total economic value (Tuner *et al*. 2003: 88).

Revealed reference: The second approach is the directly revealed reference method, which is based on actual observable choices and from which actual resource values can be directly inferred (Tietenberg 2004: 35). For example, in calculating how much fish local fishermen lose from dyke construction, the direct observation method may calculate how much the catch declined and the resulting value of the lost consumer surplus. In this case, the prices are directly observable and their use allows the direct calculation of the loss in values.

Productivity change: For flood functions that support economic activities, a third approach (productivity change) would be used to value the changes in productivity, resulting from support of those activities or use of alternatives (Babier 1992: 41). For example, the impact of sediment on rice yields can be estimated using the change in rice yields between different dyke alternatives, which assumes that other inputs for rice production are constant in these dyke areas. However, the indirect measure of productivity changes can be used to estimate the different fertilizer use in paddy fields in various areas with No dykes, August dykes or High dykes. These benefits will be taken into the cash flow of dyke construction projects.

Damage cost avoided: For flood functions that prevent economic activities, the best method is to estimate the damage cost to the economic activities currently being avoided (Babier 2992: 41). For example, rice damage costs by flood are protected by dyke systems: these costs can be measured through the market price and the amount of rice losses.

Production function: The final method is the production function approach, based on the derived demand by households for environmental quality. This approach may be used when an environmental regulation influences the profitability of producing a commercial good or service (Petersen 2003: 12). When a floodplain is being used indirectly in the sense that the ecological functions of floods (for example, ground water recharge, nutrient replenishment are effectively supporting economic activities), then the values of these functions are non-marketed. However, environmental economists demonstrate that these values can be estimated through the use of surrogate market valuation which uses information about a marketed good to infer the value of a related non–marketed good (Babier 2000:49). Some well-known techniques in applied environmental economics, such as travel cost, hedonic pricing and averting behaviour models, are based on the household production function approach (Wills 1997). The application of the production function approach may be most straightforward in the case of a single use system, but it may be slightly more problematic in the case of a multiple use system (Babier 2000: 50). For example, in a resource system, a regulatory function may support more than one economic activity: thus floods provide sedimentation for supporting rice farming, replenishing groundwater, and maintaining biodiversity. One limitation of the production function approach is that it is not able to measure the non-use benefits associated with a resource, while another is the poor understanding of physical effects on production of changes in the resources (Petersen 2003: 11 and Babier 2000: 50).

4.4.1.3. Non-market valuation approach – valuing non-use value

Since the revealed reference techniques cannot be used to value non-use values, stated reference techniques, such as contingent valuation method and choice modelling, have been applied recently (Ian 1997, Bennett and Blamey 2001). The simplest version of this approach merely asks respondents what value they would place on environmental changes such as loss of a floodplain or increased exposure to pollution from floods. These valuation techniques can be used to estimate the non-use values of floods but have potential problems of information bias, strategic bias, starting point bias and hypothesis bias for contingent valuation method, and being time-consuming and costly for choice modeling (Tietenberg 2004: 34, Morrison et al. 1996, Wills 1997).

4.4.1.4. Problems in valuing floodplain benefits

Although both market and non-market valuation methods are widely used, some problems in valuing floodplain benefits are of concern. First, floodplain values are not only indirect but also often unmarked (Babier 1992). Second, trade–offs between the various component values of the total economic value can occur even though the result of separate valuations of distinct indirect services is often aggregated along with other direct, option and existence values (Babier 1992: 42). Finally, double-counting benefits can occur for both on-site and off-site indirect uses when use and non-use values are aggregated into a net measure of total economic value (Babier 1992: 43). For example, sedimentation indirectly supports rice cultivation within flood-prone areas. If the full value of rice production is already accounted for as a direct use of floodplain services, adding the share of soil improvement service from sedimentation as an indirect use and aggregating to total economic value would double count this indirect value.

4.4.1.5. Alternative approaches to valuation of dyke development alternatives

The choice of appropriate economic valuation techniques is critical to this evaluation of costs and benefits. Babier (1993: 26) specifies three types of assessment required for various types of policy decision concerning floodplain use: impact analysis, total valuation and partial valuation. Under the first approach, assessing a specific environmental impact involves valuing the change in floodplains resulting from that impact, whereas the second approach is an assessment of the total economic value of the floodplain system. The third approach is required when one or more development options may lead to alternation of floodplain systems. This means that the choices involved in dyke construction should compare the opportunity costs of proposed options in terms of the subsequent loss in floodplain benefits. In the Mekong Delta, for example, dyke development projects are being implemented rapidly. If these projects properly control floodwaters out of the paddy fields, then any loss from floodplain benefits must be included as part of the overall project costs of the project. From the literature review, a range of critical costs and benefits for agricultural production in the area of No dykes, August dykes and High dykes are identified in Table 6.

Three assumptions are made in this study. First, the prices are not distorted in the market including government intervention such as tax and subsidies. Secondly, the biophysical conditions of other communes in Zone 2 (See Section 4.1.) are similar to three study sites so that the benefit transfer method can be applied. Finally, the farm products are sold in the market within the year so that the monthly average prices (12 months) and yearly average rice yields (five years) are used to estimate the economic values of outputs.

Table 6: The potential costs and benefits for agricultural production of dyke construction in the An Giang province

No dykes (Status Quo)	August Dykes	High Dykes
Costs		
Rice damage costs due to floods	Construction costs Maintenance costs The opportunity costs of dykes (a reduction in natural flood benefits: sedimentation, natural fish compared to No dykes)	Construction costs Maintenance costs The opportunity costs of dykes (a reduction in flood benefits: sedimentation, natural fish, and flood-based farming cultures compared to No dykes)
Benefits		
Rice farming Flood-based farming Sediment Fishery capture	Summer rice crop damage avoided compared to No dykes More opportunity for flood-based farming compared to No dykes	An additional rice and vegetable crops compared with No dykes Summer rice crop damage avoided compared with No dykes

The agricultural benefits of farming system alternatives in the area of No dykes such as rice farming and flood-based cultures ($B^{No\text{-}D}$), and the costs of not using dykes are the rice damage costs ($C^{No\text{-}D}$), then the net benefits of No dykes (the status quo) are:

$$NB^{No\text{-}D} = B^{No\text{-}D} - CN^{o\text{-}D}$$

Given the additional benefits of the August dykes ($B^{D\text{-}Aug}$) such as more opportunities for flood-based farming activities, the second rice crop damage is being avoided, and the costs of dyke construction and fish loss (C^{DAug}) compared to No dykes, then the net benefits of August dykes are:

$$NB^{D\text{-}Aug} = B^{D\text{-}Aug} - C^{D\text{-}Aug}$$

Similarly, the additional benefits of the High dykes ($B^{D\text{-}Hig}$) such as an additional rice and watermelon crops, livestock development and the second rice crop damage being avoided, and costs of the High dykes (C^{DHig}) (construction, maintenance, opportunity costs), then the net benefits of High dykes compared to No dykes are:

$$NB^{D\text{-}Hig} = B^{D\text{-}Hig} - C^{D\text{-}Hig}$$

4.4.1.6. Decision rules for independent projects

Either August dykes or High dykes are approved if the net present value ($NPV^{D\text{-}Aug}$ or $NPV^{D\text{-}Hig}$) is greater than or equal to zero, and greater than the NPV of No dykes (Perkins 1994: 68).

$$NPV^{T\text{-}Aug} \text{ or } NPV^{T\text{-}Hig} \geq 0$$

$$NPV^{T\text{-}Aug} \text{ or } NPV^{T\text{-}Hig} \geq \text{NPV of No Dykes}$$

Where: $NPV = \frac{\sum_1^n (B - C)}{(1 + r)^n}$, (r) is a real discount rate, (n) is the project life.

