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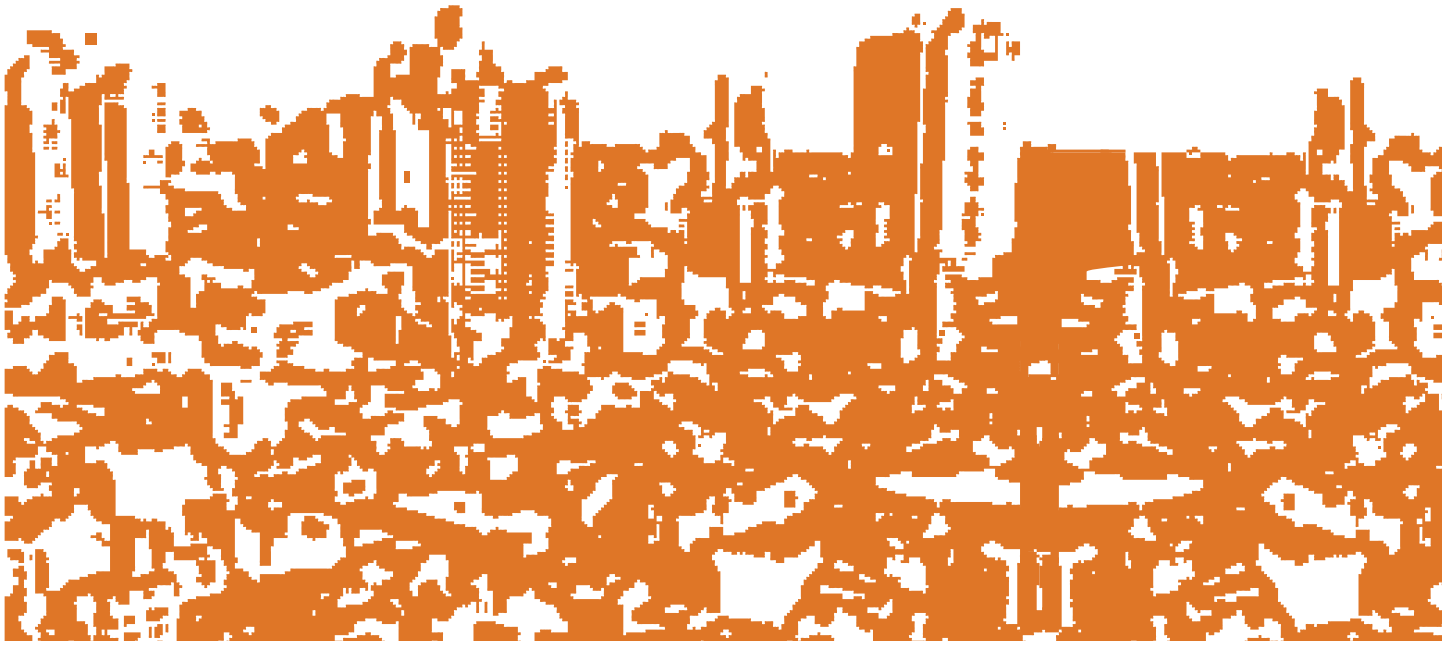
Cost–benefit analysis of mangrove restoration in Thi Nai Lagoon, Quy Nhon City, Vietnam

BY TRAN HUU TUAN AND BUI DUC TINH



Contents

List of tables and figures

Abstract

With over 10 million hectares of mangrove spread across the coastline of Vietnam, mangroves are considered an important resource for socio-economic development as well as playing a role in both the mitigation of, and adaptation to, climate change. Located in Binh Dinh province, Thi Nai is the largest lagoon with mangroves on the south central coast of Vietnam. However, in the last decade, the extensive loss of mangroves has taken place due to the expansion of urbanisation, aquaculture development and infrastructure construction. This paper presents the findings of a cost–benefit analysis of mangrove forest restoration and its alternative of aquaculture development in 150ha of wetland in Thi Nai Lagoon by using 'willingness to pay' estimates and market-based pricing methods to analyse 271 questionnaires completed during a household survey. This study reveals that mangrove forests provide important tangible and intangible benefits to local communities. In addition, in the context of climate change, mangroves also provide socio-economic development opportunities, particularly for fishing communities, such as fishing, eco-aquaculture, ecotourism, fuelwood collection, biodiversity conservation, carbon sequestration and shoreline stabilisation. Mangrove forest restoration also generates larger benefits than that of aquaculture: about VN$21 billion compared to VN$10 billion over 22 years. The benefits of mangrove restoration are approximately double that of aquaculture development, from a 5 per cent per cent to a 15 per cent per cent discount rate. In the context of climate change, with an increase in the frequency and intensity of climate change-induced hazards and sea-level rise, mangrove forest restoration generates even more benefits for communities. It is strongly recommended that policymakers should consider conducting a cost–benefit analysis of mangrove restoration and its alternative options to decide the best use of wetlands and to promote sustainable development.

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1 Introduction

Climate change-induced impacts on human life have become a burning issue, attracting the concerns of different social actors; not only governments at different levels but also communities. Climate change has been accompanied by significant changes in precipitation, temperature and the increasing frequency and intensity of climate change-related disasters, which have already been widely experienced in many countries in the world. There is evidence that 85 per cent of all natural disasters and 75 per cent of economic losses due to natural disasters from 1980 to 2005 were in Asia (Fransisco 2008). These changes have caused adverse impacts on natural and human systems, independently or in combination with other determinants, to alter the productivity, diversity and functions of many ecosystems and livelihoods around the world. Yet these impacts will not be distributed or felt uniformly, as those 'with the least resources have the least capacity to adapt and are the most vulnerable' (IPCC 2001). The impact of climate change on global GDP has caused losses of about 1.5 to 3.5 per cent, and developing countries are expected to suffer a larger percentage of damages (IPCC 2007). These losses are estimated to be even higher, about 11 per cent of global GDP, where greenhouse gases (GHG) are concerned (Stern 2007).

Vietnam is located on the tropical monsoon and typhoon centre of the East Sea, one of the biggest typhoon centres of the world. Vietnam is one of the ten countries most prone to, and 'at risk' from, the impacts of climate change (Francisco 2008). Examples of impacts felt in different provinces of Vietnam include a significant shift noted in the timings of the summer and winter rains, causing prolonged dry days as well as floods, with significant damages to local livelihoods. An increase in the frequency and intensity of annual extreme disasters are associated with increases in vulnerability and the need for local adaptation, especially in central provinces. In recent years, this has attracted considerable concern from governmental and non-governmental organisations and local communities in Vietnam.

Using a medium emission scenario A1F1[1], the central government developed a climate change scenario for the country and a national mitigation and adaptation strategy. It projects an increase in storm and flood frequency and intensity coupled with sea-level rise. There have been great efforts made to adopt different adaptation measures in order to adapt to climate change at both national and community levels. Promoting the protection and rehabilitation of mangrove forest in coastal areas is one such activity that has been initiated. For example, the Vietnamese Red Cross Society implemented a 17-year project to plant and restore almost 9000 hectares of mangrove forest across eight coastal communes, with an emphasis on the potential offered by mangroves for disaster risk reduction (IFRC 2011). This aimed to mitigate the impact of sea-level rise and storm floods in coastal areas. It should be recognised, however, that in recent years, a rapid industrialisation and urbanisation process has been implemented in many coastal provinces, which has resulted in an imbalance between economic development efforts and environmental protection and social development, particularly in the context of climate change. The expansion of both urban and aquaculture development into low-lying coastal areas and lagoons has threatened the mangrove restoration and reduced the mangrove forest area. This has particularly affected the poor who do not have the resources to transcend the risks associated with this imbalance and climate change (Powell *et al.* 2012).

1 *The Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (IPCC 2000) outlines a series of climate change scenarios dependant on various development paths. The A1 scenario family assumes rapid economic growth followed by the rapid introduction of new and more efficient technologies. Within this family, A1F1 represents a fossil-fuel intensive path to growth.*

2 Background

Vietnam has a diverse wetland ecosystem, with over 10 million hectares throughout the country with different types of wetland such as lagoons, fluvial bogs, mangrove forests and lakes. Mangrove forests are an important resource, providing direct use value and indirect value for many communities, including coastline protection and coastal storm and flood impact mitigation (Tang 2005; Hong *et al.* 2008).

It is stated that despite the important role of mangrove forests in socio-economic development and in mitigating the impacts of climate change, large areas of mangrove forest and wetland along the coastal provinces have been reduced by the expansion of economic activities such as agricultural production, aquaculture and urbanisation (UNEP-GEF 2003; Tuan 2002). It is estimated that about 180,000ha of mangrove forest has been converted for aquaculture, infrastructure construction and the expansion of urban projects (UNEP-GEF 2003). The quality of mangrove forests has been rapidly declining, due to environmental pollution from industrialisation processes, overuse of chemical components in agricultural production, and the weakness of government management systems (Torell *et al.* 2008).

A review of the current literature regarding the evaluation of mangrove forests and wetland ecosystem services points to the fact that there is only fragmented information or even a lack of information about the value of mangrove forests, particularly at local-government levels. This explains why many valuable mangrove forests such as in Tam Giang Lagoon and Thi Nai Lagoon have been privatised for economic use. Limited information about the total value of mangrove forests is available to government, even though some studies examine the direct use value for certain stakeholders rather the important role of mangrove forests for whole communities (Hong *et al.* 2008, UNEP-GEF 2003).

Government efforts to restore mangrove forests should be recognised, as the country was a signatory to the Ramsar Convention.[2] In 2003, the Vietnamese Government issued Decree No. 109/2003/ND-CP to regulate the conservation and sustainable development of mangrove forests and approved the national plan for the conservation and sustainable development for mangrove forests in the period 2004–2010 under the management of the Ministry of Natural Resource and Environment (MONRE) (Socialist Republic of Vietnam 2003). Central government has given priority to research projects which examine mangrove forests and integrate the results of these studies into management plans, in which the focus is on the evaluation of the total economic value of mangrove forests (MONRE 2004).

It is important to note that, in recent years, under a period of rapid economic development, a high demand for the use of natural resources and wetland resources in particular has emerged, leading to a decline in the availability of natural resources. The value of these natural resources has thus increased rapidly. This means that information about the value of resources for decision-making is increasingly important, particularly for policymakers. Some recent studies have addressed this. Nhuan *et al.* (2008) use contingent valuation methods (CVM) to estimate the direct use value of wetlands in the Mekong Delta region of Vietnam and to provide important recommendations for policymakers. Hoa *et al.* (2006) use market-based methods to calculate the economic value of shrimp aquaculture in the wetlands of Xuan Thuy National Park, in Nam Dinh Province. Tuan *et al*. (2009) use a market pricing method to value direct use values of Tam Giang-Cau Hai Lagoon wetlands in Thua Thien Hue province.

2 *The Convention on Wetlands (Ramsar, Iran, 1971) – called the 'Ramsar Convention' – is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their wetlands of international importance and to plan for the 'wise use', or sustainable use, of all of the wetlands in their territories. See www.ramsar.org.*

Mangrove forests are valuable ecosystems for environmental protection. They play an important role in disaster prevention and socio-economic development, particularly by providing important sources of income for poor communities. This study evaluated the non-use values of the mangrove forest in Thi Nai Lagoon and conducted a cost–benefit analysis of mangrove forest restoration.

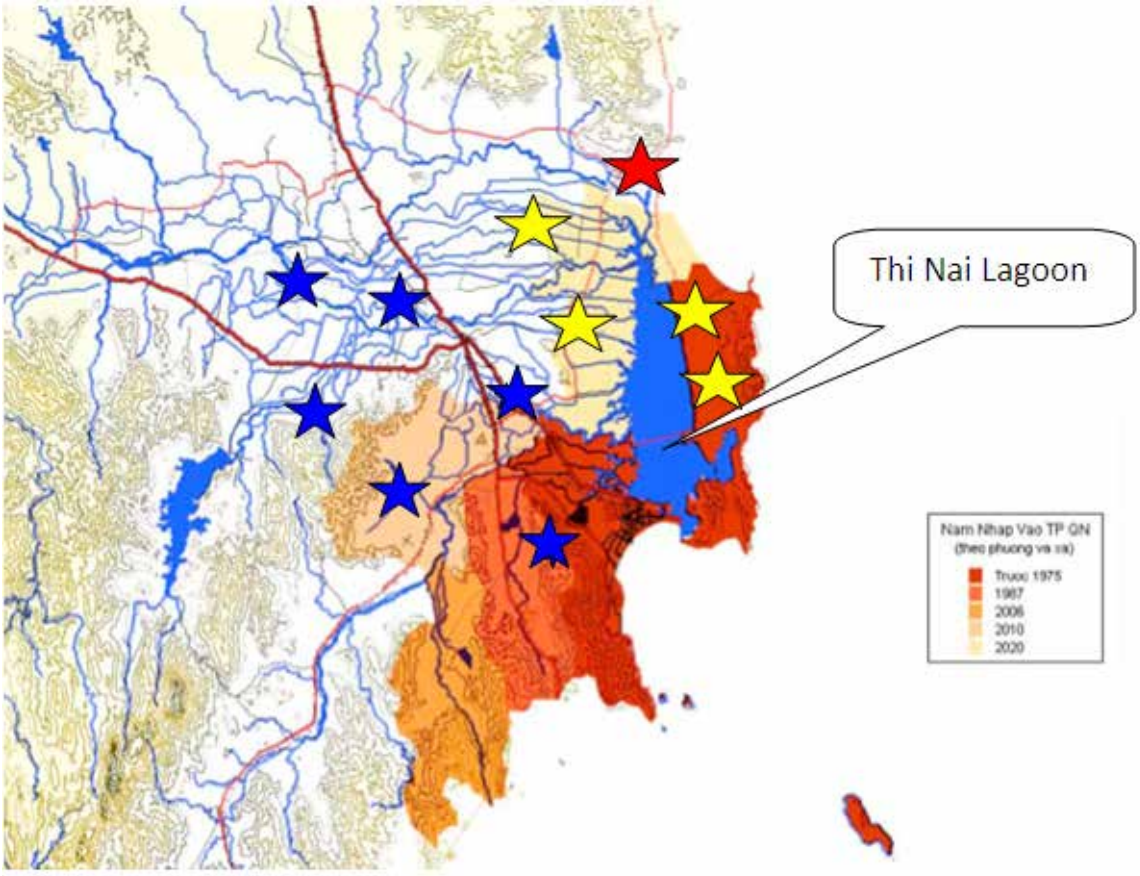
2.1 Case study site: Thi Nai Lagoon, Binh Dinh Province

Located on the south central coast, Binh Dinh is one of Vietnam's coastal provinces. Binh Dinh Province includes 10 districts and Quy Nhon City, a young and rapidly developing city which is the capital of the province. In the last decades, Binh Dinh Province, particularly Quy Nhon, has been affected by many natural hazards, such as coastal storms, floods, sea-level rise and droughts. Emerging changes in climate have threatened the city with an increase in both the frequency and intensity of these disasters.

Located on the coastline of Binh Dinh Province, Thi Nai is one of the biggest brackish water lagoons in the south central coastal region of Vietnam. The total area of Thi Nai Lagoon is 5060ha, which used to include over 1000ha of diverse mangrove forest. The Thi Nai Lagoon area is spread over an area which includes Quy Nhon City and Tuy Phuoc District. Mangrove forest in Thi Nai is an important resource for socio-economic development for Quy Nhon and Tuy Phuoc as well as an important source of income-generation for local communities (Figure 1).

Mangroves in Thi Nai Lagoon play an important role in providing sources of income for households, particularly the poor, with direct use values and indirect use values of the mangrove. More particularly, direct use values include both commercial and non-commercial activities such as fishing, collecting fuelwood, and using the mangroves for recreation. Indirect use values refer to values provided by mangroves that maintain and protect natural and human systems through services such as maintenance of water quality and flow, flood control and storm protection, and the production and consumption activities they support.

Figure 1. Map of Thi Nai Lagoon and surveyed sites



Blue stars denote sites selected. Red stars denote communes selected in Tuy Phuoc district

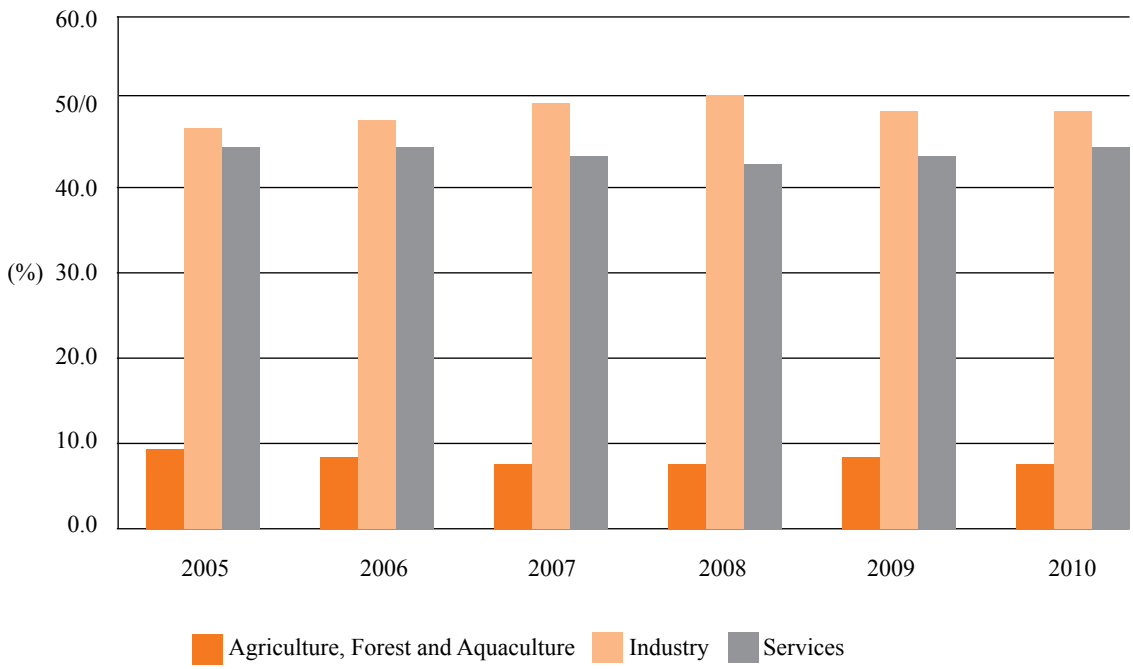
There are 281,513 people living in over 58,000 households in Quy Nhon and 254,847 people in Tuy Phuoc District, which is one of the districts surrounding the Thi Nai Lagoon in Binh Dinh province. Over 49 per cent of the population is female. Over 46 per cent of the total population are of working age, 63 per cent of the labour force works in the agricultural sector, and 54 per cent work in industry and services (see Table 1).

Table 1. Population and number of households in Quy Nhon City and Tuy Phuoc District

	2008	2009	2010
Population of Quy Nhon City	276,237	280,707	281,153
Number of households in Quy Nhon	57,549	58,481	58,574
Population of Tuy Phuoc District	252,654	253,563	254,847
Number of households in Tuy Phuoc	51,562	51,748	52,010

Source: Binh Dinh Statistical Yearbook (2012).

Figure 2. Economic contribution by sector in study site



It is important to note that despite about half of the labour force working in agricultural production, their contribution to GDP is low in comparison with the industrial and services sectors, about less than 10 per cent from the period 2005 to 2010 (Binh Dinh 2012) (see Figure 2). The industrial sector provides the most important contribution to economic development of Quy Nhon, providing about 50 per cent of total GDP. This explains why government has prioritised developing industry and urbanisation over the last decade. This is also a reason for the decline in the size and quality of the mangrove forest in Thi Nai Lagoon.

In the course of the study, discussions with local informants highlighted that a large area of coastal zone around Thi Nai Lagoon has been the site of both industrial and urban developments, which posed a risk to the mangrove forest. As one key informant explained,

> … recognising the importance of the industrial sector, government planned to develop an economic strategy based on industry and service sectors with more industrial zone construction and urban construction too. More infrastructure has been built to support that strategy… however, you do not see many companies in the industrial zone, this has been seriously affected by the economic crisis...

Overall, this is consistent with the general situation of the industrial zone construction policy of the Vietnam Government, when almost all provinces and cities in Vietnam built industrial zones, but the coverage of enterprises in industrial zones is very low. It means that while many households have lost their livelihoods, the creation of new jobs in the industrial zones in Binh Dinh Province has also been very limited.

One of local fisherfolk living in Nhon Phu Ward and participating in study reported that

> … now areas around my house have been upgraded for industrial zone, even near my shrimp pond has been reclaimed for industrial zones… my son is now a worker in the Phu Tai industrial zone, but his salary is very low, while the cost of daily transportation and food is expensive…

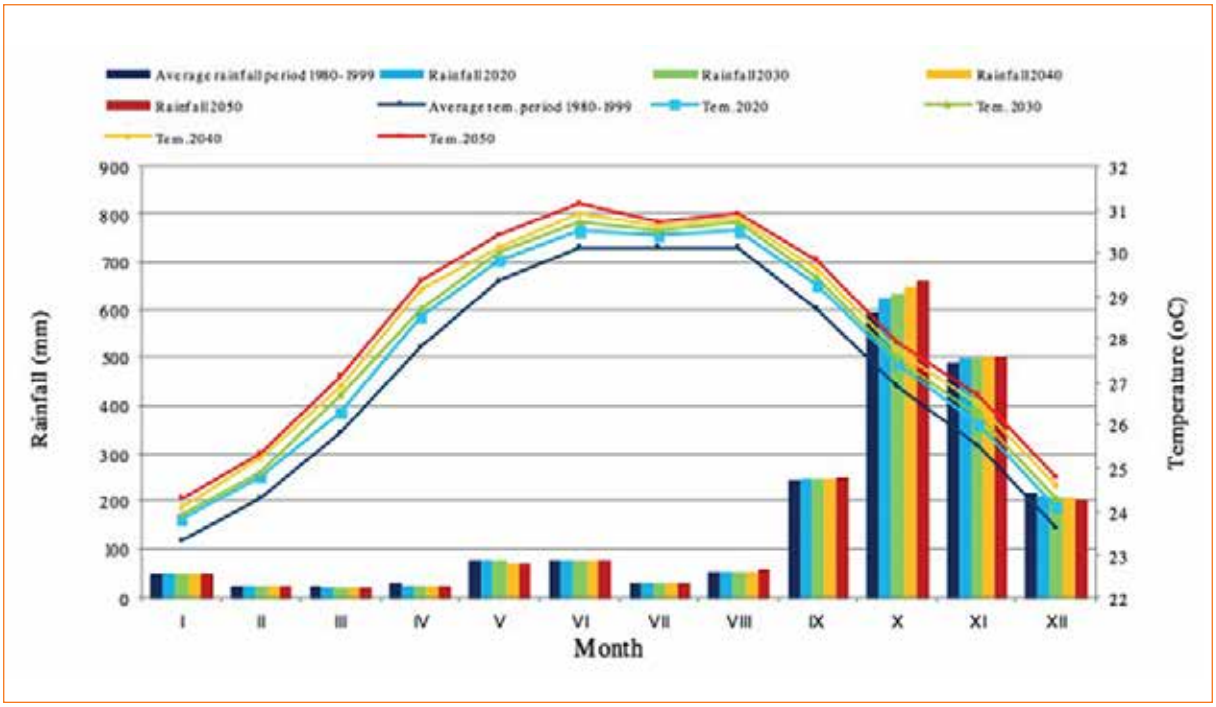
The above statements pointed to the fact that the mangrove forest has been under threat of urbanisation and industrialisation in Binh Dinh Province, which has developed despite the lack of information to policymakers from any systematic study examining the total economic value of mangrove forests or cost–benefit analysis of mangrove forest restoration.

The loss of mangrove forests along Thi Nai Lagoon's shores and Quy Nhon City has taken place over the past 15–20 years, in part due to government policies that encouraged conversion to aquaculture ponds for export-oriented production and to the increased settlement and rapid expansion of urban services such as roads and dykes. Recently, due to urbanisation, the rate of mangrove loss has increased and therefore the local community is more vulnerable to climate change, particularly in low-lying areas around Quy Nhon City. This area lies mostly outside the city's current boundaries, but the city has been growing in both population and size due to migration and the annexation of adjacent rural communes. The city population was about 200,000 in 1990, and is now around 300,000. It is projected to increase to 500,000 by 2020.

As a low-lying area, Thi Nai is recognised as prone to both floods and storms. Statistical data shows that a large proportion of the population is living around and has livelihoods depending on access to Thi Nai Lagoon. This means that they are highly exposed to hazards and vulnerable to climate change. Using a B2 climate change scenario (which is built upon an assumption of slower population growth and medium A1F1 emissions) the national scenarios of climate change show that central Vietnam will experience hotter weather with more severe droughts and typhoon (MONRE 2009). As shown in Figure 3, monthly temperature increases of about 0.7^{o}c are expected by 2020 and 1.5^{o}c by 2050. The rainfall during the dry season (from May to September) will decrease by about 14.5mm while rainfall will increase in the flooding season by 82.2mm (Michael and Van 2012). In combination with sea-level rise, this will cause serious damage and losses to local communities.

It is also projected that sea-level rise will increase during the storm season, which will lead to an increase in the frequency and intensity of floods and the salinisation of irrigation systems in paddy fields surrounding Thi Nai Lagoon. It is estimated that in the context of climate change, the sea-level rise will possibly cover a large area of Binh Dinh, with a total area estimated about 1.4km^2 by 2020 and 8.4km^2 by 2100 (Michael and Van 2012). Given the role of mangroves in protecting coastal communities from storm surges and coastal erosion (IFRC, undated), it seems that reforesting mangroves in the Thi Nai Lagoon would play an important part in the city of Quy Nhon's package of approaches to adapting to climate change.

Figure 3. Changes in temperature and rainfall in Quy Nhon at B2 Scenario (MONRE 2009)



Quy Nhon is one of three Vietnamese cities participating in the Asian Cities Climate Change Resilience Network (ACCCRN), an eight-year initiative funded by the Rockefeller Foundation which seeks to increase the capacity of cities to plan for and respond to climate change impacts across six Asian countries. This includes funding city-level interventions, and in Quy Nhon one of these projects focuses on ecosystem services. The project is called Urban Mangrove Restoration for Storm Surge Protection and Resilient Land Use Practice.[3] It aims to reduce the climate vulnerability of poor people living on the edge of the expanding city of Quy Nhon by restoring the ecosystem of the mangrove forest in Thi Nai Lagoon and restoring 150 hectares of mangrove. The project recognised the risk of the expansion of urban development into vulnerable low-lying coastal sites along this lagoon, thus mangrove reforestation will make a significant contribution to ecologically sustainable and climate-resilient urban development for local communities living around Thi Nai lagoon.

This paper presents the findings of the valuation study on non-use values of the mangrove forest and conducts a cost–benefit analysis (CBA) of the mangrove restoration. Results from this CBA study would provide not only baseline information for justifying the continued protection and conservation of this mangrove forest in Quy Nhon, but would also make a significant contribution to the economic analysis of mangrove reforestation throughout Vietnam. The CBA of mangrove restoration is a key input (along with other considerations such as operational or administrative capacity, social acceptability, financing feasibility) for decision makers on justifying public spending on restoration activities and mangrove management.

3 *See www.acccrn.org/initiatives/vietnam/quy-nhon/city-projects/urban-mangrove-restoration-storm-surge-protection-and-res*

3 Conceptual framework and methodology

3.1 Valuation of non-use values of mangroves

The concept of total economic value (TEV) of mangrove forests includes both use and non-use values. Use values can be derived from people's direct or indirect uses of wetlands through wetland goods and services. Direct uses of mangrove forests could involve both commercial and non-commercial activities such as harvesting fish, collecting fuelwood and using the mangrove forest for recreation. Indirect use values refer to values provided by mangrove forests that maintain and protect natural and human systems through services such as maintenance of water quality and flow, flood control and storm protection, and the production and consumption activities they support. A special category of use value is the option value, which is a premium placed on maintaining wetland resources for future possible use. Non-use values are associated with benefits derived from knowing that a resource is maintained. Non-use values include biodiversity, cultural heritage and bequest values. In general, use values involve some human interaction with the resource, whereas non-use values do not (Barbier *et al.* 1997). Table 2 presents a classification of TEV for mangrove forest.

Table 2. Classification of the total economic value for mangrove forest

Use values			
Direct use value	**Indirect use value**	**Option value**	**Non-use values**
■ Fishing ■ Agriculture ■ Fuelwood collection ■ Recreation ■ Transport ■ Harvesting wildlife ■ Peat/energy	■ Nutrient retention ■ Flood control ■ Storm protection ■ Groundwater recharging ■ External ecosystem support ■ Micro-climatic stabilisation ■ Shoreline stabilisation	■ Potential future uses (as per direct and indirect uses) ■ Future value of information	■ Biodiversity ■ Cultural heritage ■ Bequest values

Source: Adapted from Barbier *et al.* (1997).

In this research, the non-market valuation method known as the Contingent Valuation Method (CVM) was used for valuing non-use values of mangrove forest. The use of CVM aims to assess the willingness to pay of people for the conservation and restoration of mangrove forests in Thi Nai Lagoon. CVM (Mitchell and Carson 1989) is a survey-based approach that involves developing a hypothetical market, which an individual uses to state his or her willingness to pay (WTP) for the conservation of an environmental service in a particular location. Over the past decades, the use of CVM for measuring WTP for social projects has been widely used in developing countries (VEPA-IUCN 2000; Thang and Bennett 2005; Hoa and Ly 2009; Do and Bennett 2009).

The theoretical explanation of the CVM can be found in Annex 1.

3.2 Cost–benefit analysis of mangrove restoration

3.2.1 Analytical framework

This cost–benefit analysis was carried out in five steps, as described below.

Step 1: Design of policy options

The descriptions of these options are in Table 3.

Table 3. Design of policy options for cost–benefit analysis

Options*	Description of option
Option 1: Using Thi Nai wetlands for aquaculture development	Rapid aquaculture development has degraded the mangrove forest as stakeholders convert wetland, with or without mangrove forest, into aquaculture ponds. It means that there is a trade-off in the use of wetland between aquaculture development and mangrove forest restoration.
Option 2: Mangrove restoration	Restoration of mangrove forest (as per ACCCRN City Resilience Strategy project).