4.4.1.7. Decision rules for mutually exclusive projects

The dyke construction is approved if its NPV compared to NPV of No dykes is positive. If both dyke types have positive NPV compared with No dykes, then the decision rule for mutually exclusive projects is therefore to accept the project with the highest NPV (Perkins 1994: 68).

4.4.1.8. Dealing with the different years of data obtained and choosing discount rate

Due to time constraints, the research was conducted using secondary data from relevant studies in the region. Therefore, data on economic costs and benefits of farming alternatives and dykes construction were available in different time periods. Dealing with these problems, the economic costs of dykes in different years were converted into the prices in the year of 2005 using GDP deflator[3] calculated by the An Giang Department of Statistics (AGDS 2005). All economic costs of dykes and benefits of farming activities which occurred before the year 2005, were converted into the year 2005 using GDP deflator, and then the year 2005 is assumed as the origin for the project. The economic values of farming activities for the year 2005 were used as a benchmark (constant) for the whole project (20 years). The present values of these farming benefits and costs of dykes were estimated using a real discount rate.

In financial analysis, the market prices are used to value the project outputs and inputs even if these prices are not distorted (Perkins 1994:59). The market price of capital investment to the project implementer is the market interest rate, and this represents the costs to the implementers of capital investment in the project. If the farmers are net borrowers in dyke capital investment, this market borrowing rate should be used as the financial discount rate for the project appraisal. If farmers considering a dyke investment is a net lender, so they should invest these funds in financial market and earn market

[3] GDP deflator is the ratio between the current GDP and the real GDP in a given year (Rudiger, Stanley and Colm 2000). The GDP deflator gives us a useful measure of inflation (Rudiger, Stanley and Colm 2000).

earning rate. The nominal market interest rates are considered as discount rates when the inflation rate is zero.

However, most countries are affected by inflation in reality; therefore most project appraisals must take account of price inflation (Perkins 1994: 61). According to IMF (2005), the nominal market interest rate on medium-term borrowing made by the project was 12.9 per cent[4] in Vietnam while the inflation rate was 8.3 per 5 cent in 2005. Perkins (1994: 61) illustrates the relationship between the real discount rate (r) and the nominal discount rate (R), and the inflation rate (f) in the equation:

$r = \frac{(1+R)}{1+f} - 1$; Therefore, the $r = \frac{(1+0.129)}{1+0.083} - 1 = 4.2\%$

The NPV of this analysis was estimated using a real discount rate at 4.2 per cent for No dykes, August dykes and High dykes.

[4] From IMF Country Report No 06/52 (02/2006)
[5] From CEIC Asia Database, APSEG, ANU (05/10/2006)

Chapter 5 Results

5.1. The economic costs of dyke construction

5.1.1. Overview of dyke costs

There are various scales of dyke construction in the Mekong delta. They included dyke systems to control flood along Tien and Hau River, dykes to control floods for urban and residential areas, dykes to control the August flood and protect the summer rice crop, and High dykes to control floods for intensification of rice farming (Hoi 2005). For both August dyke and High dyke systems, about 300 to 1,500 ha of rice were constructed dykes along irrigated canals (Hoi 2005). This study was estimated the investment costs of August and High dykes. There are three main types of investment costs. Firstly, the construction cost was paid by local farmers at the beginning of the project. Secondly, the maintenance cost was contributed in the subsequent years of the project life. Finally, the opportunity costs such as fish loss, soil degradation and loss of flood-based farming incurred after the construction of dykes.

5.1.2. The economic cost of No dykes compared with August and High dykes

There were no costs obviously for dyke construction in the areas of No dykes, but its costs were associated with the rice damage costs caused by the flood. The costs were unusual because these often occurred at the same time as the high flood season. According to the leader of the OLV commune (pers. comm. Trung 2006), the rice damage occurred in the years of high floods such as in 1999, 2000. The estimated rice loss was 30 per cent of the rice yields due to the early harvest to avoid the floods in 1999 and 2000 (pers. comm. Trung 2006)[6]. However, rice damage costs has not occurred in

[6] An interview with Mr Trung, a commune president of O Long Vi, he said that rice damage only occurs in the high and soon flood season in 1999, 2000. The rice damage cost occurred unusually because of the level of floods.

the August and High dyke areas of the Chau Phu district (pers. Comm. Khanh 2006)[7]. This cost was not taken into account for the economic cash flow calculation of No dykes as it was not a typical occurrence, but it was considered in the sensitivity analysis of No dyke areas.

5.1.3. The economic costs of August dykes compared with No dykes

5.1.3.1. The investment costs of August dykes compared with No dykes

The total economic costs of constructing August dykes compared to No dykes included capital investment for making the mud dykes, the maintenance costs and an additional cost of fish loss during 20 years of the project life. The total capital investment was VND 0.4 million per ha in 1997 (pers. comm. Sieu 2006)[8]. Besides the capital investment costs, farmers have to contribute the maintenance costs of VND 0.45 million per ha for every three years after the completion of the construction (pers. comm. Phieu 2006). The construction period took one year only in 1997 in TMT commune (pers. comm. Sieu 2006). All the costs were converted into the year of 2005 for the consistency in comparison. The costs incurred before 2005 were converted using the GDP deflator for construction (AGDS 2005). With the GDP deflators were 125, and 135 for the year 1997 and 2005 respectively (AGDS 2005), the construction cost was VND 0.432 million per ha in 2005 (Table 8). However, the maintenance cost will incur after the year 2005 and will be converted into the present value at the year 2005. With the discount rates of 4.2 per cent per annum, the present value of the total costs were estimated at VND 2.2 million (AUD[9] 183) per ha respectively for the whole project life (Table 7).

[7] An interview with Mr Khanh, a head of Chau Phu Bureau of Agriculture and Rural Development, he informed that thanks to the August and high dyke systems, the rice damage loss of the second rice crop have not occurred so far.
[8] Mr Phieu is the vice president of the Thanh My Tay commune
[9] 1 AUD equals to VND 12,000 in 2005

Table 7: The economic costs of the August dykes

Parameters	Values (VND 1,000)	PV (VND 1,000)
		r=4.2%
Total costs	Construction + maintenance	2,206
		(AUD 183)
Construction	432/ha	
Maintenance	450/ha/every 3 years	

Source: Interview with Mr Sieu at TMT commune (2006)

5.1.3.2. The opportunity cost of August dykes compared with No dykes

Besides the investment cost, August dykes involved in the opportunity cost (fish loss) compared to No dykes (Figure 9). The cost can be seen clearly through the fishery capture loss due to the construction of August dykes having known other causes, such as natural decline and population growth (Nha 2006). So far, there is no existing information about fishery capture in the TMT commune; however, it is assumed that the fishery capture in the TMT commune is the average as in other areas in Zone 2 as mentioned in study site selection section. A survey from Nha (2006) each fishing household[10] lost 351 kg of fish due to the August dykes construction, having known other factors in Vinh Loi commune of the Chau Thanh district which is closed to TMT commune. The average fish price of VND 15,000 per kg in 2005, each fishery household lost the amount of VND 5.2 million (438 AUD) each year. Using the discount rate of 4.2 per cent, the preset value of fish loss was estimated at VND 70.3 million (AUD 5,858). This cost was the additional cost of the August dykes and therefore it must be taken into the economic cash flow when examining the economic benefits of August dyke construction.

[10] A fishing household is the family whose life bases on fishery capture. The number of fishing households varies in different communes in the Chau Phu district. For example, There were 56 households conducted fishery capture in OLV commune in 2001 whereas 40 and 38 households did in the VTT and TMT respectively at the same year (VTT, OLV, and TMY 2001)

Figure 9: Fishery capture during the flood season in TMT commune

5.1.4. The economic costs of High dykes compared with No dykes

5.1.4.1. The investment costs of High dykes compared with No dykes

In the VTT commune of the Chau Phu district, the total cost of High dykes involved construction and maintenance costs. The construction cost was paid at the first year of the project with the amount of VND 1.5 million per ha (pers. comm. Dung 2006). The investment period started and completed within one year (in 2002). The maintenance cost was contributed every three years with the amount of VND 0.8 million per ha (pers. comm. Dung 2006). All costs were converted into the year 2005 using GDP deflators for construction from the AGDS (2005) and the real discount rates for converting into the present value of the maintenance cost. The GDP deflators for construction were 130 and 135 for the year 2002, and 2005 respectively (AGDS 2005), so total investment costs were estimated at VND 1.5 million per ha in 2005 (Table 9). With the discount rates of 4.2 per cent per annum, the present value of the costs (construction, maintenance) were estimated at VND 4.7 million (AUD 475) per ha for the whole project life (Table 8).

Table 8: The investment costs of High dykes

Parameters	Value (1,000 VND)	PV (VND 1,000)
		r=4.2%
Total costs		4,700
		(AUD 475)
Construction	VND 1,577/ha	
Maintenance	VND 800/ha/every 3 years	

Source: Interview with Mr Dung at VTT commune (2006)

5.1.4.2. The opportunity costs of High dykes

Besides the investment costs, the High dykes included the opportunity costs. These costs involved fishery capture loss, an increase in fertilizer use for the first rice crop, and no opportunity for flood-based farming. The economic values of these losses were estimated in the following sections.

Firstly, there was an additional cost of increasing the amount of fertilizer use for the first rice crop. Nha (2006) indicates that there was a significant difference in nitrogen fertilizer use between No dykes and High dyke areas in Cho Moi district where High dykes were established in 2000. In particular, farmers applied 81 kg for the first rice crop in No dyke areas before the year 2000, but fertilizer use increased by 15 kg in the High dyke areas (after 2 years of dyke construction). However, this was insignificant for the second and the third rice crops after two years of dyke construction (Nha 2006). Therefore, High dykes have significant impacts on use of nitrogen fertilizer in the first crop in comparison with No dykes. In particular, this impact costs farmers an extra average of 15 kg of nitrogen fertilizer per annum in the high dyke areas. With the average price of VND 5.0 thousand per kg of nitrogen fertilizer, rice farmers lost an extra of VND 75 thousand per ha each year. Using the discount rate of 4.2 per cent, the present value of fertilizer use increase was estimated at VND 1.0 million (AUD 83) per ha for the whole project (Table 9).

Secondly, the High dykes resulted in the fishery capture loss having known other causes. A survey from Nha (2006) shows there was a reduction in the fishery capture output of 1,072 kg per household per year in the high dyke areas compared to No dykes, in the Chau Phong commune of the Tan Chau district. Before the high dyke project (No dykes), each household caught 1,470 kg fish per year but this amount was only 398 kg per year after the construction of the High dykes due to the prevention of fish flow into the high dyke areas, having known other natural fish decline. Because there is no available data on the impacts of the High dykes on fishery capture in three communes of this study, using extrapolation for these areas is to estimate the additional costs for the High dykes in the VTT and OLV communes of the Chau Phu district. With an average price of VND 15 thousand per kg of fish, the loss was estimated at VND 16 million (AUD 1,340) per household per year. Using the discount rate of 4.2 per cent, the present value of fish loss was estimated at VND 214 million (AUD 17,892) per ha for the whole project (Table 9).

Table 9: The opportunity costs of the High dykes

Parameters	Unit (1,000 VND)	PV (VND 1,000)
		r=4.2%
Additional cost of fertilizer	VND 75/ha/annum	1,001
Natural fish loss (gross value)	VND 16,080/household/annum	214,713

Finally, construction of High dykes interrupted the flood-based farming compared to No dykes. Without floodwaters, farmers lost the opportunity of flood-based farming such as

Neptunia-Oleraceae, Snake Head fish, and giant freshwater prawn cultures. The flood benefits of No dykes are the opportunity costs of High dykes. These losses were taken into the economic cash flow of High dykes and discussed in the further sections.

5.1.5. Summary

In comparison with No dykes, August dykes and High dykes required high capital investment costs while the investment and opportunity costs in High dykes were the highest. The present value of High dyke's total costs was much higher than that of August dykes. The No Dyke system would avoid those costs, but it might include rice damage costs due to the high floods[11]. This cost was much higher than the investment of August and High dykes.