** In the research proposal, we attempted to design three policy options: Option 1: The base case: aquaculture; Option 2: Urban development; and Option 3: Mangrove restoration. However, in reality, assessing costs and benefits of mangrove restoration under Option 2 (urban development – building infrastructure for urban development, including building basements for residential housing or industrial factories) is not feasible as there was only one pilot project on urban development planned, which was delayed. To date, the completion date remains uncertain and no products have reached the market. We made great efforts to collect secondary data and key informant interviews on this option, but unfortunately we could not find enough information. In particular, key informants from this project rejected invitations to be interviewed due to difficulties relating to the real estate crisis in Vietnam (i.e. the market for real estate has dramatically declined). A lack of progress and clarity regarding their project meant it was not feasible to include it in this study. Thus, this option was eliminated from this CBA analysis.*

Step 2: Estimation of the costs and benefits of each option

Option 1: The results from a fieldtrip highlighted that there are two important and popular options for wetland use in Thi Nai Lagoon. The option of aquaculture development has been used for the CBA estimate in this study. The cost–benefit of this option is a direct cost, which is based on a market-pricing approach. The costs and benefits are accrued to aquaculture owners who are individual farmer households living around Thi Nai Lagoon, using a small-scale pond of about less than 1ha per household, and suitable only for household labour. Additionally, in the context of low-benefit aquaculture, owners

capitalise on their own labour to reduce the costs of aquaculture. There are no additional benefits generated for society from aquaculture development.

Option 2: The costs include those relating to restoration and the costs of maintenance and protection of the mangrove forest. These can be derived from the current ACCCRN-supported mangroves restoration project entitled Ecosystem Services for Climate Resilience in Quy Nhon City. This project is being implemented over a period of four years (2012–2015), funded by the Rockefeller Foundation and implemented by the Binh Dinh Climate Change Coordination Office (CCCO) with support from the Institute for Social and Environmental Transition (ISET) Vietnam as the ACCCRN country coordinator. The benefits include those assessed by the valuation of non-use values, and those assessed under the consultation study conducted by the Hue team (Tuan *et al.* 2012), using market-based approaches to estimate use values of the Thi Nai Lagoon wetlands.

Step 3: Calculation of net present value (NPV) of each option

Net present value (NPV) and present value were calculated using formulas (i) and (ii).

$$PV\ (X) = X_t \frac{1}{(1 + r)^t} \quad \text{(i)}$$

Where X is the present value of costs (C) or benefits (B) at time (t) at the interest rate (r)

$$NPV = \Sigma B_t(1 + r)^{-t} - \Sigma C_t(1 + r)^{-t} \quad \text{(ii)}$$

Step 4: Perform sensitivity analysis

The sensitivity analysis for the results of the CBA analysis is a very important step in this study, as the benefits and costs are largely dependent on a discount rate, which fluctuates in accordance with economic development. Selection of the discount rate for the sensitivity analysis was considered very carefully, as according to information gathered from key informant interviews and the local community the lifecycle of a mangrove forest is 22 years. In order to reflect the local perception of mangrove forests, it was decided to use 22 years as the time period over which to apply the discount rate. This means that small differences in the discount rate could possibly make significant changes to the net benefit of the project. There is on-going debate on using the discount rate to conduct an analysis of the sensitivity of CBA of a project for ecosystem services, which is mainly dependent on researchers, the prediction of well-being and the nature of project, but the range of discount rates should be from zero to 20 per cent. According to Weitzman (2007), a discount rate of 6 per cent is very reasonable. The details of the discount rate selection are described clearly in Section 4.2.

Internal rate of return (IRR) was used to measure and compare the profitability of investment. IRR refers to the fact that its calculation does not incorporate environmental factors, such as bank interest rates, inflation or deflation. IRR calculations are commonly used to evaluate the desirability of investments or projects. The higher a project's IRR, the more desirable it is to undertake the project.

Benefit and cost ratio (BCR): the BCR is calculated by dividing all benefits by all costs. If the resulting ratio exceeds 1.0, this means that benefits exceed costs, which suggests that, in economic terms, the proposed project should go ahead. This ratio is also used to compare and select the more profitable option of a project that should be put into operation.

Step 5: Make recommendation based on the NPV and sensitivity analysis

Based on the result of a cost–benefit analysis with a sensitivity analysis using different discount rates, the study will provide policy implications for government at both national and provincial levels.

3.2.2 Data collection

Conducting a valuation of non-use value and a cost–benefit analysis of mangrove restoration requires a robust dataset for analysis. In this study, mixed methods were used to collect data, including secondary data collection, key informant interviews, focus group discussions, and household questionnaires.

a. Secondary data

Secondary data was collected from various agencies, which helps to contextualise the project site and to identify the target group for other methods. Secondary data (such as socio-economic data, population, disasters and damages, and about Thi Nai Lagoon) was collected from the Binh Dinh Climate Change Coordination Office, the Provincial Department of Statistics, from communes and wards of Quy Nhon city, and from other stakeholders.

b. Key informant interviews

Based on the literature review and secondary data collection, a list of important issues was developed, such as the current situation of the mangrove forest, planning for urbanisation and infrastructure development, the non-use value of the mangrove forest, the costs and benefits of mangrove forest restoration, climate change issues and the role of mangrove forests in Thi Nai Lagoon, Quy Nhon plans for adaptation to climate change, and action plans for mangrove conversion and development. Questions based on these were asked in key informant interviews. Twelve key informants were selected and interviewed from provincial to commune level, and from real estate companies.

c. Focus group discussions

Focus group discussions (FDGs) were the core method for collecting qualitative information for this study. Two FDGs were organised. In the first FDG, participants were representatives of environmental management organisations including the Binh Dinh Department of Environment and Resources, Department of Agricultural and Rural Development, Department of Culture, Sport and Tourism, Department of Fisheries, Office for Aquatic Resources Exploitation and Protection, Binh Dinh Tourism Promotion Centre, the management board of ConChim-Thi Nai Lagoon,[4] Tuy Phuoc District's Office of Agriculture, extension service staff from Phuoc Son, Phuoc Thuan and Nhon Binh communes/wards and the leader of the Con Chim Ward. In the second FDG, participants were representatives of leaders and households of selected communes and wards (see Table 4).

The main purpose of the FGDs was to tackle important issues such as local awareness about climate change and its risks, the mangrove and its benefits, current threats to the mangrove forest, and the current use and management of mangrove forests in Thi Nai Lagoon. This information was used to develop scenarios for the questionnaire surveys. Results of the FDGs were also used to develop materials for information-sharing meetings used while conducting the household surveys, which will be discussed in the next section.

d. Household questionnaire survey

Based on the literature review and focus group discussions, questionnaires were designed and pre-tested with 15 households in order to make sure that all questions raised were answerable and information was available to respond with. The questionnaire (Annex 2) included three main sections: the first section was designed to collect information about the mangrove forest in Thi Nai Lagoon and local access to mangrove forests, and local awareness about current mangrove forest management. The second section was developed with questions relating to the current scenario applicable to the Thi Nai mangrove forest and future scenarios for mangrove forest restoration, as well as mechanisms relating to fee collection, the management of project implementation, and people's willingness to pay either in cash (through bid levels) or

4 *The management board is responsible for managing the mangrove forest in Con Chim Island, Thi Nai Lagoon.*

through the contribution of labour, as many households are cash poor. The third section was used to collect demographic information about respondents.

As mentioned previously, local awareness about mangrove forests and their use or non-use values as well as their role in addressing climate change impacts is very limited. The project recognised this research process as an important opportunity to raise local awareness about the project and its importance and about climate change issues in Binh Dinh Province, in particular related to the mangrove forest. In order to ensure that local communities and particularly respondents were fully informed before participating in the questionnaire, they were invited to information-sharing meetings on climate change and its impacts on local communities in correlation with the importance of mangrove protection. Eleven information-sharing meetings were held with households living in Quy Nhon City, particularly those surrounding Thi Nai Lagoon, with 271 households involved. Participants were provided with information about climate change, climate change-induced impacts and climate-related hazards, and current adaptation measures at both the government and household level, using the simplest terms and methods.

First, respondents were introduced to climate change, its causes, and how it affects both global and local communities. The meeting facilitators explained the relationship between the daily practices of local communities and climate change, such as raising livestock, transportation and felling timber in the forests. The benefits of mangrove forest to their lives in the context of climate change were also discussed. The meeting facilitators introduced some important impact mitigation practices, including a focus on what households are able to do to reduce the impact of climate change on their lives, including reforestation. However, researchers recognised that participants might over-value the benefits of mangrove restoration and so remained neutral when explaining the role of mangroves in relation to climate change mitigation, so as not to influence their subsequent bids, but rather to ensure that respondents were fully aware of all possible use and non-use values of the mangrove.

The outcome of these information-sharing meetings was that local participants were better informed about the potential risks of climate change-induced impacts and particularly future risks associated with an increase in the frequency and intensity of hazards. It was also important because the local community recognised the importance of mangroves and understood how they might contribute to the mitigation of climate change impacts. The direct use and non-use values of mangrove forests were discussed in the information-sharing meetings, so that participants knew of the importance of the mangrove forests in Thi Nai Lagoon.

The researchers ensured that the respondents clearly understood the objectives of the study and its scenarios and the CVM methods used in order to mitigate any concerns that the study might have a negative impact on their households. The researchers explained that the research project aimed to provide policy recommendations for better management of mangrove forests in Thi Nai Lagoon. They also explained that bid levels should be given based on the importance of mangrove forest to the respondents' lives, particularly in the context of future adaptation to climate change. Therefore the study should have no negative impacts, but instead may benefit their family in the future, such as maintaining a better environment. Therefore, attempts were made to ensure that strategic bias was minimised. Ethics were also considered carefully. While the research team ensured that information was delivered in a neutral way during the information-sharing meetings, it is nevertheless important to bear in mind that these sessions may have influenced participants' responses to the survey questionnaire.

To determine a statistically viable sample size for the CVM study, we used the following formula:

$$n = \frac{N}{1 + Ne^2}$$

Where

- n = sample size;
- N = total number of households in the area, and
- e = design margin of error.

The population of this study is defined as local residents of Quy Nhon City and Tuy Phuoc District, Binh Dinh Province. According to statistical data of Binh Dinh in 2010, there are about 536,000 people in these two administration units with

110,584 households. With a designed margin of error of 6 per cent, a total minimum sample size of 277 households was planned to be sampled in the survey. With an expected high rate of no-response and incomplete questionnaires due to its complexity, the total number of respondents to be targeted for an interview was about 300 households. These were proportionally allocated in each commune/ward in these two units, using the total number of households per commune/ward as the basis of allocation. There were 271 questionnaires completed, checked and entered into a statistical package for the social sciences (SPSS) for analysis.

The distribution of sample size is presented in Table 4. Eleven communes/wards were selected randomly from Quy Nhon City and Tuy Phuoc District. Four of these are from Tuy Phuoc, including Phuoc Hoa, Phuoc Son, Phuoc Thang and Phuoc Thuan and seven are from Quy Nhon City.

Table 4. Distribution of surveyed respondents by commune/wards

Communes	Number of respondents	Valid per cent
1. Ngo May	23	8.5
2. Dong Da	21	7.7
3. Nhon Binh	20	7.4
4. Nhon Hoi	34	12.5
5. Nhon Phu	22	8.1
6. Phuoc Hoa	18	6.6
7. Phuoc Son	26	9.6
8. Phuoc Thang	27	10.0
9. Phuoc Thuan	22	8.1
10. Thi Nai	30	11.1
11. Tran Quang Dieu	28	10.3
Total	**271**	**100.0**

Source: surveyed for this study in 2012.

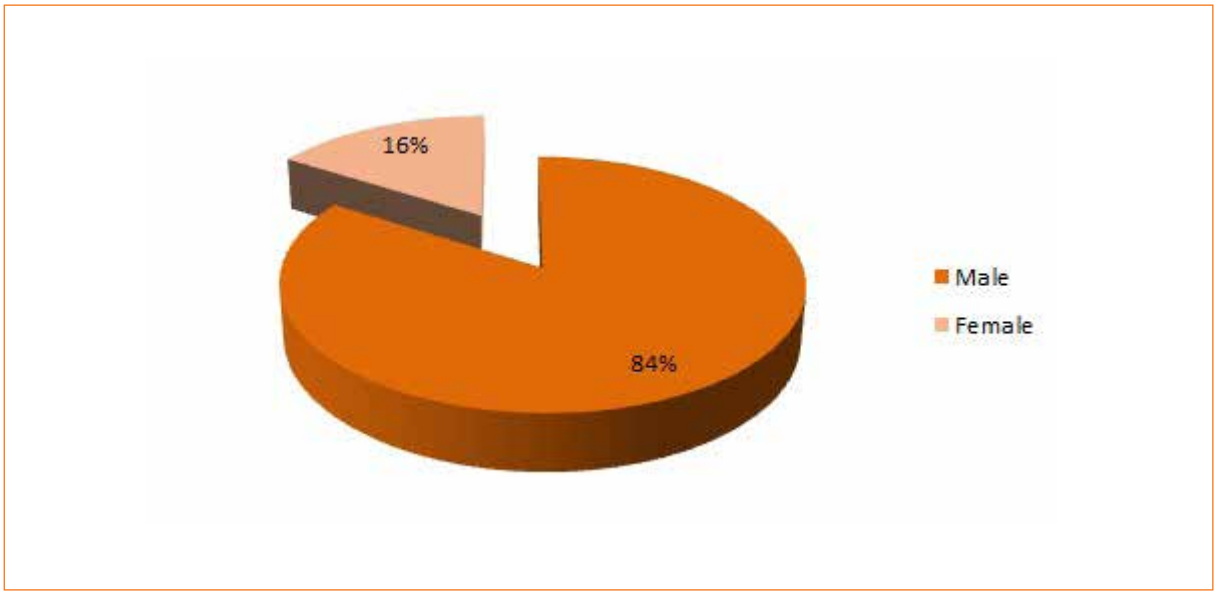
4 Data analysis and results: non-use values and cost–benefit analysis

4.1 About the respondents: demographic information

4.1.1 Gender

It is important to note that there are gender issues in rural areas, where the men are in charge of the physical labour and public relations for each household. Results from this study reflect this. Although we considered gender issues for this study by sending invitations to both women and men equally, only 16 per cent of the 271 respondents were female and about 84 per cent were male (Figure 4). This may have skewed results, as men may have been willing to bid higher levels than women as they often generate more income for the family and are in charge of physical work related to the mangrove forest such as aquaculture, fishing and cultivation. They may also have a better awareness of the importance of the mangroves.