5.2. The economic benefits of farming alternatives

5.2.1. The economic benefits of farming alternatives in OLV commune (No dykes)

5.2.1.1. Farming system alternatives

In the No dyke areas of the Mekong Delta, there are four main farming system alternatives. The first and most common system are two rice crops per year which are grown from November to July each year. The second system is called two main rice crops plus one Neptunia-Oleraceae crop during the flood season. This system resulted in higher economic benefits than that of the first system. The third farming system includes one rice crop in the first season and one flood-based giant freshwater prawn culture in the net fences on the paddy fields during the flood season. This system is quite new and requires high capital investment but provided high economic return to local farmers. The final system is the flood-based Snake Head fish farming in the net cages during the flood season which also provided high economic return to the local farmers. This system was suitable for the poor and landless farmers (pers. comm. Khanh 2006). The economic values of the farming system are critically analyzed in the subsequent sections.

[11] High flood is the flood which floodwater is more than 4 meters in depth

5.2.1.2. The first farming system: two rice crops per year

Rice is the main crop in the No dyke areas of the region (Figure 10). The first rice crop starts in November and is harvested in February each year. The average rice yield was 6.76 tonnes per ha for five years (2001-2005) from the Chau Phu Statistics (2005). With the average market price of VND 2,269 per kg in 2005, the total benefits of the first rice crop were VND 15.3 million per ha (CPBARD 2005). The production costs consisted of land preparation, seeds, fertilizer, pesticides, herbicides, labour, and harvests which were about VND 7.4 million per ha (CPBARD 2005). The total costs did not involve in opportunity cost of home labour for rice production. After subtracting all costs, the net benefits of the first rice crop were VND 7.9 million in 2005 (Table 10). However, the net benefits of the second rice crop were VND 2.5 million which were lower than the first crop due to low yields (Table 10). The total net benefits for two rice crops reached to VND 10.4 million (AUD[12] 867) per ha per year (Table 10). This value was double compared to the average GDP per capita in An Giang provice in 2002[13].

Figure 10: Rice farming in No Dyke areas of OLV commune

[12] 1 AUD equals to VND 12,000 in 2005

[13] The GDP per capita was VND 5.4 million in 2002 (An Giang Statistics Year Book 2002)

Table 10: The economic benefits of two rice crops per year

Parameters	Unit	The first rice crop[14]	The second rice crop[15]	Total
Yield	Tones/ha	6.76	4.38	
Price	VND 1000/kg	2.269	2.269	
Total benefits	VND 1000/ha	15,338	9,938	25,276
Total costs	VND 1000/ha	7,437	7,425	14,862
Net benefits	VND 1000/ha	7,901	2,513	10,414
Net benefits	AUD/ha	658	209	867

Sources: Chau Phu Bureau of Agricultural and Rural Development (2005)

5.2.1.3. The second farming system: rice and Neptunia-Oleraceae

Neptunia-oleraceae is a kind of aquatic vegetable which is suitable for growing in the medium flooded areas (Figure 11). After harvesting the second rice crop in July, local farmers cultivates Neptunia-Oleraceae during the flood season and its products were sold in domestic market. This crop also required less capital investment but generated many jobs for the local people during leisure months of flooding (pers. comm. Trung 2006). The net benefits of Neptunia-Oleraceae without opportunity cost of home labour were estimated at VND 5.2 million (AUD 437) per ha (Thanh *et al.* 2005) (Table 11). With net benefits of two rice crops of VND 10.4 million, the total net benefits of this system were VND 15.6 million (AUD 1,305) per ha in 2005. The economic return of this system was much higher than that of the first system.

[14] The first rice crop is 'Winter-Spring' crop which starts in November and harvests in February each year.
[15] The second rice crop is 'Summer-Autumn' crop which starts in April and harvests in July each year.

Figure 11: Neptunia-Oleraceae farming in paddy fields during the flood season

Table 11: The economic benefits of Neptunia-Oleraceae growing in the OLV commune

Parameters	Unit	Neptunia- Oleraceae
Total benefits	VND 1000/ha	9,475
Total costs	VND 1000/ha	6,041
Net benefits	VND 1000 ha	3,434
Net benefits without home labour	VND 1000/ha	5,249
Net benefits without home labour	AUD/ha	437

Sources: Thanh, Duyen, Cuong, Tuyen, Huy and Ha (2005)

5.2.1.4. The third farming system: rice and prawn cultures

The third farming system in the No dyke areas of the OLV commune is one rice crop in the first season and one flood-based giant freshwater prawn culture during the flood season (Figure 12). Basically, after harvesting the first rice crop in January each year, farmers cultivate giant freshwater prawns in the net fences on the paddy fields during six months of floods (pers. comm. Tung 2006)[16]. The net benefits of rice and prawn were VND 7.9 and VND 44.7 million per ha respectively. The opportunity costs home labour did not include in this analysis. The total net benefits were VND 52.7 million (AUD

[16] Mr Tung is a technical assistant for aquaculture development at the Chau Phu Farming Extension Services.

4,396) per ha per annum which were much greater than that of the first and second systems in the No Dyke areas (Table 12). This could be considered as a profitable farming system for the flooded areas without any dyke intervention because it shows a great economic returns compared with the conventional system of two rice crops per annum.

Figure 12: Flood-based giant freshwater prawn farming in net fences

Table 12: The economic benefits of rice and prawn farming in net fences

Parameter	Unit	The first rice crop	Prawn culture	Total
Yields	Tones/ha	6.76		
Price on sale	VND 1000 /kg	2.269		
Total benefits	VND 1000 /ha	15,338	102,540	117,878
Total costs	VND 1000 /ha	7,437	57,790	65,117
Net benefits	VND 1000 /ha	7,901	44,750	52,761
Net benefits	AUD/ha	658	3,979	4,396

Source: Chau Phu Bureau of Agricultural and Rural Development (2005)

5.2.1.5. The flood-based Snake Head fish farming in net cages

Besides three main farming systems in the areas of No Dykes, the Snake Head fish culture in the net cages provided significant benefits to local communities (Figure 13). This activity required little capital investment (land and labour) but generated many benefits for poor and landless households. Fish farming was conducted along internal canals and fish ponds (pers. comm. Trung 2006). Farmers used the natural products captured from the inundated paddy fields such as golden snail, small prawn and fish for feeding the Snake Head fish. With the average 32.73 m3 volume of net cages per household in Chau Phu district, the average net benefits were estimated at VND 4.1 million (AUD 346) per household per annum (Table 13). According to O Long Vi's report (2005), there were 98 households conducted Snake Head fish in net cages which were estimated that the net economic return to the commune were VND 406.9 million (AUD 35,673) per flood season.