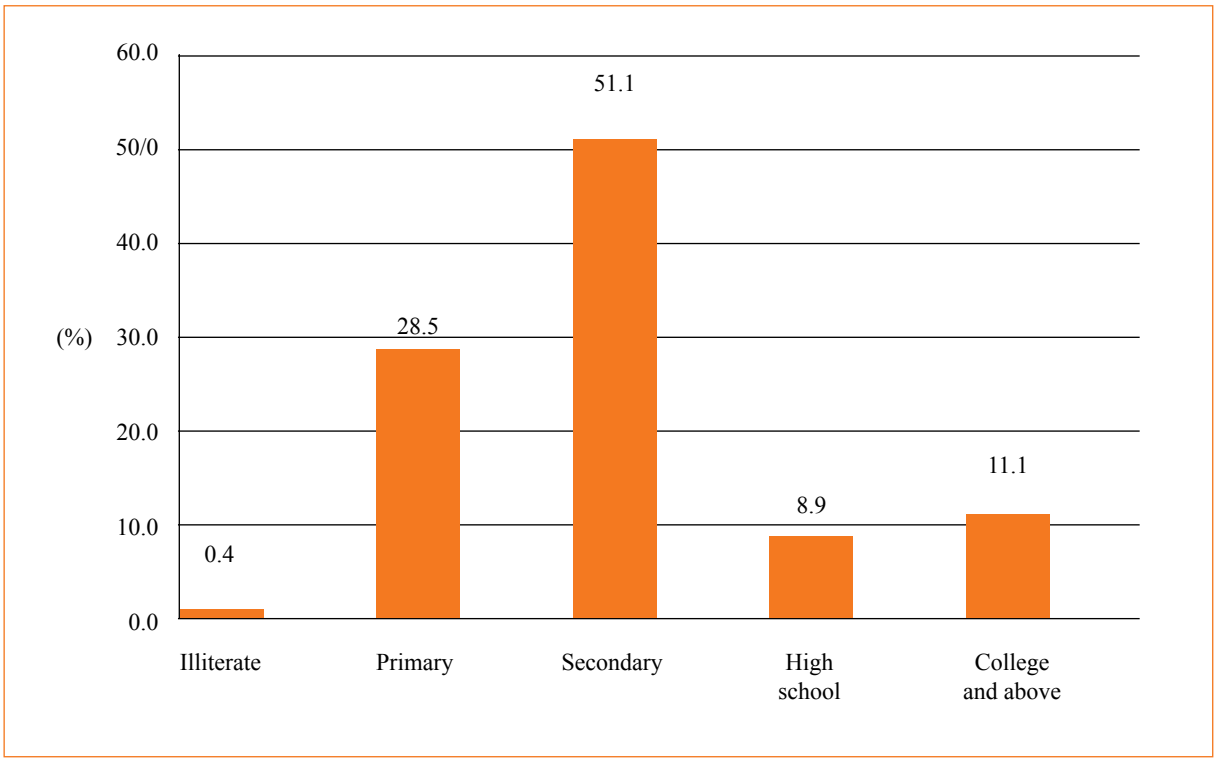
Figure 4. Gender of respondents



4.1.2 Education

Regarding the education of respondents, it was expected that the education level would correlate positively with their bid level of mangrove forest restoration. Respondents with higher education levels may have opted to provide higher bid levels. The survey results show that respondents have low education levels, with over a quarter of respondents having completed only primary school and over a half of respondents having completed secondary school. Only 9 per cent of respondents had completed high school and 11 per cent hold college or university degrees (see Figure 5).[5]

Figure 5. Education level of respondents

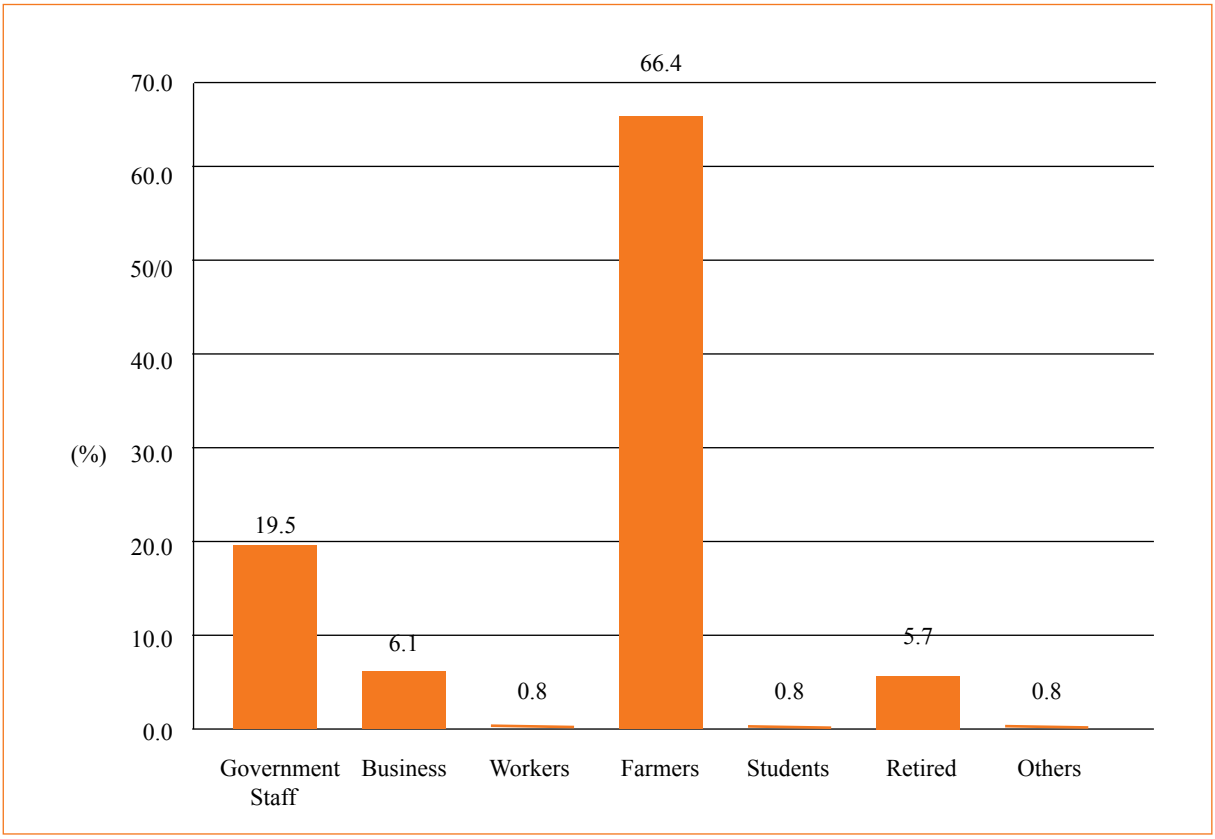


4.1.3 Employment

The jobs of respondents may have also affected their bid levels. Respondents with livelihoods more reliant on Thi Nai Lagoon could have provided higher bid levels. At 66 per cent, most respondents involved in this study were farmers. However, the term 'farmers' in the context of this study is a broad term including those who are working in agricultural production, such as fishermen, and those raising livestock, producing rice or working in aquaculture. About 19 per cent of respondents are from government offices and agencies at town, district, ward and commune levels or state-sponsored mass membership social organisations. The distribution of respondents in the surveyed sample is consistent with the distribution of the labour force by sector in the statistical yearbook for Binh Dinh Province.

5 *In Vietnam, the education system is as follows: primary (grades 1–5), secondary (grades 6–9) and high school (grades 10–12).*

Figure 6. Type of work of respondents



4.1.4 Income

It was assumed that a respondent's income would have a strong positive correlation with their bid level. In other words, respondents with a better income would bid at higher levels. The result of this study found that about 14 per cent of respondents had an annual income of less than VN$5 million (about US$250), while most respondents had an annual income of between VN$20–50 million (about US$1000–2500). About a quarter of respondents had an annual income of between VN$10–20 million/year (about US$500–1000). In other words, about 14 per cent of respondents are poor households, which is similar to the poverty rate for Binh Dinh (see Table 5).

When running the model, the type of house (permanent, semi-permanent or temporary) was used as a proxy for income in order to avoid endogeneity in the model, as income can be linked to other factors such as educational level, and influence the bid level.

Table 5. Distribution of respondents by annual income

Annual income level of households(VN$ million)	Number of respondents	Valid per cent
Up to 1	14	5.2
Between 1 and 3	14	5.2
Between 3 and 5	9	3.3
Between 5 and 10	28	10.4
Between 10 and 20	75	27.8
Between 20 and 50	102	37.8
Over 50	28	10.4
Total	270	100.0
Missing system	1	
Total	271	

Source: surveyed for this study in 2012.

4.1.5 Household size

It is likely that the size of respondents' households will correlate with the income and living costs of each household. Households with more family members may have more labour available to make a living for the family, while they will also spend more resources on each family with higher spending at the household level. In this study, the size of the family is expected to have negative impacts on bid levels. In other word, households with more family members will have lower bid levels. The result of survey shows that the average size of household in the study site is about 4.87 people per family, which is representative of the normal family size in Binh Dinh Province. The largest household is 10 people, and the smallest is 1 person.

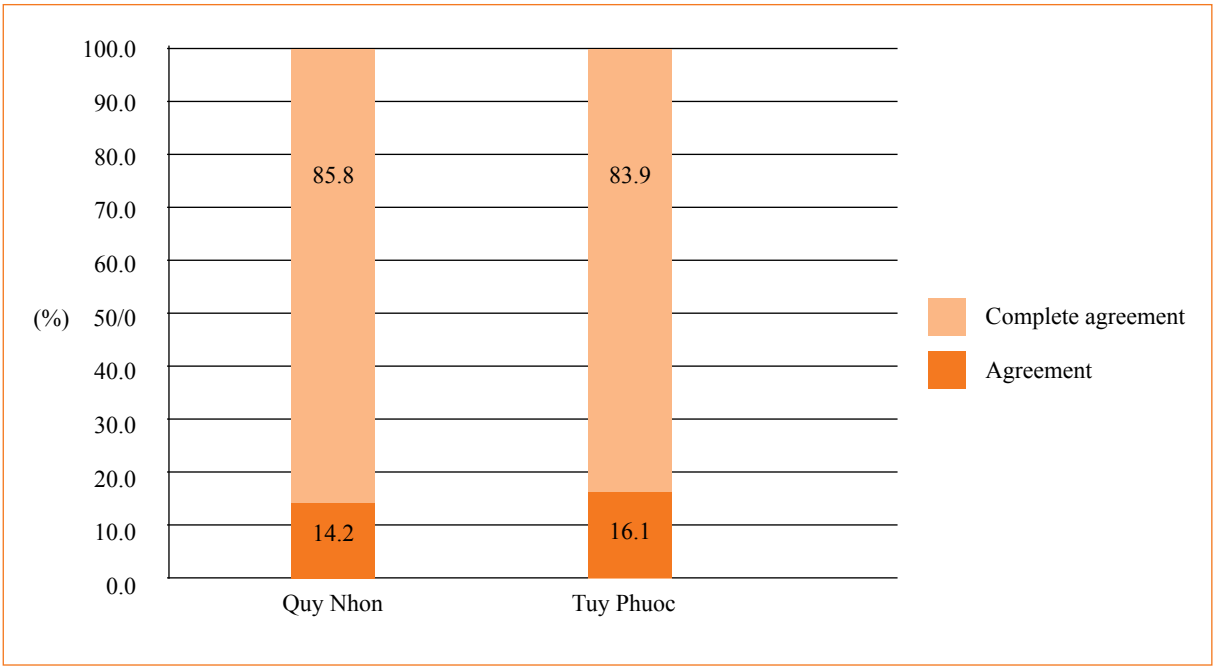
4.2 Local awareness about mangrove restoration in Thi Nai Lagoon

Respondents involved in this study were asked to choose an option relating to mangrove restoration in Thi Nai Lagoon, with five options available (see below). Results show that almost all respondents (85 per cent) completely agreed with the need to restore the mangrove forest in Thi Nai Lagoon with about 15 per cent of respondents confirming their opinion at agreement level.

- Completely agree with restoring mangroves in Thi Nai
- Agree with restoring mangroves in Thi Nai
- Neither agree nor disagree
- Disagree with restoring mangroves in Thi Nai
- Completely disagree with restoring mangroves in Thi Nai

A comparison of opinions between respondents in different districts and shows that there is no significant difference between respondents in Quy Nhon and Tuy Phuoc: a large proportion of respondents in all these districts are completely agreed with the need to restore the mangrove forest (see Figure 7).

Figure 7. Respondents' opinions on mangrove restoration in Thi Nai



Findings were similar when respondents were asked to rate the importance of functional and non-use values provided by the mangrove forest in Thi Nai. As explained above, they were first invited to information-sharing meetings about climate change, the role of the mangrove forest in Thi Nai and its direct and indirect values, and where the study scenarios were also discussed. Results showed that over 80 per cent of respondents rated the direct and indirect functions of mangrove as 'important' and 'very important'. Nearly 90 per cent of respondents rated mangroves and related livelihoods as extremely important, and their comments below demonstrate how the mangroves are essential to their ways of living. One interviewee engaged in aquaculture stated that:

> …mangrove forest is a very important factor, helping us to gain profit from aquaculture. As you know in recent years, aquaculture households deal with many difficulties such as environmental pollution and diseases of aquaculture livestock, however our pond is still OK, which is thanks to mangrove planting on the dams of my pond. We use traditional shrimp farming and our pond is built in mangrove forest, thus environment is good. Furthermore, we do not have to reinforce our pond against wave damage…

Another fisherman reported that:

> …many households in this community get benefit from Thi Nai Lagoon and mangrove, we catch crab, collect clams and fish daily. Mangrove is the habitat of fisheries… our lives are embedded in this lagoon, we understand the mangrove for our survival… we tried to restore it but just do it in our pond, we could not plant it in Thi Nai as we are poor…

Table 6 shows that providing recreational value is rated as less important compared with the potential for other functions, and mitigating the impacts of storms and floods (see Table 6).

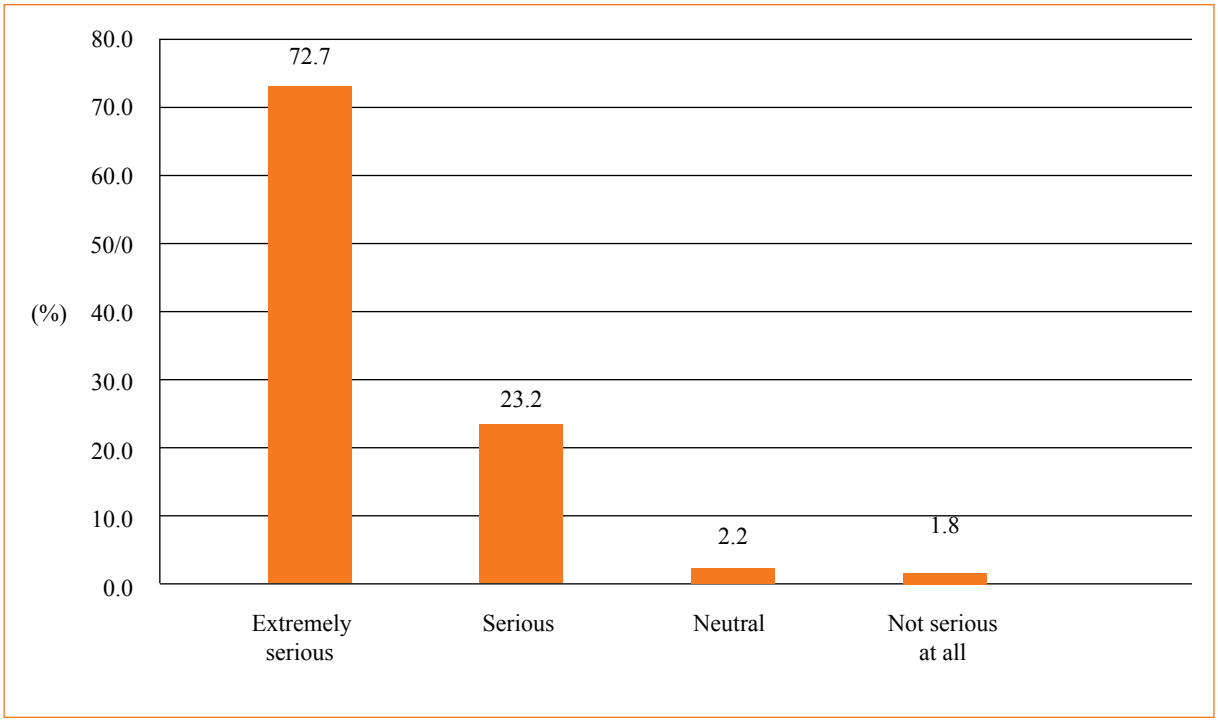
Table 6. Respondents rate the functions of Thi Nai mangroves in importance (per cent)

Function of mangrove	Completely not important	Not important	Neutral	Important	Very important
Sustaining livelihoods	4.4	2.2	6.3	17.8	69.3
Providing recreation	2.6	4.8	10.0	38.7	43.9
Mitigating the impacts of storms and floods	2.2	0.0	3.0	15.6	79.2
Conserving biodiversity	3.7	1.9	4.1	29.3	61.1
Potential for future uses	1.1	0.0	0.4	13.7	84.8

Source: surveyed for this study in 2012.