Figure 13: The flood-based Snake Head fish farming in the net cages

Table 13: The economic benefit of flood-based Snake Head fish farming in the net cages

Parameters	Unit	Total
The volume of net cages	m3/household	32.73
Yields	Kg/m3	40.10
Price on sale	VND 1000 /kg	17.23
Total benefits	VND 1000 /m3	822.00
Total costs	VND 1000 /m3	695.11
Net benefits	VND 1000 /m3	126.89
Net benefits per household	VND 1000 /household	4,153
Net benefits per household	AUD/ha	346

Sources: Thanh, Thuy, Thu, Phat, Hai, and Nam (2005)

5.2.2. Summary

There are four main types of farming activities in the No dyke areas of the OLV commune. The first conventional system is two rice crops per year and generates the lowest economic return compared with the second system using two rice crops and a flood-based Neptunia- Oleraceae crop in the flood season (Table 14). Significantly, the third system (one rice crop and one flood-based prawn) results in the highest economic benefit compared with the first, second and fourth alternatives in the No dyke system.

Table 14: The summary of economic values of farming alternatives

Farming Alternatives	Unit	Net benefit	AUD
Two rice crops per year[17]	VND 1000/ha	10,414	867
Two-rice - one neptunia- oleraceae crop[18]	VND 1000/ha	5,249	437
One rice crop - one flood-based prawn[19]	VND 1000/ha	52,761	4,396
Snake head fish farming	VND 1000/household	4,153	346

[17] The area with two rice crops per year and allow floods into paddy fields for fishery capture
[18] The area with two rice crops and one neptunia-ole crop during flood season
[19] The area with only one rice crop and one prawn season during floods

5.3. The economic benefits of August dykes compared with No dykes

5.3.1. Farming system alternatives

There are five main types of farming systems conducted in the August dykes of VTT and TMT communes (VTT and TMT 2006). The first four systems (two rice crops, two rice crops-Neptunia, one rice crop-prawn, and Snake Head fish) are similar to the four farming systems in the No dyke areas (CPBARD 2005). Additionally, August dykes have more opportunity to conduct the fifth system of two main rice crops and one flood-based giant freshwater prawn in net fences. The economic benefits of these farming systems were estimated in Table 15.

Table 15: The economic values of farming alternatives of August dykes

Farming Alternatives	Unit	Net benefit	AUD
Two rice crops per year	1000 VND/ha	10,450	870
Two rice – Neptunia Oleraceae per year	VND 1000/ha	15,699	1,308
One rice-one prawn per year	VND 1000/ha	52,353	4,379
Flood-based Snake Head fish farming	VND 1000/household	4,153	346

Source: Chau Phu Bureau of Agricultural and Rural Development (2005)

However, the fifth farming system in the August dykes generated the higher economic return to local farmers than the one rice and prawn system in areas of No dykes, because farmers grew two rice crops and one prawn culture in the flood season Table 16.

Table 16: The economic values of two rice crops and one flood-based prawn

Parameters	Unit	Two rice crops	Flood-based Prawn	Total
Total benefits	VND 1000/ha	25,094	99,900	124,994
Total costs	VND 1000/ha	14,644	54,740	69,384
Net benefits	VND 1000/ha	10,450	45,160	55,610
Net benefits	AUD/ha	870	3,767	4,634

Source: Chau Phu Bureau of Agricultural and Rural Development (2005)

5.3.2. Summary

In summary, the first system in the August dyke areas provides the lowest net economic return while the third and fifth systems generates the highest net economic benefit to local farmers (Table 15). In comparison with No dyke areas, the fifth farming system results in highest economic return to local farmers, whereas the economic benefits of other farming systems are quite similar. Therefore, the fifth system is more preferable in the areas of August dykes.

5.4. The economic benefits of High dykes compared with No dykes

5.4.1. Farming system alternatives

As discussed in the theoretical framework, the main target of High dyke construction was to control the flooding fully and to intensify rice farming from two rice crops into three rice crops per year. There are two main farming systems being conducted in the high dyke areas of the VTT and OLV communes (VTT and OLV 2006). The first system is three main rice crops per year while the second system was the combination of two main rice crops and the third vegetable crop. In comparison with No dykes, the High dykes generated an additional rice crop and a watermelon crop and avoided the second rice crop damage by floods, but they also incurred the opportunity costs: the loss of flood-based farming practices, the loss of fish and an increase in fertilizer use due to a lack of sediment in the paddy fields. These costs were taken into the economic cash flow of High dykes.

5.4.2. The additional rice crop compared with No dykes

Three rice crops per year are the main farming system in the areas of High dykes in the Chau Phu district (Figure 14). In comparison with the two main rice crops in No dyke areas, farmers benefit from a third rice crop with the amount of VND 3.7 million (AUD 311) per ha per year in the High dyke areas (Table 17). The third rice crop showed the lowest net benefit compared to that of the first and second rice crops due to the lower yields in the High dyke areas. Moreover, the net benefit of the third rice crop was much lower than that of the flood-based Neptunia crop (VND 5.2 million per ha), Snake Head fish, and giant freshwater prawn (VND 52.7 million per ha) in the No dyke areas.

Figure 14: Three rice crop system in High dyke areas

Table 17: The economic benefit of a third rice crop in High dyke areas of VTT commune

Parameters	Unit	The third rice crop[20]
Yield	Tones/ha	5.0
Price	VND/kg	2,269
Total benefits	VND 1,000/ha	11,549
Total costs	VND 1,000/ha	7,814
Net benefits	VND 1,000/ha	3,735
Net benefits	AUD/ha	311

Source: Chau Phu Bureau of Agricultural and Rural Development (2005)

5.4.3. The economic benefit of a watermelon crop compared with No dykes

Alternatively, an additional watermelon crop is grown in the areas of High dykes. After harvesting the first rice crop, farmers could grow one watermelon crop (about 45 days) which would result in higher net benefits compared to the first, second and third rice crop respectively in the High dyke areas. The net benefit of watermelon was estimated at VND 8.9 million (AUD 745) per ha per year (Table 18). This is a potential crop for the high dyke areas in Chau Phu district because it generates higher net economic return than that of other single rice crop. In comparison with the net benefit of two rice crops in the No dyke areas, farmers can improve incomes through one more rice crop and an additional vegetable crop.

[20] The third rice crop is the 'Autumn–Winter' crop

Table 18: The economic benefit of a watermelon crop in the OLV commune

Parameters	Unit	Water melon crop
Price	VND/kg	700
Yield	Tonnes/ha	20
Total benefits	VND 1,000 /ha	14,000
Total costs	VND 1,000 /ha	5,050
Net benefits without home labour	VND 1,000 /ha	8,950
	AUD/ha	745

Source: Chau Phu Bureau of Agricultural and Rural Development (2005) and OLV (2005)

5.4.4. Summary

In the areas of High dykes, farmers could diversify their income through the intensive rice and watermelon farming. The economic benefits of the third rice crop plus a vegetable crop were much higher than that of the flood-based Neptunia crop per ha. However, if farmers grew an additional third rice crop only compared to No dyke areas, the net benefit of the third rice crop was lower than that of the flood-based Neptunia crop. More importantly, farmers lost the opportunity to culture a high economic value of flood-based giant freshwater prawn.