Respondents were provided with information describing the current situation of the mangrove forest in Thi Nai Lagoon, which has been rapidly declining due to aquaculture development, the expansion of urban areas, industrialisation and environmental pollution. The impact of climate change and sea-level rise were also provided. Respondents were then asked to rate the seriousness of the current situation. Nearly three quarters of respondents felt the situation would become extremely serious and almost all the remaining respondents felt these were serious issues. Only 3 per cent of respondents rated the issue as neutral or less serious (Figure 8).

Figure 8. Respondents rate the current mangrove management scenarios



4.3 Non-use value of mangrove forest

4.3.1 Non-parametric estimation

Non-parametric methods were used to estimate the total non-use value of mangrove forest and showed that average willingness to pay (WTP) was around VN$131,670 per household (see Table 7). This average figure, multiplied by the total number of households in the study site, provides a total output of VN$14,633,320.000/year (equivalent to about US$700,000).[6] The WTP estimate using the non-parametric method is lower than that of the parametric one, which is consistent with the theory of the contingent method, as the non-parametric method uses a lower-bound value of bid ladders. The total non-use value of mangrove forest/ha is VN$9,755,466/ha.

Table 7. Willingness to pay for non-use value of mangrove forest

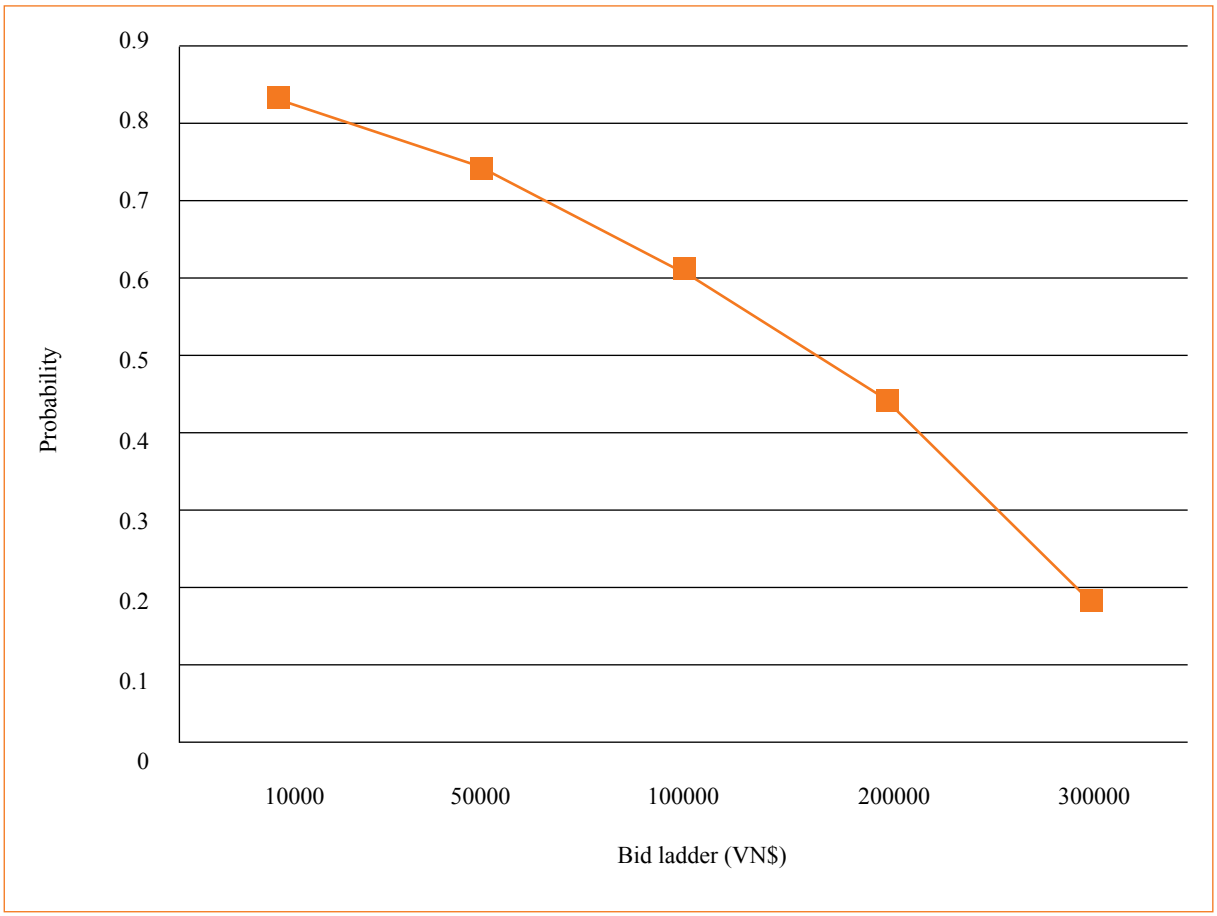
Bid level	Total respondents	Yes	Total	Probability	Lower bound (VN$)
10,000	54	45	0.83	0.09	879
50,000	55	41	0.75	0.13	6717
100,000	54	33	0.61	0.17	16,667
200,000	54	24	0.44	0.26	51,852
300,000	54	10	0.19	0.19	55,556
Total	271	153			131,670

Source: surveyed for this study in 2012.

The result of probability and its distribution show that the probability decreases when bid levels increase. This means that the lower the bid level, the higher the probability of a ‘yes’ response regarding the willingness to pay for non-use values.

6 *Here, US$1 is equivalent to VN$20,800 (Vietcombank).*

Figure 9. Distribution of probability of WTP by bid ladder



4.3.2 Parametric estimation

Whether or not to use logistic regression or probit methods to estimate the WPT of respondents is a subject of ongoing discussion among researchers. Probit regression is closely related to logistic regression; in fact, if the researchers choose the logistic transformation, this procedure will essentially compute a logistic regression with a small sample size and with observational studies. The probit analysis procedure will estimate the effective values for various rates of responses, while the logistic regression procedure does estimates of odd ratios for independent variables, which will be used to calculate the probability of an observation of 'yes' and to estimate willingness to pay for designed experiments. In this study, we have a sample of 271 observations. Thus, logistic regression using maximum likelihood methods to estimate each household's WPT for the non-use value of mangrove forests further assessed correlations of different respondent characteristics (such as gender, age or education) with their bid level. The logistic model measures whether respondents respond with a 'yes' when asked whether they would pay for a non-use value (see Tables 8 and 9).

Prob (Yes) = intercept + b1 Gender + b2 Education + b3 Household size + b4 House type + B5 Age + b6 Livelihoods + b7 Attitudes + b8 Bid ladder.

Table 8. Description of variables used in the binary model

	Variable	Description	Value
1	Odd ratio (Yes)	Probability of a respondent willing to pay for non-use value of mangrove	1 = Yes WTP 0 = No WTP
2	Age	Age of respondent	Numeric variables
3	Male	Gender of respondents: if the respondent is male	1 = Male 0 = Female
4	Education	If respondents were educated to high-school level or above	1 = High school and above 0 = Otherwise
5	Household size	Number of members of each households	Numeric variables
6	House type	Type of house: if the respondent's house is permanent. This is a proxy of income.	1 = Permanent house 0 = Otherwise
7	Livelihoods	Livelihoods for each household: if the livelihoods are related to the lagoon wetlands and mangroves	1 = Yes 0 = No
8	Attitude	Respondent's attitude: if the current situation of the mangroves is severe	1 = Yes 0 = No
9	Bids	Bid ladder (1000 VN$)	10, 50, 100, 200, 300

Table 9. Determinants of the willingness to pay (WTP) function

Variables	**B**	**S.E.**	**Sig.**	**Mean**
Age	0.0037	0.0128	0.771	48.28
Male	0.7013	0.4489	0.118	0.84
Education	0.8249	0.5293	0.119	0.59
Household size	0.0654	0.1015	0.519	4.87
House type (*)	1.6892	0.3343	0.000	0.47
Livelihoods (*)	0.8029	0.3225	0.013	0.54
Attitude	0.2259	0.3679	0.539	0.72
Bids (*)	–0.0114	0.0016	0.000	
Constant	–1.0228	0.8396	0.223	
Log likelihood	126			
Pseudo R-square	0.29			

(* Significant at alpha = 5 per cent)

The results of this parametric assessment show that at least three variables affect a person's willingness to pay for restoring the mangroves. These include the bid ladder, the type of house and livelihoods. The beta coefficient of bid ladder shows a negative relation, which is reasonable as when the bid ladder increases, the probability of saying 'yes' is decreased at 1 per cent significant level.

The livelihoods variable is significant at 5 per cent and has a positive sign, implying that if the householder's livelihoods are related to the lagoon wetlands and mangroves he/she is likely to pay more for the restoration of the mangroves.

House type has a positive correlation with the willingness to pay for mangrove restoration of households, implying that households with permanent houses are likely to pay more (a permanent house in this case can be a proxy of the household's wealth or income).

Based on the formula in Annex 2, the estimated willingness to pay for mangrove restoration in Thi Nai is approximately VN$146,700/household/year. Total non-use value of mangroves using this parametric estimated method is approximately VN$15.7 million (equivalent to about US$760,000/year). Average non-use value of mangroves is equivalent to about VN$10.5 million/ha.

5 Cost–benefit analysis of mangrove restoration

As mentioned previously, there are two options used in this cost–benefit analysis: using lagoon wetlands for aquaculture development or for mangrove restoration.

5.1 Option 1: Cost–benefit analysis of aquaculture development

Aquaculture development currently takes place in Thi Nai Lagoon. The source of information to calculate the cost–benefit of aquaculture to households in Thi Nai Lagoon has been done and disseminated in the consultancy report of the Climate Change Coordination Office of Binh Dinh Province by Tran Huu Tuan and the research team from Hue College of Economics (Tuan *et al.* 2012) (see a brief introduction to this study in Annex 3).

As mentioned previously, this study aimed to conduct CBA for two options and compare the cost–benefit of each option. Based on that, this study provides policy implications for the use and management of mangroves in Thi Nai Lagoon.

Field trips revealed that aquaculture ponds have been developed widely in Thi Nai Lagoon. Large lagoon areas have been converted into ponds for shrimp and crab aquaculture, which has reduced the overall mangrove areas in the lagoon. Aquaculture development is thus considered a base case for this CBA study. The cost–benefit has accrued to certain stakeholders (pond owners) and aquaculture pond development does not create any addition social costs or benefits. In this study, we assumed that the costs and benefits of aquaculture development which accrued to pond owners. The cost of aquaculture development is a market-based measurement, including pond construction, seed, food, labour, pond reinforcement and protection, while the net benefit is the difference between total revenue and total cost. The study assumed that a total of 150 hectares was available for conversion into aquaculture ponds.

5.1.1 Total cost of aquaculture

The average cost of 1 hectare of aquaculture development is about VN$64.6 million, in which pond preparation accounted for about 42 per cent of the total cost. The second largest cost item is feed (industrial feed and fresh feed) which is about 23 per cent of the total cost. Breeding costs are about 18.6 per cent of the total cost. The total revenue from 1ha of aquaculture is about VN$72.1million/year. Net benefits of aquaculture reached about VN$7.49 million/ha/year. The total cost–benefit analysis presented in Table 10 will be used to conduct CBA analysis in this study by multiplying 150ha by 22 years.

Table 10. Total cost–benefit analysis of 1ha aquaculture/ year in Thi Nai lagoon

	Cost items	Values (VN$1000)	per cent of total cost
1	**Pond preparation**	27,000	41.8
2	Breeding	12,000	18.6
3	Industrial feed	4,300	6.7
4	Fresh feed	11,000	17.0
5	Labour	6800	10.5
6	Materials (lime, medicine) for ponds	1250	1.9
7	Other	2300	3.6
	Total cost	**64,650**	100.0
	Total revenue	**72,140**	
	Net benefit	**7,490**	

(Sources: Tuan et al. 2012; consultancy report for CCCO Binh Dinh).

For aquaculture production, the annual costs and benefits are accrued to certain households, and the costs and benefits accrued from Year 1 to Year 22 are the same (see Table 11). This is a reasonable assumption as there is only pond preparation, the costs of which will be accrued annually for certain pond owners, and in this study, pond preparation is calculated by the depreciation of the total costs of pond construction and annual costs of pond reinforcement. Other cost items are accrued annually.

Table 11. Cost–benefit of 150 hectares of aquaculture over 22 years in Thi Nai

Year	Total cost (VN$1000)	Total benefit (VN$1000)	Discount rate (10 per cent	Present value of benefit (VN$1000)	Present value of cost (VN$1000)	Net present value
1	9,697,500	10,821,000	0.9091	9,837,371	8,815,997	1,021,374
2	9,697,500	10,821,000	0.8264	8,942,474	8,014,014	928,460
3	9,697,500	10,821,000	0.7513	8,129,817	7,285,732	844,086
4	9,697,500	10,821,000	0.683	7,390,743	6,623,393	767,351
5	9,697,500	10,821,000	0.6209	6,718,759	6,021,178	697,581
6	9,697,500	10,821,000	0.5645	6,108,455	5,474,239	634,216
7	9,697,500	10,821,000	0.5132	5,553,337	4,976,757	576,580
8	9,697,500	10,821,000	0.4665	5,047,997	4,523,884	524,113
9	9,697,500	10,821,000	0.4241	4,589,186	4,112,710	476,476
10	9,697,500	10,821,000	0.3855	4,171,496	3,738,386	433,109
11	9,697,500	10,821,000	0.3505	3,792,761	3,398,974	393,787
12	9,697,500	10,821,000	0.3186	3,447,571	3,089,624	357,947
13	9,697,500	10,821,000	0.2897	3,134,844	2,809,366	325,478
14	9,697,500	10,821,000	0.2633	2,849,169	2,553,352	295,818
15	9,697,500	10,821,000	0.2394	2,590,547	2,321,582	268,966
16	9,697,500	10,821,000	0.2176	2,354,650	2,110,176	244,474
17	9,697,500	10,821,000	0.1978	2,140,394	1,918,166	222,228
18	9,697,500	10,821,000	0.1799	1,946,698	1,744,580	202,118
19	9,697,500	10,821,000	0.1635	1,769,234	1,585,541	183,692
20	9,697,500	10,821,000	0.1486	1,608,001	1,441,049	166,952
21	9,697,500	10,821,000	0.1351	1,461,917	1,310,132	151,785
22	9,697,500	10,821,000	0.1228	1,328,819	1,190,853	137,966
				94,914,237	85,059,682	9,854,556
				NPV	9,854,555	
				BCR	1.12	

(Note: total cost–benefit was calculated by using average cost of 1ha of aquaculture (see Table 14 and multiply by 150ha).