5.5. The economic analysis of dyke alternatives

The economic analysis of dyke constructions was carried out partially. Firstly, the present value (PV) of each farming alternatives and costs of No Dykes, August Dykes and High dykes was estimated. Secondly, the comparison of costs and benefits between August dykes and No dykes, the High dykes and No dykes were conducted to show the change the consumer surplus in terms of the present value.

The costs and benefits of No dykes are shown in Table 19. There were not both construction costs for the No dykes. However, No dykes involved the opportunity costs of rice damage (PV=VND 39.8 million) and net benefits of a third rice crop (PV=VND

49.8 million) compared with High dyke areas. The benefit of farming alternatives in the No dykes involved rice, flood-based Neptunia, Snake Head fish and giant freshwater prawn. Firstly, the net benefit for two rice crops was estimated at VND 10.4 million per ha per year with the present value of VND 139 million. Secondly, the net benefit for the flood-based Neptunia crop was VND 5.2 (PV = VND 70 million). Thirdly, the net benefit of giant freshwater prawn was VND 44.7 million per ha per year (PV = VND 597.5 million). Finally, each Snake Head fish farmer gained the net benefit of VND 4.1 million (PV= VND 55.4 million).

More importantly, with the construction of August dykes, farmers had more farming opportunities compared with No dykes. As discussed in Section 5.3.1, farmers could cultivate two rice crops and one flood-based giant freshwater prawn in the August dykes compared to only one rice crop and one flood-based giant freshwater prawn in the No dyke areas. The net benefit of the second rice crop was estimated at VND 2.5 million per ha per year. This was the main different agricultural benefit between No dykes and August dykes. The present value (PV) of second rice crop in the August dykes was estimated at VND 32.5 million per ha for the whole project compared to the No dykes. However, the August dykes incurred the fish loss with the gross value of VND 5.2 million per household compared to the No dykes. Because there were 38 fishing households in TMT commune, the total fish loss values were quite small compared to the total benefits of a second rice crop (VND 2.5 million per ha) for the total rice areas of the commune (2,929 ha). Furthermore, the August dykes could save a 30 per cent in rice yield of the second rice crop with PV of VND 39.8 million per ha in the sensitivity analysis. Therefore, the NPV of the August dykes was positive compared to No dykes and the dyke development project will be acceptable.

In contrast, the High dykes not only required a higher investment but they also had more significant opportunity costs compared to the No dykes. The PV of the investment cost was VND 4.7 million per ha for the whole project. Even though High dykes generated an additional third rice crop (PV=VND 49.8 million), but its value was much lower than the opportunity costs in No dykes. The opportunity cost involved the additional fertilizer cost (PV=VND 1.0 million per ha), fish loss (PV=VND 214.7 million per household, the loss of a flood-based Neptunia (PV=VND 70 million per ha), flood-based prawn (PV = VND 597.5 million per ha) (Table 19). The total costs of High dykes were much higher than the net benefits of additional rice and watermelon crops in the No dykes (Table 19). Therefore, the net agricultural benefit of the High dykes was negative if the opportunity costs were taken into account. Compared to No dykes, the NPV of High dykes was negative because their opportunity costs were so high. Furthermore, the project may not be approval because they are not as profitable as the August dykes. Table 20 showed that comparison of the present value of costs and benefits of the August dykes and the High dykes with No dykes.

Table 19: Summary of the economic costs of dyke alternatives and agricultural benefits of farming system alternatives

Costs and Benefits	Unit	No Dykes	August Dykes	High Dykes
A. Total costs				
A1. Investment costs (PV)	VND 1,000	0	1,011	4,700
Construction cost	VND 1,000/ha	0	432	1,577
Maintenance cost	VND 1,000/ha	0	150 (every 3 years)	800 (every 3 years)
A2. Opportunity costs				
Neptunia	VND 1,000/1000m2/year	0	0	5,249
(PV)	VND 1,000			70,008
Prawn	VND 1,000/ha/year	0	0	44,750
(PV)	VND 1,000			597,537
A third rice crop	VND 1,000/ha/year	3,735	3,735	0.0
(PV)	VND 1,000	49,872	49,872	0.0
Additional fertilizer cost	VND 1,000/ha/year	0	0	75.00
(PV)	VND 1,000			1,001
Natural fish loss	VND 1,000/household/year	0	5,265	16,080
(PV)	VND 1,000		70,302	214,713
B. Total economic benefits				
Rice		Two rice crops	Two rice crops	Three rice crops

	VND 1,000/ha/year	10,414	10,450	14,118
(PV)	VND 1,000	(139,055)	(139,536)	(210,586)
Neptunia	VND 1,000/ha/year	5,249	5,249	0
(PV)	VND 1,000	(70,008)	(70,008)	0
Watermelon	VND 1,000/ha/year	0	0	8,950
PV	VND 1,000	0	0	(119,507)
Prawn	VND 1,000/ha/year	44,750	45,160	0
PV		(597,537)	(603,001)	0
Snake Head Fish	1,000/household/year	4,153	4,153	0
		(55,454)	(55,454)	0

Table 20: The comparison of the economic costs and benefits between August dykes and High dykes to No dykes

Costs and Benefits	Unit	No Dykes	August minus No Dykes	High minus No Dykes
A. Total costs	VND 1,000			
A1. Investment costs (PV)	VND 1,000/ha	0.0	1,011	4,700
Construction cost	VND 1,000/ha	0.0	432	1,577
Maintenance cost	VND 1,000/ha	0.0	150 (every 3 years)	800 (every 3 years)
A2. Opportunity costs				
Neptunia (PV)	VND 1,000/ha	0.0	0.0	70,008
Prawn (PV)	VND 1,000/ha	0.0	0.0	597,537
Additional fertilizer cost (PV)	VND 1,000/ha	0.0	0.0	1,001
Natural fish loss (PV)	VND 1,000/household	0.0	70,302	214,713
Snake Head Fish (PV)	VND 1,000/household	0.0	0.0	55,454
A third rice crop (PV)	VND 1,000/ha	49,872	49,872	0.0
B. Total Benefits				
Rice (PV)	VND 1,000/ha	Two rice crops 139,055	Two rice crops 0,481	Three rice crops 49,872

Neptunia (PV)	VND 1,000/ha	70,008	0.0	
Watermelon (PV)	VND 1,000/ha	0.0	0.0	119,507
Prawn (PV)	VND 1,000/ha	597,537	38,044	
Snake Head Fish (PV)	VND 1,000	55,454	0.0	

5.6. Sensitivity Analysis

5.6.1. The sensitivity scenarios

The sensitivity analysis was to test how sensitive predicted net benefits are to changes in assumptions. If the sign of net benefits did not change when we considered the range of reasonable assumptions, then our analysis was robust and we could have greater confidence in its results.

In this project, the sensitivity analysis was carried out to test the impacts of significant changes on the key variables to determine the impact of such manipulations on the project's net present value. The following scenarios were discussed with the communal leaders[21] and prawn farmers[22].

Scenario 1: There was a reduction in 30 per cent of rice yields due to floods.
Scenario 2: There was a reduction in 30, 40 and 50 per cent of prawn yield respectively due to the environmental problem from floods.

5.6.2. Result of the sensitivity analysis

If there are 30 per cent of rice damage in yields of the second crop due to floods in the No dykes, the PV of the two main rice crops system was still positive compared to the rice damage cost (Table 21). However, farmers got the negative economic return (VND-0.486 million per ha per year) from the second rice crop due to the flood damage. If there are no dyke systems (whether August or High dykes), rice farmers may loss VND 0.4 million per ha per year due to flood damage.

However, the net agricultural benefit of August dykes compared to No dykes was improved by the saving of the rice damage costs due to floods. The rice damage was

[21] Mr Trung, Mr Sieu, and Mr Dung, are communal leaders of three selected study sites.
[22] Mr Hoa, Mr Tap and Mr Dinh are prawn farmers in thee communes.

estimated at VND 2.9 million (PV=VND 39.8 million) per ha per year which was the benefit of August dykes. This benefit was much higher than the investment cost of the August dykes and fish loss (the present value of VND 39.8 million per ha compared to the construction of VND 1.0 million per ha and VND 70 million of fish loss per household due to August dykes) (Table 21). Because there are only 30 fishmen in the commune, the total fish loss was quite small compared to the value of rice saving.

Table 21: Sensitivity analysis of the 30 per cent reduction in rice yields for the second rice crop

Costs and Benefits	Unit	No Dykes	August minus No Dykes	High minus No Dyke
A. Total costs				
A1. Investment costs (PV)	VND 1,000	0	1,011	4,700
Construction cost	VND 1,000/ha	0	432	1,577
Maintenance cost	VND 1,000/ha	0	150 (every 3 years)	800 (every 3 years)
A2. Opportunity costs				
Rice damage cost 30% (PV)	VND 1,000/ha	39,804	39,804	39,804
Additional fertilizer cost (PV)	VND 1,000/ha	0	0	1,001
Natural fish loss (PV)	VND 1,000/household	0	70,302	214,713
B. Total Benefits				
Rice (PV)	VND 1,000/ha	Two rice crops 139,055	Two rice crops 0,481	Three rice crops 71,513
Neptunia (PV)	VND 1,000/ha	70,008	0	70,008
Watermelon (PV)	VND 1,000/ha	0	0	119,507
Prawn (PV)	VND 1,000/ha	597,537	38,044	-597,537
Snake Head Fish (PV)	VND 1,000/household	55,454	0	-55,454

Similarly, the benefit of the High dykes was also improved by the saving of 30 per cent reduction in rice yields for the second rice crop compared to No dykes. However, due to the high opportunity costs of High dykes such as prawn benefits, therefore the net benefits of changes were negative (Table 21).

If there were 30, 40 per cent reduction in the prawn yields respectively, their PV of prawn benefit was positive in both No dykes and August Dykes (Table 22). However, the PV of prawn benefit was negative when there was 50 per cent reduction in yields (Table 22). In this case the net benefit of the prawn was very risky. Therefore, the construction of High dyke will be more preferable if there is 50 per cent of prawn yield loss.

Table 22: The sensitivity analysis of prawn benefits

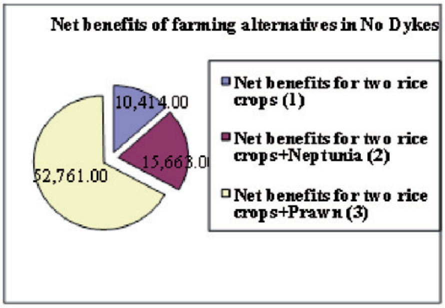
Prawn production	30 % (reduction in yields)	40% (reduction in yields)	50% (reduction in yields)
Unit	VND 1,000/ha	VND 1,000	VND 1,000
Net benefit	8,858	3,734	-6,520
Present value	114,673	49,859	-87,060

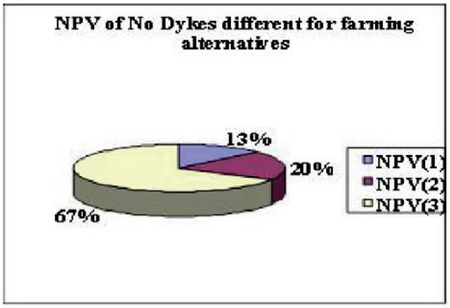
Chapter 6 Discussions and Conclusions

6.1. Discussion of the result

With different farming alternatives in the No Dyke areas, Figure 15 showed that the third alternative farming provides the highest economic return to local farmers. The conventional farming system of two-rice crops system per annum, however, generated the lowest net benefits. The second alternative was also preferable for the small size households as they could improve their income through an extra Neptunia crop during the flood season. In addition, each fishery household could benefit from the flood with the minimum amount of VND 16 million per annum which avoided by the fish loss from the high dyke systems. Furthermore, other farmers could improve their income through flood-based Snake Head fish culture with the estimated net benefit of VND 4.1 million per household per annum. Significantly, the flood may cause a reduction in rice yields which leads to the negative net benefit for the second rice crop.

Figure 15: The magnitude of net benefit and NPV of farming alternatives in the no dyke areas





More differently, farmers could diversify the farming system in the August dyke areas compared to the No dykes. In particular, the system of two rice crops plus one flood-based prawn resulted in higher net benefit compared to other farming systems in the No dyke areas. These figures explained the trend to develop flood-based prawn culture in recent years. The net benefits of Snake Head fish and Neptunia crop in the August dykes were similar to that of the No dykes. However, the August dyke system leads to a reduction in fishery capture of VND 5.2 million per fishery household per year. This value was quite low compared to the benefit of the second rice crop for the total rice areas in the commune. In general, the August dyke systems were more profitable than the No dykes because it required the low capital investment costs but generated the highest economic return to farmers particular in prawn, Neptunia, and Snake head fish. Rice damage was also avoided by the construction of the August dykes. The value of saving rice damage costs was much higher than the opportunity cost of August dykes. Therefore, NPV of August dykes was higher than No dykes.

In contrast, two common farming systems were conducted in the high dyke areas. These systems provided positive NPV compared to the construction costs of High dykes, but the NPV of each alternative was relatively lower than that of the one rice crops plus flood- based giant prawn in the No dykes and August dykes. Furthermore, the High dykes generated the highest opportunity costs, the loss of flood benefits, such as loss of sediment, fish, and flood-based farming (Table 21). Overall, High dykes generated lower agriculture economic return per ha compared No dykes if the opportunity costs were taken into account.