It is clearly evidenced that if we convert 150ha of mangrove in Thi Nai Lagoon into aquaculture development, the total cost would be roughly VN$85 billion and gain about VN$94 million over the next 22 years, without factoring in risks associated with climate change, environmental pollution and epidemic disease of shrimp (see Table 11). The total net present value reached about VN$9.8 billion, and the ratio of BCR is about 1.12 at a discount rate of 15 per cent, which is very low compared with mangrove restoration. Furthermore, aquaculture development only brings benefit to certain stakeholders, without any additional benefits for communities. In this study, the costs and benefits of aquaculture development do not factor in potential negative impacts on aquaculture development. It means that the benefit of aquaculture should be lower and is threatened by risks associated with climate change.

5.2 Option 2: Cost–benefit analysis of mangrove restoration

The total benefit of mangrove reforestation was calculated using two sources of information: this project and another project called Ecosystem Services for Climate Resilience in Quy Nhon (Tuan *et al.* 2012). The total benefit of mangrove restoration is the sum of the total non-use values and was estimated using the non-parametric method and parametric ones, and combining the total direct use value and indirect value for 150 hectares of mangrove. The result of key informant interviews and focus group discussions confirmed that the lifecycle of a mangrove forest is about 22 years after it is planted, after which the mangrove will decline and need to be replanted. This length of time will be used to estimate the total benefit and cost for this project. The total cost of restoration includes the restoration cost and costs for the maintenance and protection of the mangrove. A market-based approach was used to estimate the total cost.

5.2.1 Total cost of mangrove restoration

The total cost of 150 hectares of mangrove restoration in Thi Nai Lagoon under the project was calculated from project information and from the results of focus group discussions and consultancy meetings between local communities and governments (see Table 12). The length of time needed to complete mangrove forest restoration for 150ha in Thi Nai Lagoon is estimated at about 4 years and costing about US$850,000, thus the annual cost of restoration is about VN$3.6 million. After the first 4 years, once the mangrove planting is complete, the restoration cost is zero. Maintenance and protection costs will vary during the first 4 years and then remain constant for the rest of the project life (22 years). These maintenance costs include protection and re-planting of any areas of the mangrove which have died or been damaged. Participants estimated the cost of mangrove protection to be about VN$1 million/ha/year, and this protection activity should be assigned to villagers.

Table 12. Total cost of mangrove restoration

Year	Mangrove restoration cost/ha (VN$1000)	Mangrove maintenance and protection (VN$1000)	Total cost (VN$1000)
1	3,568,986	200,000	3,768,986
2	3,568,986	200,000	3,768,986
3	3,568,986	200,000	3,768,986
4	3,568,986	200,000	3,768,986
5	0.0	150,000	150,000
6	0.0	150,000	150,000
7	0.0	150,000	150,000
8	0.0	150,000	150,000
9	0.0	150,000	150,000
10	0.0	150,000	150,000
11	0.0	150,000	150,000
12	0.0	150,000	150,000
13	0.0	150,000	150,000
14	0.0	150,000	150,000
15	0.0	150,000	150,000
16	0.0	150,000	150,000
17	0.0	150,000	150,000
18	0.0	150,000	150,000
19	0.0	150,000	150,000
20	0.0	150,000	150,000
21	0.0	150,000	150,000
22	0.0	150,000	150,000
Total	**14,275,944**	**3,500,000**	**17,775,944**

5.2.2 Total benefit of mangrove restoration

Research on the use value of mangrove restoration done by Tran Huu Tuan and the research team for Binh Dinh CCCO in 2012 (see Tables 13 and 14 and Annex 3) shows that the total benefit of mangrove restoration is a sum of direct use value, indirect use value and non-use value. The direct use value of mangroves in Thi Nai includes benefits from shrimp, crab and fish aquaculture and fishing practices. Mangrove forests provide an important source of income for local communities living in Thi Nai Lagoon, with a share of 45 per cent of total economic value of VN$35.8 million/ha/year. Indirect use values and non-use values of mangrove restoration are estimated to have a value of VN$9.9 million and VN$9.7 million respectively. The total economic value of mangrove restoration is 35.8 million/ha/year with non-parametric method and VN$36.6 million/ha/year with parametric method (see Tables 13 and 14).

Table 13. Total benefit of mangrove restoration estimated with non-parametric method

	Total economic value	Value/ha (VN$1000)	Share of total value (per cent)
I	**Direct use value**	**16,150.0**	**45.1**
1	Aquaculture	7490.0	20.9
2	Fishing	8460.0	23.6
3	Forest protection earnings	200.0	0.6
II	**Indirect use value**	**9940.0**	**27.7**
1	Ecosystem services	7200.0	20.1
2	Shoreline stabilisation	1870.0	5.2
3	Carbon sequestration	870.0	2.4
III	**Non-use value (CVM)**		**27.2**
1	Non-parametric estimated	9755.0	27.2
Total		**35,845.0**	100.0

Source: Tuan *et al.* 2012; consultancy report for CCCO Binh Dinh.

Table 14. Total benefit of mangrove restoration estimated with parametric method

	Total economic value	Value/ha (VN$1000)	Share of total value (per cent)
I	**Direct use value**	**16,150.0**	**44.2**
1	Aquaculture	7490.0	20.5
2	Fishing	8460.0	23.1
3	Forest protection	200.0	0.5
II	**Indirect use value**	**9940.0**	**27.2**
1	Ecosystem services	7200.0	19.7
2	Shoreline stabilisation	1870.0	5.1
3	Carbon sequestration	870.0	2.4
III	**Non-use value (CVM)**		**28.6**
	Parametric estimated	10,469.0	28.6
Total		**36,559.0**	100.0

Source: Tuan *et al.* 2012; consultancy report for CCCO Binh Dinh.

The total economic value is estimated by multiplying the average total economic value/ha/year by the total project area of mangrove restoration of 150ha, assuming a 22-years lifecycle.

5.2.3 Total economic value of mangrove restoration estimated with non-parametric methods

As shown in Annex 4, the total present value cost of the mangrove restoration project with a discount rate of 10 per cent is VN$12.787 billion for the whole life of the project. The total benefit is a sum of non-parametric estimated non-use values, indirect use values and direct use values and comes to VN$32.963 billion. The internal rate of return (IRR) of the project reaches 17 per cent at this discount level, and the benefit/cost ratio is 2.58. It is thus reasonable to conclude that the mangrove restoration project would be a valuable investment, particularly in the context of economic crisis and climate change.

5.2.4 Total economic value of mangrove restoration estimated with parametric methods

Estimates of the total economic value of mangrove restoration made using parametric methods come to VN$36.559 million/ha/year. This is higher than estimates from non-parametric methods. The same assumptions were used: that restoration costs would be incurred in the first 4 years, and costs from Year 5 to the final year would be lower, as they would only include maintenance and protection costs. Benefits from mangrove restoration would also be accrued differentially, with 25 per cent of total benefits accruing in Year 3 and 50 per cent of total benefits in Year 4. The total benefit of mangrove restoration is accrued from Year 5 to Year 22. As shown in Annex 5, with a discount rate 10 per cent, the total present benefit of mangrove restoration is VN$33.6 billion; total costs are VN$12.8 billion (see Annex 5). The IRR reached 17 per cent, the benefit/cost ratio is 2.63, which represents a high potential for investment.

5.3 Sensitivity analysis

Given the merits of cost–benefit analysis, it is used widely as a decision-making tool by many organisations globally, including the World Bank, policymakers and investors. The traditional criteria for evaluation include the net present value (NPV), the benefits and costs ratio (BCR) and the internal rate of return (IRR). However, cautions must be taken into account when choosing a discount rate, as is extensively discussed (Dietz 2008 and Nordhause 2007). This is because even small changes in the discount rate for a long-term ecosystem restoration can result in a significant difference in the present value of new benefits, thus researchers conducting a CBA study should include present values of the sensitivity analysis. In this study, the sensitivity of NPV of a project with a lifetime of 22 years was analysed. Holding constant other factors, the project is not sensitive to changes in the discount rate.

In this study, with the purpose of ensuring the feasibility of NPV estimates for the project, discount rates of 5 per cent, 10 per cent and 15 per cent were compared for the sensitivity analysis. This is reasonable and acceptable considering the existing literature and the context of socio-economics in the study site. The discount rate of 5 per cent was used as the mangrove restoration is a social welfare development project, with its effect being mainly seen in the long term. The discount rate of 10 per cent is the common base for a CBA study, which is widely cited in the existing literature (Dietz 2008; Tuan *et al.* 2009; Thang and Bennett 2005; Truong 2011). The discount rate of 15 per cent is used to describe the current context of economic crisis. As shown in Table 15, the NPV does not become negative at a discount rate from 5 per cent to 15 per cent, and IRR still reached 11.45 per cent at a discount rate of 15 per cent. The ratio of benefit and cost changes from 3.72 to 1.88. It is reasonable to conclude that the mangrove restoration project is better choice for the use of Thi Nai Lagoon resources than using it for aquaculture development.

Table 15. Sensitivity analysis of mangrove restoration project

Index	Unit	Discount rate (%)		
		5%	10%	15%
IRR	%	22.09	16.5	11.45
NPV	(VN$1000)	40,272,997	20,176,756	9,973,002
BCR	(Time)	3.72	2.58	1.88

The economic index shown in Table 15 related to the mangrove restoration project demonstrates potential for investors, with a range of changes in the discount rate from 5 per cent to 15 per cent. In other words, in the context of economic crisis where the real estate market and stock markets are dramatically in decline, the investment in mangrove restoration is still a high IRR and BCR which are valuable for investors. It would be even more valuable and meaningful when we consider the future context of climate change, with an increase in the frequency and intensity of hazards, particularly typhoons, sea-level rise and floods. Restoring the mangrove forest in Thi Nai will make a significant contribution in terms of reducing the impacts of climate change on communities living in Quy Nhon and around Thi Nai Lagoon. It is also an important intervention for climate change mitigation, by absorbing greenhouse gases.

5.4 Comparing cost–benefit of mangrove restoration with aquaculture development

Different discount rates were used to analyse the sensitivity and compare costs and benefits of the two options for using the 150ha of mangroves in Thi Nai Lagoon (see Table 16). As mentioned previously, the risks of epidemic disease affecting aquaculture livestock, climate change impacts and environmental pollution were not taken into account when conducting the cost–benefit analysis of aquaculture development. This means that if such risks happened, the cost of aquaculture would increase and benefits would decrease significantly. The result of focus group discussions shows that in the last decades, large areas of Thi Nai Lagoon have been converted for aquaculture development. However, many of these have suffered losses and epidemic diseases and environmental pollution are among the common reasons for failure.

Table 16. Comparing benefits of mangrove restoration with aquaculture development

	Unit	Discount rate (per cent)		
		5%	10%	15%
Option 2: Mangrove restoration				
NPV	VN$1000	40,272,997	20,176,756	9,973,002
BCR	Time	3.72	2.58	1.88
Option 1: Aquaculture development				
NPV	VN$1000	14,788,293	9,854,556	7,143,887
BCR	Time	1.33	1.12	1.11
Difference between Option 2 (Mangrove restoration) and Option 1 (Aquaculture)				
NPV	VN$1000	25,484,704	10,322,201	2,829,115
BCR	Time	2.39	1.46	0.77

In terms of economic issues, however, Table 16 shows that with the large investment costs needed for aquaculture, the net present value of aquaculture at three discount rates from 5 per cent, 10 per cent and 15 per cent are all much lower than that for mangrove restoration. As shown in Table 16, there is a significant difference in both NPV of mangrove restoration and the BCR. For example, at a discount rate of 5 per cent, the difference in NPV is VN$25.4 billion and BCR is 2.39 times higher than that of aquaculture. At a discount rate of 15 per cent, the mangrove restoration still generates more, approximately VN$2.8 million in benefits than aquaculture development.

Beside the high economic value of mangrove restoration investment, mangrove restoration is also more equitable (with better social welfare) for communities than aquaculture, because aquaculture development only involves certain stakeholders (it is a private investment which benefits only a few). In comparison, mangrove restoration provides ecosystem services for the whole community and beyond, such as carbon sequestration, shoreline stabilisation and biodiversity protection. Mangrove restoration should also be prioritised because it is a mitigation measure for addressing climate change, with mangroves acting as carbon sinks.

6 Discussion and conclusion

6.1 Discussion

The emerging desire to measure the costs and benefits of human activities and the benefits of environmental protection and restoration has challenged both government policymakers and communities. In reality, due to a lack of information and a desire to accrue short-term benefits, many areas of environmental resources have been used for private economic purposes such as aquaculture and agricultural production. Such decisions only benefit certain stakeholders, but do not sustain more equitable long-term economic, environmental and social development and resilience in the face of climate change. Meanwhile, the use of mangroves and wetlands is always controversial amongst policymakers and social stakeholders. A cost–benefit analysis of different options for the use of mangroves can play an important role in providing useful information to support improved mangrove and environmental decision-making (Barbier *et al.* 1997; De Groot *et al.* 2002).

CVM methods can be complex as their application may be subject to judgement, uncertainty and bias. However, CVM is mature and capable of providing useful information to support decision-making in the use and management of the environment (Glover 2003; Fisher 2000). The economic values of mangrove forests only materialise from economic transactions when stakeholders are willing to pay for the use of mangroves. The respondents involved in this study were also invited to information-sharing meetings where they were introduced to current and future scenarios for the mangroves in Thi Nai Lagoon. Climate change and its impacts and the role of mangroves in terms of supporting adaptation to climate change and sustaining local livelihoods were explained before respondents were asked to bid for the non-use value of mangroves. This study therefore demonstrates that communities place a high value on protecting their natural resources due to the ties to their livelihoods. Informing them about potential climate change-related benefits of restoring the mangroves will also affect their willingness to pay for the restoration and conservation.

The validity and reliability of CBA results are largely dependent on judgement and option definition and local well-being (Jakobsson and Dragun 1996; Freeman 1993; Glover 2003). The study was originally designed with three options for the use of 150ha out of over 5000ha of mangroves in Thi Nai Lagoon: urban development, mangrove restoration and a base case of aquaculture development. However, due to a lack of information about and the delay in the urbanisation development project, the study conducted CBA analysis for only two options: mangrove restoration and aquaculture development. This possibly affects the output of the CBA analysis as the study could not cover the full number of options for possible wetland use. Additionally, the lower returns from aquaculture in the last few years also explain why benefits from aquaculture development are much lower than those from mangrove restoration as shown in the results above. This is a reasonable assumption as present trends in aquaculture, such as incidences of epidemic disease, combined with the projected risks of future climate change, mean that aquaculture development is projected to worsen as a development option. This is reflected by the findings of this study, which can be used to inform decision-making by government and other stakeholders.

It is important to confirm that mangroves in Thi Nai Lagoon play a very important role in providing economic and environmental support for local communities. Local communities are well aware of the role that the mangrove plays in their lives and its importance for future generations, and they are willing to get involved in mangrove restoration. The

mangrove in Thi Nai Lagoon provides the main sources of income for a large proportion of the population, both in direct ways (such as aquaculture, fishing and agro-forestry) and indirect ways (such as nutrient retention, flood control, and storm protection). In the context of climate change impacts, indirect values and non-use values are being increasingly acknowledged by the respondents. These results are consistent with findings from Powell *et al.* (2012) who confirmed that mangrove restoration is a valuable adaptation measure to climate change in Vietnam (UNEP-GEF 2003; VEPA-IUCN 2000).

The willingness to pay for the non-use value of mangroves in Thi Nai Lagoon is very much dependent on the characteristics of respondents, and their willingness to pay for the non-use value of mangroves declined as the bid level increased. The findings of this study reflect research conducted by Barbier *et al.* (1997), Hong *et al.* (2008), Powell *et al.* (2012) and Thang and Bennett (2005) who found that education levels, income and gender correlation influence the willingness to pay for the non-use values of mangroves: better-off households have a higher willingness to pay for non-use values; men are willing to pay more for non-use values and mangrove restoration than women, as men are often in charge of manual work related to mangrove access in Thi Nai and income-generation for the family. The well-being of respondents also has a positive correlation with the bid level: households with better incomes will bid higher levels, despite whether their homes are closer to or further away from Thi Nai lagoon.

The cost–benefit analysis of mangrove restoration provides important information for policymakers as it reveals potential returns with significant changes in discount rates from 5 per cent to 15 per cent. Investment in mangrove restoration should generate higher benefits in the long term than base-case aquaculture over a range of discount rates from 5 per cent to 15 per cent. With increases in the frequency and intensity of typhoons, floods and sea-level rise expected under climate change in Quy Nhon, mangrove restoration is likely to make an even bigger contribution to the local economy in the face of climate change. This should incentivise policymakers to give priority to mangrove restoration in Thi Nai Lagoon. In the context of climate change, mangrove restoration can be an effective measure to reduce its impacts, particularly in countries with long coastal lines like Vietnam, as reforestation is considered an effective mitigation solution to deal with climate change impacts. The importance of this should be recognised and given priority in the national strategy to prevent and mitigate the impacts of climate change (Hong *et al.* 2008; Reid 2011; Powell *et al.* 2012).

6.2 Conclusion and recommendations

6.2.1 Conclusion

Wetlands with mangroves are providing tangible and intangible benefits for human beings who have direct and even indirect interactions with them. Households involved in this study understand and recognise the importance of mangroves in Thi Nai Lagoon for their livelihoods. A large number of communities live around Thi Nai Lagoon whose livelihoods depend on access to wetlands and mangroves. Mangroves in Thi Nai Lagoon have significant economic value to local communities both through direct use, indirect use and non-use values.

The climate is changing and its induced impacts on local communities have been become pressing issues in Quy Nhon City and Thi Nai Lagoon (Michael and Van 2012). Increases in temperatures in May to September have been observed, with many heat waves and droughts, while rainfall during this period has been decreasing. This has severely affected communities. Observed rainfall increases in the storm season along with sea-level rise have caused severe floods in the region. However, the term ‘climate change’ and the role of mangrove restoration as an adaptation measure to climate change seem to be new themes to the respondents involved in this study. It is important to conduct awareness-raising activities about climate change and the role that mangroves can play for local communities living around Thi Nai Lagoon in adaptation to climate change. This will increase their awareness about the importance of mangrove restoration and protection in the future. Households involved in this study are willing to pay for the non-use value of mangroves and mangrove restoration in Thi Nai lagoon. Bid levels (the amount they are willing to pay) vary according to various demographic characteristics, such as age, gender, education, employment and household income. Households with permanent houses are more willing to pay for mangrove restoration; and households with livelihoods that are more

dependent on the mangroves have a higher willingness to pay for mangrove restoration. It is also important to note that mangrove restoration can create great benefits for communities, especially in helping them to avoid the impacts of climate change in the future. Investing about VN$17.7 billion over four years to restore 150ha of mangroves will create about VN$32 million (about US$1.7 million) in return.

Sensitivity analysis confirms the figures for IRR, NPV and BCR of mangrove restoration, which all show as positive with discount rates of from 5 per cent to 10 per cent and 15 per cent. Benefits from restoration are roughly double those expected from using the 150 hectare site for aquaculture development, particularly as large areas of wetland lagoon that were converted for aquaculture development have suffered losses due to a variety of factors including epidemic disease and environmental pollution. This is useful information for policymakers, local government and short-term investors. Such restoration would also improve sustainability of both local livelihoods and socio-economic development in the context of climate change.

Demands on the wetland in Thi Nai Lagoon are varied and increasing. These include urbanisation development, aquaculture development and mangrove restoration. It should be recognised that the trade-offs between different uses of the wetland exist amongst stakeholders and over different time periods. Decision-making regarding mangrove management can be very complex. The resources are limited, and many demands cannot be fulfilled simultaneously. Therefore, the cost–benefit analysis in this study provides useful information for decision makers wishing to achieve the sustainable use of mangroves in the Thi Nai Lagoon.

6.2.2 Recommendations

Based on the findings of this project, it is strongly recommended that:

1. Mangrove restoration is supported both through resource provision for local communities and by enlarging the protection zone. This not only provides better economic value but also creates important environmental services in comparison with other economic activities. In particular, it supports agricultural production as a whole. Central government regulations restrict the conversion of agricultural land into other land uses, and wetlands and mangroves should also be subject to these restrictions to prevent conversion for other utilisation purposes. From an economic viewpoint, mangrove restoration provides higher benefits to communities and improved equity in access to resources than other economic activities such as aquaculture (where benefits are lower and accrue only to certain stakeholders, and may be eroded by epidemics affecting livestock). Policymakers should thus use economic valuation as a means to compare the trade-offs involved with alternatives.
2. Raising local awareness of climate change issues and the importance of mangrove restoration as a climate change adaptation and mitigation measure is an important step to get local involvement in mangrove restoration and protection. Local communities have a low awareness of climate change and the role of mangroves in adaptation to climate change.
3. Mangrove restoration activities should involve local communities from the beginning of the project. Those who have more stable incomes and higher educational levels could be targeted because they can work as key community actors for conducting mangrove restoration and protection activities. Men should also be recognised as important stakeholders involved in mangrove forest restoration.
4. Government should collaborate with tour operators in order to develop tours to visit the mangrove forest and services in Thi Nai Lagoon. This will raise awareness about the benefits of the use of the mangrove forest for local communities, thus incentivising local communities to enlarge (through reforestation) the mangrove forest in Thi Nai Lagoon. The result of key informant interviews with a representative of the Binh Dinh Provincial Department of Agriculture and Rural Development shows that annually they organise visits for more than 10 groups of guests who visit their department to the mangrove forest on Con Chim Island in Thi Nai Lagoon. This activity generates large benefits for restaurant and boat owners surrounding Thi Nai Lagoon. Training local communities to operate tourist services and develop products for tourist businesses could be an important alternative source of income for local residents.

5. Mangrove restoration can bring many benefits to communities as a whole in terms of both use values and non-use values, which are even higher than the net present value of aquaculture development. Accordingly, mangrove restoration should be encouraged amongst different stakeholders, particularly households involved in aquaculture in Thi Nai Lagoon in both the wetland itself and also in dams built for aquaculture ponds. Results from focus group discussions revealed that aquaculture ponds bordered by mangrove forests will save on household costs as mangrove forests protect the pond from waves and sea-level rise, particularly in the stormy season. Aquaculture ponds with mangroves on their dam walls have cleaner water and the shrimps in them are less disease-ridden than land-dammed ponds. Governments should request or encourage households to plant mangroves on the dam walls of ponds.

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Annex 1. The contingent valuation method (CVM)

Using CV questions, the discrete choice CV question is most widely adopted because other types of question suffer the problem of incentive compatibility (Carson *et al.* 2001). It is analysed using a random utility model, which is discussed in Haab and McConnell (2002) and Bateman *et al.* (2002), where the utility function of respondent j is:

$$u_{ij} = u_i(y_j, z_j, \varepsilon_{ij}) \tag{1}$$

Where I = 0 is the status quo, and i = 1 is the condition where the environmental services are supplied. Utility is a function of income y, a vector of the respondent's characteristics z and ε_{ij} is the unobservable component.

Respondents are willing to pay or 'yes' to the payment t_j if the utility with the environmental improvements after the payment exceeds the utility of the status quo, or:

$$u_{1j} + u_1(y_j - t_j, z_j, \varepsilon_{1j}) > u_0(y_j, z_j, \varepsilon_{0j}) \tag{2}$$

Because of the unobservable component, one can only estimate the probability of a 'yes' or 'no' response:

$$\Pr(yes_j) = \Pr(u_1(y_j - t_j, z_j, \varepsilon_{1j}) > u_0(y_j, z_j, \varepsilon_{0j})) \tag{3}$$

The utility function is assumed to be separable in deterministic and stochastic preference:

$$u_i(y_j, z_j, \varepsilon_{1j}) = v_i(y_j, z_j) + \varepsilon_{ij} \tag{4}$$

The probability statement then becomes:

$$\Pr(yes_j) = \Pr(v_1(y_j - t_j, z_j) + \varepsilon_{1j} > v_0(y_j, z_j) + \varepsilon_{0j}) \tag{5}$$

Assume the utility function is linear:

$$v_{1j}(y_j) = \sum_{k=1}^{m} \alpha_{1k} z_{jk} + \beta_1(y_j) \tag{6}$$

The deterministic part of utility from environmental improvements is:

$$v_{1j}(y_j - t_j) = \sum_{k=1}^{m} \alpha_{1k} z_{jk} + \beta_1(y_j - t_j) \tag{7}$$

The status quo utility is:

$$v_{0j}(y_j) = \sum_{k=1}^{m} \alpha_{0k} z_{jk} + \beta_0(y_j) \tag{8}$$

Change in deterministic utility is:

$$v_{1j} - v_{0j} + \sum_{k=1}^{m} (\alpha_{1k} - \alpha_{0k}) z_{jk} + \beta_1(y_j - t_j) - \beta_0 y_j \tag{9}$$

Since marginal utility of income in the two situations is the same, $\beta_1 = \beta_0$ then:

$$v_{1j} - v_{0j} + \sum_{k=1}^{m} \alpha_k z_{jk} - \beta t_j \tag{10}$$

The probability statement becomes:

$$\Pr(yes_j) = Pr\left(\sum_{k=1}^{m} \alpha_k z_{jk} - \beta t_j + \varepsilon_j > 0\right) \tag{11}$$

Welfare measure:

Non-parametric estimation:

Non-parametric estimation techniques for the discrete choice valuation format are receiving increasing interest because of the concern associated with incorrect specifications of functional forms and distributions in parametric estimation approaches (Cooper 1994). In addition, there is greater confidence in using parametric results if they could be validated through non-parametric techniques (Salazar and Marques 2005). With this intention, a non-parametric approach is applied in this study to obtain the mean WTP (Bateman *et al.* 2002).

Non-parametric estimation of willingness to pay was used to estimate total willingness to pay upon lower bound of payment ladder responses. In this study, the payment ladder (bid) is from VN$ thousand 0–10, 11–50, 51–100, 101–200 and 201–300.[7] Using lower bound method of payment ladder lets N denote the number of households in the sample and t_j the level of bid (j=0 to J, where J is the highest level of bid and t_0 is always zero). The probability of a household answering 'yes' is equal to the total number of households which have confirmed their willingness to pay per total household answer by type of bid. Let h_j be the number of households with WTP higher than or equal to t_j. The total number of households in the sample with WTP higher than or equal to t_j is:

$$n_j = \sum_{k=j+1}^{J} h_k \tag{12}$$

Then the survivor function will be:

$$S(t_j) = \frac{n_j}{N} \tag{13}$$

From the above analysis:

$$\alpha_1 z_j + \beta(y_j - t_j) + \varepsilon_{j1} = \alpha_0 z_j + \beta y_j + \varepsilon_{j0} \tag{14}$$

Therefore:

$$WTP = \frac{\alpha z_j}{\beta} + \frac{\varepsilon_j}{\beta} \tag{15}$$

Assume that $\frac{\varepsilon_j}{\beta}$ has mean zero and variance $\frac{\alpha^2}{\beta^2}$, then mean WTP is:

The mean WTP is calculated using:

$$MeanWTP = \sum_{j=0}^{j} S(t_j)[t_{j+1} - t_j] \tag{16}$$

Based on payment ladder responses, the mean of the values ticked can be taken as the lower bound willingness to pay. That is, the average value respondents were certain they would pay each year for practicing mangrove restoration.

Parametric estimation: The parametric method was used to estimate the total by using logit regression, in which dependent variables are the household saying 'yes' to pay for t_i or 'no' to payment for the t_i bid level. The list of independent variables were subjected to a regression analysis, which is used to estimate the effect of each variable to the WTP of each household including household income, household size, education, age, gender and damages to their property due to annual hazards.

From the above analysis:

$$\alpha_1 z_j + \beta(y_j - t_j) + \varepsilon_{j1} = \alpha_0 z_j + \beta y_j + \varepsilon_{j0} \tag{17}$$

7 *The exchange rate is VN$20,080/US$1.*

Therefore:

$$WTP = \frac{\alpha z_j}{\beta} + \frac{\varepsilon_j}{\beta} \tag{18}$$

Where $\alpha = \alpha_1 - \alpha_0$ and $\varepsilon_j = \varepsilon_{j1} - \varepsilon_{j0}$. Assume that $\frac{\varepsilon_j}{\beta}$ has mean zero and variance $\frac{\sigma^2}{\beta^2}$, then mean WTP is:

$$MeanWTP = E(WTP \mid \alpha, \beta, z_j) = \frac{\alpha z_j}{\beta} \tag{19}$$

Annex 2. The CVM questionnaire

Questionnaire on mangrove restoration in Thi Nai Lagoon

Hello. My name is ……. from the Hue University of Economics. I am involved in a study on mangrove protection and restoration in Thi Nai Lagoon. I would like to ask you a series of questions. Your answers will be used for research purposes only. Would you please help us?

Section 1: Background information

Show Card A: read information on mangroves in Thi Nai Lagoon

CARD A: GENERAL INFORMATION ON MANGROVES IN THI NAI LAGOON

Thi Nai Lagoon has an area of 5.060ha. It used to be distributed with about 1000ha of mangroves and 200ha of sea-bed. These ecosystems have created favourable conditions for the high productivity and biodiversity of the water resource, the richness of the seafood resource, and for maintaining the stability of the environment for the harmonised development of aquatic species and communities living around the lagoon.

Results from previous research show that mangrove resources in Thi Nai Lagoon provide various benefits to humans, including supporting likelihoods for local communities (fisheries, agriculture, aquiculture) and providing ecosystem services (such as storm prevention, climate protection, nursing seedlings, and protecting biodiversity).

Please let us know your opinion on mangrove protection:

☐ 1. Strongly agree with mangrove protection

☐ 2. Agree with mangrove protection

☐ 3. No opinion

☐ 4. Disagree with mangrove protection

☐ 5. Strongly disagree with mangrove protection

Below are some reasons for mangroves protection in Thi Nai Lagoon, please let us know your opinion.

Reasons for mangrove protection	Not very important 1	Not important 2	No opinion 3	Important 4	Very important 5
Mangroves help sustain local likelihoods					
Mangroves provide recreational value, e.g. scenary					
Mangroves provide services such as storm prevention and climate protection					
Mangroves help protect biodiversity					
Mangroves will provide opportunities and benefits for future generations					

Have you heard of the mangroves in Thi Nai Lagoon?