In summary, based on the results as discussed in the previous chapter, the hypothesis that the August dyke systems provide the highest net agricultural economic benefits was accepted. The NPV of two rice crop and one flood-based giant freshwater prawn farming in the August dyke system provided the highest economic returns to local farmers than that of No dyke and High dyke systems even though August dykes resulted in fish capture loss and consisted of dyke construction cost. However, a precaution should be taken into account when estimating the high value for flood-based giant freshwater prawn culture. The negative environmental impacts from floodwaters on prawn, which may result in a reduction in prawn productivity (pers. comm. Khanh 2006) are presented in the sensitivity analysis (Table 22).

6.2. Some strengths and limitations of this research

The economic values of farming alternatives in thee locations are sufficient to support the economic analysis of dyke construction alternative in the An Giang province.

- The benefit transfer method has been used to estimate the costs and benefits of dyke alternatives. This allows using the existing studies in An Giang province to interpolate the estimation of costs and benefits of dyke alternatives in the selected communes because of the low costs and shorter time requirements for data collection. More importantly, when the secondary data in the selected study sites are not available, the benefit transfer method may be the best solution having known the possible biases. For example, the net benefit of Snake Head fish, fertilizer cost and fishery capture loss were estimated using benefit transfer from other studies in the similar geographical conditions with the Chau Phu district of An Giang province in this study.

- Nonetheless, there remains with some limitations in this analysis. Firstly, this study uses a market-based approach and assumes hat the market prices are not distorted by government intervention. In reality, the government is often active in the pricing of basic commodities, particularly rice, which leads to some level of distortion which may change overtime. This may lead to a bias in estimation.

- The second limitation is the lack of time-consistent primary data. This study uses secondary data, collected over different time periods, and where possible averages information to get a standardized measure. However, a study would be significantly improved if all data used had been collected at the same time, from the study locations. In consequence, the result can be best regarded as approximations, and remain subject to the stated assumptions.

- The third limitation is that this study measures the use and part of indirect use values of flood and dyke benefits. If the non-use values of floods are taken into account, the total economic values of No dykes, August dyke and High dykes may be different.

- The fourth limitation is a lack of data on the net benefit of fishery capture per ha in three selected locations that leads to inconsistency in the unit of measurement. Therefore, those benefits were compared separately and were not included in the economic cash flow of the No Dykes, the August dykes and the High dykes.

- There was insufficient secondary data to allow the study to analyse the benefits and costs of livestock development in the selected study sites. It is possible that livestock rearing could contribute additional economic benefits that were not included here, and therefore, the economic benefits of High dykes may be underestimated.

- More importantly, the non-market value of the High dykes may be significant. For example, people are more convenient (living conditions and transportation), and they feel safer in the High dykes. If these values were taken into account, the total economic values would be higher. Those can be explained why the High dykes were developed in recently. Therefore, the total economic values of the High dykes may be underestimated.

- Because the flood occurs unusually, this may result in different flood damage situations. Therefore, this variation should be taken into account in the economic cash flow of dyke project.

6.3. Policy implications

There are two main kinds of policy implications which have been raised. The first implication is related to flood management in the Mekong Delta and the second highlights gaps in the current knowledge and suggests areas for further research to inform the policy discussion.

6.3.1. Flood management

Because floods provide both use and non-use value to local farmers, it is essential to take this into consideration when deciding on an appropriate flood management strategy. The August dyke system may be the best method for managing floods, allowing farmers to exploit the significant benefits of floods and still receive protection from flooding. The findings here indicate that the government and local farmers should jointly analyse the costs and benefits of different flood management options when considering the flood mitigation measures, and not be afraid to consider other options which may provide a higher economic return to local community from agricultural activities.

Additionally, it is important to consider the economic values of floods in terms of cost and benefit analysis of farming alternatives. Significantly, the economic values of floods should be well understood by policy makers and farmers in other provinces of the Delta. While only quantitative direct and indirect use values are examined in this study, as discussed in Section 6.2, the qualitative measures of use and non-use values of floods may provide significant inputs for a decision making process in flood management in the Mekong Delta.

Moreover, a series of policies on land use changes to exploit the flood benefits could be draw up for each flood-affected region. These policies could include finance and technical assistance to local farmers in order to assist them to restructure their activities and maximise the opportunities provided by flood-based farming activities. Furthermore, the policy could include comprehensive rural development plans to develop export market for fish, prawns and other farm produce.

6.3.2. Suggestion for future research

As a master thesis, this investigation has been limited to a focused investigation of agricultural economic value for three flood management options. Secondary data was used as it was not feasible to collect primary data given the scope of the thesis. As a result, several avenues for future research remain. The potential social benefits from High dykes, including better living conditions, safety, opportunity for transportation and other social benefit issues, have yet to be quantified and suggest an important area for further study.

Additionally, more research on the options for flood-based livelihoods, including livestock rearing and other diversified agricultural activities, would create a more accurate picture of the opportunities and costs of different farming options.

6.4. Conclusions

Dyke development projects have rapidly increased over the last ten years due to the economic value of rice farming and social demands in the Mekong Delta. However, this study shows that August dykes provide a viable alternative, and indeed may bring the greatest net economic benefits to local farmers. The lack of information on total economic values of flood benefits has meant that in some cases the decision to erect High dykes may not have been the best outcome in terms of agricultural economic opportunities. This research fills the gap by carrying out an economic evaluation of dyke construction alternatives in the Mekong Delta. It compares the costs and benefits of three available dyke alternatives: No dykes, August dykes and High dykes.

The study finds that the August dyke farming system where two rice crops are grown and prawns are farmed generated the highest NPV to local farmers. Even though High dykes have one more rice crop and a watermelon crop, these economic values are much lower the systems of rice and flood-based prawn in No dykes and August dykes. Because August dykes have more farming opportunities than No dykes, for example, two rice crops and one prawn compared to only one rice crop plus prawn, August dykes provide higher economic benefits than No dykes.

More detailed research should now be conducted to estimate the environmental, social and economic benefits and costs of dyke alternatives. In particular, the social, economic and environmental impacts of dykes should be integrated into the cost-benefit analysis to give a more accurate assessment of the outcomes from different flood management strategies. This would include the estimation of use, non-use and option values of floods, the opportunity costs of dykes and non-use values of High dykes.

In conclusion, floods contribute significantly to local livelihoods. By conducting flood-based farming activities, the August dyke system plays its important role to sustain the farming activities and replenish the soil condition. The No dyke systems have similar function to the August dykes, but there remains the risk of rice damage by flooding. The High dykes generate a rice crop and a watermelon crop, but the economic return of these crops are much lower than the benefits of other flood based crop and aquaculture in No dykes and August dykes. Overall, August dykes are more profitable because they may provide the highest agricultural benefits to local farmers compared to either No dykes or High dykes.

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