☐ 1. Yes ☐ 0. No

SHOW MAP: This map shows the major mangrove areas in Thi Nai Lagoon.

Have you ever visited the mangroves in Thi Nai Lagoon?

☐ 1. Yes ☐ 0. No

What benefits, if any, do you currently get from using the mangrove area and its natural resources?

☐ 0. No benefit

☐ 1. Do not know

☐ 2. Seafood

☐ 3. Income from fishing

☐ 4. Recreation

☐ 5. Forestry products (e.g. poles/charcoal)

☐ 6. Research/education

☐ 7. Habitat for wildlife and bird species

☐ 8. Amenity/scenary (fresh air/shade)

☐ 9. Flood and storm prevention/preventing soil erosion/environmental protection

☐10. Benefit for next generation

☐11.Others, please specify _____

Are you likely to visit the mangroves in the next 5 years?

☐ 1. Yes/Likely ☐ 0. No/Unlikely

I am now going to give you some information about problems related to mangrove resources uses and management that these mangroves face today.

Read information on Card B: problems related to mangrove resources uses and management that the mangroves in Thi Nai Lagoon face today

Card B: Problems related to mangrove resources uses and management

Loss of mangrove forests along the shores of Thi Nai Lagoon has taken place over the past 15–20 years, in part due to government policies that encouraged conversion to aquaculture ponds for export-oriented production and in part through increased settlement and expansion of urban services such as roads, dykes, etc. Recently, due to urbanisation, the rate of mangrove loss has increased and therefore the local community is more vulnerable to climate change impacts, particularly in low-lying areas around Quy Nhon City. In addition, the process of urbanisation itself may make mangrove protection and restoration more difficult due to pollution and habitat loss from developing areas near the mangrove protection zone.

One of the greatest risks is due to **increased population density and infrastructure development** in this coastal zone as urbanisation expands. This makes protection of the coastline an important strategic objective for urban development and a key part of the city's resilience strategy as they proceed with urban planning.

The other greatest risk is the **impact of climate change and rising sea levels**. According to the Institute for Meteorology, Hydrology and Environment (IMHEN), the projected potential sea-level rise means parts of the city could be submerged at high tide, if no protective measures are taken. The area affected will be 1.4km2 (in 2020), 1.5km2 (in 2050), 2.8km2 (in 2070) and up to 8.4km2 (in 2100). The flooded area is located in the lowest terrain of the city in Nhon Binh, Nhon Phu, Quang Trung wards and a small part of Phuong Mai Peninsula. The flooded areas have a high density of population, which is likely to cause heavy damages to property.

(Show maps: these maps show scenarios of sea-level rise in 2020, 2050, 2070, and in 2010.)

Results of vulnerability assessments indicate that the city is directly vulnerable to six main hazards: storms, inundations, coastal and lagoon-side erosion, saline intrusion, drought, and sand movement. These hazards can cause disasters involving damage to property, facilities and infrastructure, hardship for communities and households, and loss of life. The welfare of Quy Nhon's people would also be impacted through changes in supply and demand for water, food, energy, and other tangible goods that are derived from these systems; changes in opportunities for non-consumptive uses of the environment for recreation and tourism; changes in non-use values of the environment such as cultural and preservation values; changes in incomes; and changes and loss of property and lives from these extreme disasters.

Recognising the above problems, DONRE and the CCCO, together with the Research Center for Resources and Rural Development (*RECERD*), proposed a mangrove protection and restoration plan in Thi Nai under the project Ecosystem Services for Climate Resilience in Quy Nhon City.

The objectives of this restoration programme include:

- Preventing the expansion of urban development into vulnerable low-lying coastal sites along the lagoon by protecting these for mangrove restoration.
- Strengthening urban food security.
- Raising awareness of the local community and administrators about the importance of mangroves.
- Contributing to ecologically sustainable and climate-resilient urban development as Quy Nhon expands around Thi Nai lagoon.

Is this information new to you?

☐ 1. Yes, very new

☐ 2. Only some of it is new

☐ 3. I know all this already

How severe in your opinion is the likely damage to the mangroves in Thi Nai Lagoon if the trend highlighted in Card B continues?

☐ 1. Very severe

☐ 2. Severe

☐ 3. Not so severe

☐ 4. Not at all severe

Section 2: Willingness to pay

As described, management and restoration of mangroves in Thi Nai Lagoon is necessary to reduce vulnerability to climate change though the following mechanisms:

- Helping to protect against sea-level rise by accumulating depositional floodplain sediments and stabilising weak shorelines.
- Protecting housing and infrastructure such as ponds, dykes and roads from damage by storms.
- Strengthening livelihoods of impoverished local households vulnerable to flooding and storm damage by increasing the habitat for valuable juvenile fish and crustacean species, and creating new livelihood options in mangrove areas such as community ecotourism or mollusc culture.
- Providing supplemental income for local communities through payments for mangrove plantation and protection in the short term.
- Preventing increased future vulnerability due to urban expansion into low-lying coastal mangrove areas, by ensuring that mangrove ecosystems are restored and protected.

Obviously, the implementation of this protection and restoration project would cost money and people would have to pay their share of the costs on a continuing basis if they want to enjoy the benefits that the restoration of mangroves offers. As such, in order to protect and restore the mangroves, you would be asked to pay a fee to a TRUST FUND, which will be established and managed by the local government unit to help protect and restore the mangroves in Thi Nai Lagoon. Possible projects to protect and restore the mangroves in Thi Nai Lagoon are

- Planting mangroves and coastal plants to reduce impacts of climate change.
- Monitoring of fish, plant life and mangroves.
- Promoting environmentally sensitive tourism activities (e.g. birdwatching, boat trips, etc.).
- Establishing visitor centres.
- Supporting alternative livelihoods for local people.
- Community awareness-raising and community-based disaster risk management.
- Patrolling mangrove areas to prevent illegal activities.

Suppose a TRUST FUND was set up to which all citizens of Binh Dinh could contribute. The fund could then request international organisations to provide the same amount of money or more, according to the money raised locally. The money raised by the fund will only be used to protect the mangroves in Thi Nai Lagoon.

Please keep in mind:

- The issues discussed here are only a few among many other environmental problems Vietnam faces.
- This interview is about the mangroves in Thi Nai Lagoon and not about other environmental issues or other mangroves around the country.

- Your own personal income is limited and has important alternative uses.
- There are no right or wrong answers and you should answer for yourself.

Would you be willing to pay <**bid level**> a year to protect and restore the mangroves in Thi Nai Lagoon? (*Bid levels will be designed via focus group discussions and pre-tests*)

☐ 1. Yes ☐ 0. No

If 'YES' what was it that made you willing to vote for the restoration programme?

(Check the most appropriate answer.)

I think the management plan is a good one	1
I feel this is a reasonable amount to pay	2
I am concerned about the loss of mangroves/biodiversity	3
It is what I can afford to pay	4
I am not sure I could pay what I said but I wish I could	5
Don't know/not applicable	6
Other: please specify	7

If 'NO', can you tell me why you would vote against the programme?

(Check the most appropriate answer.)

I have no spare income but would otherwise contribute	1
I don't believe the system would bring the changes you describe	2
It is the government's responsibility	3
I feel that environmental protection of the mangroves in Con Chim is unimportant	4
I'd rather have the current situation than pay more	5
The user should pay	6
I believe that this improvement will take place without my contribution	7
I fail to understand the question	8
Don't know/not applicable	9
Other: please specify	10

Under your current circumstances, instead of paying anything to the biodiversity fund, would you be prepared to volunteer some of your time to help with projects to protect and restore the mangroves in Thi Nai? Would you be willing to act as a volunteer? Please remember that your time has several competing uses.

☐ 1. Yes (*Go to 3.5*) ☐ 0. No (*Go to 4.1*)

If yes, how many hours per month on a continuous basis?

None	0
Hours per month	
Do not know	

Section 3: Socio economic background

The following are a few questions about your background that will only be used for statistical purposes

1.14 Gender of the respondent: ☐ 1.Male ☐ 0.Female

1.15 Age: …….. years

1.16 What is the highest level of education you have obtained?

☐ 1. No formal education

☐ 2. Primary

☐ 3. Secondary

☐ 4. Technical diploma

☐ 5. Bachelors degree

☐ 6. Masters degree

☐ 7. Other: please specify

What is your occupation?

☐ 1. Civil servant

☐ 2. Own business

☐ 3. Private employee

☐ 4. Labourer/farmer

☐ 5. Student

☐ 6. Retired

☐ 7. Other: please specify

Number of members of your household:

What is your household's annual income? (include all wages, salaries, pensions and other forms of income)

1	Under 500,000 đồng	6	4.1 to 5 billion đồng
2	500,000 to 1 billion đồng	7	5.1 to 10 billion đồng
3	1.1 to 2 billion đồng	8	10.1 to 20 billion đồng
4	2.1 to 3 billion đồng	9	20.1 to 50 billion đồng
5	3.1 to 4 billion đồng	10	Over 50 billion đồng

What is the status of your house?

☐ 1. Permanent house

☐ 2. Semi-permanent house

☐ 3. Temporary house

What re your household's assets?

Yes	Name of asset	Yes	Name of asset
1	Motorbike	5	TV
2	Fridge	6	Computer
3	Air conditioning	7	Cooking-stove
4	Telephone/mobiles	8	Other: please specify

Present address: commune…….

District ……

Last of all, what did you think of this questionnaire?

	Yes	**No**
1. Interesting	1	0
2. Too long	1	0
3. Difficult to understand	1	0
4. Educational	1	0
5. Unrealistic/not credible	1	0
6. Other: please specify	1	0

Do you have any other suggestions/comments about this interview?

(End interview, thank respondent.)

Annex 3. Brief introduction to the consultancy report for CCCO Binh Dinh (Tuan et al. 2012)

The main objectives of this study are aimed at valuing the main use values of mangrove forests in the wetlands of Thi Nai Lagoon, Binh Dinh Province. The use values taken into consideration in this study included direct use values (aquaculture, fishing, and earnings from forest protection) and indirect use values (ecosystem services, shoreline stabilisation and carbon sequestration). For valuing direct use values, a market-based approach was used. For valuing indirect use values, different methods were used. More particularly, for valuing ecosystem services and shoreline stabilisation, a production function approach was used; for estimating carbon sequestration, a benefit transfer method was used. The full report of this study is available in Vietnamese. Below is a summary of results.

Main use values of wetlands in Thi Nai lagoon, Binh Dinh Province

		Value/ha	Share of total value
	Total economic value	**(VN$1000)**	**(%)**
I	**Direct use values**	**16,150.0**	61.90
1	Aquaculture	7490.0	28.71
2	Fishing	8460.0	32.43
3	Forest protection earnings	200.0	0.77
II	**Indirect use values**	**9940.0**	38.10
1	Ecosystem services	7200.0	27.60
2	Shoreline stabilisation	1870.0	7.17
3	Carbon sequestration	870.0	3.33
	Total (I + II)	**26,090.00**	**100.00**

Annex 4. Cost–benefit analysis of 150ha of mangrove restoration in Thi Nai Lagoon

Year	Total Cost (VN$1000)	Total benefit (VN$1000)	Discount rate (10 %)	Present value of benefit (VN$1000)	Present value of cost (VN$1000)	B–C (VN$1000)
1	3,768,986	0	0.9091	0	3,426,385	–3,426,385
2	3,768,986	0	0.8264	0	3,114,690	–3,114,690
3	3,768,986	1,344,188	0.7513	1,009,888	2,831,639	–1,821,751
4	3,768,986	2,688,375	0.683	1,836,160	2,574,217	–738,057
5	150,000	5,376,750	0.6209	3,338,424	93,135	3,245,289
6	150,000	5,376,750	0.5645	3,035,175	84,675	2,950,500
7	150,000	5,376,750	0.5132	2,759,348	76,980	2,682,368
8	150,000	5,376,750	0.4665	2,508,254	69,975	2,438,279
9	150,000	5,376,750	0.4241	2,280,280	63,615	2,216,665
10	150,000	5,376,750	0.3855	2,072,737	57,825	2,014,912
11	150,000	5,376,750	0.3505	1,884,551	52,575	1,831,976
12	150,000	5,376,750	0.3186	1,713,033	47,790	1,665,243
13	150,000	5,376,750	0.2897	1,557,644	43,455	1,514,189
14	150,000	5,376,750	0.2633	1,415,698	39,495	1,376,203
15	150,000	5,376,750	0.2394	1,287,194	35,910	1,251,284
16	150,000	5,376,750	0.2176	1,169,981	32,640	1,137,341
17	150,000	5,376,750	0.1978	1,063,521	29,670	1,033,851
18	150,000	5,376,750	0.1799	967,277	26,985	940,292
19	150,000	5,376,750	0.1635	879,099	24,525	854,574
20	150,000	5,376,750	0.1486	798,985	22,290	776,695
21	150,000	5,376,750	0.1351	726,399	20,265	706,134
22	150,000	5,376,750	0.1228	660,265	18,420	641,845
				32,963,913	**12,787,157**	20,176,756
		IRR	**17 per cent**			
		NPV	**20,176,756**			
		BCR	**2.58**			

Source: surveyed for this study in 2012.

Annex 5. Cost–benefit analysis of mangrove restoration using parametric estimation method

Year	Total cost (VN$1000)	Total benefit (VN$1000)	Discount rate (10 %)	Present value of benefit (VN$1000)	Present value of cost (VN$1000)	B–C (VN$1000)
1	3,768,986	0	0.9091	0	3,426,385	–3,426,385
2	3,768,986	0	0.8264	0	3,114,690	–3,114,690
3	3,768,986	1,370,963	0.7513	1,030,004	2,831,639	–1,801,635
4	3,768,986	2,741,925	0.683	1,872,735	2,574,217	–701,483
5	150,000	5,483,850	0.6209	3,404,922	93,135	3,311,787
6	150,000	5,483,850	0.5645	3,095,633	84,675	3,010,958
7	150,000	5,483,850	0.5132	2,814,312	76,980	2,737,332
8	150,000	5,483,850	0.4665	2,558,216	69,975	2,488,241
9	150,000	5,483,850	0.4241	2,325,701	63,615	2,262,086
10	150,000	5,483,850	0.3855	2,114,024	57,825	2,056,199
11	150,000	5,483,850	0.3505	1,922,089	52,575	1,869,514
12	150,000	5,483,850	0.3186	1,747,155	47,790	1,699,365
13	150,000	5,483,850	0.2897	1,588,671	43,455	1,545,216
14	150,000	5,483,850	0.2633	1,443,898	39,495	1,404,403
15	150,000	5,483,850	0.2394	1,312,834	35,910	1,276,924
16	150,000	5,483,850	0.2176	1,193,286	32,640	1,160,646
17	150,000	5,483,850	0.1978	1,084,706	29,670	1,055,036
18	150,000	5,483,850	0.1799	986,545	26,985	959,560
19	150,000	5,483,850	0.1635	896,609	24,525	872,084
20	150,000	5,483,850	0.1486	814,900	22,290	792,610
21	150,000	5,483,850	0.1351	740,868	20,265	720,603
22	150,000	5,483,850	0.1228	673,417	18,420	654,997
				33,620,525	12,787,157	20,833,368
				IRR	17 per cent	
				NPV	20,833,368	
				BCR	2.63	

Cost–benefit analysis of mangrove restoration in Thi Nai Lagoon, Quy Nhon City, Vietnam

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