Willingness to pay for mangrove preservation in Xuan Thuy National Park, Vietnam: Do stakeholders' knowledge and interest play a role?

Hung Vo Trung[*], Thanh Viet Nguyen[†], Michel Simioni[‡]

Abstract

Xuan Thuy National Park, a special nature reserve with mangrove swamps located in the Red River Delta in North Vietnam, plays an important role in combating coastal erosion and provides a habitat for many endangered bird species. Nevertheless, this wetland faces a dual threat from human development pressures and from natural hazards. This study applied double-bounded dichotomous choice contingent valuation method to directly estimate how much locals are willing to pay for mangrove conservation at Xuan Thuy National Park in the context of climate change. In particular, the technique was used to provide better assess to the non-use value of biodiversity and ecosystem support of mangroves. Survey respondents from 350 households in the buffer zone were presented with a hypothetical scenario describing a policy that quantifies the environmental change to be achieved by 2030, and specifying a lump sum payment. Non-parametric estimate of mean WTP was found at 511,090 VND per household (22.03 USD) whereas parametric estimate of mean WTP derived from the log-logistic specification was found at 619,908 VND (26.73 USD) per household. Awareness of mangrove benefit and interest in conservation activities have

[*]MOISA,INRA, University of Montpellier, France

[†]University of Economics and Business, Vietnam National University, and Hanoi University of Natural Resources and Environment

[‡]MOISA,INRA, University of Montpellier, France, and IREEDS-VCREME, Hanoi

a positive impact on WTP responses, in addition to income. The findings will help policy-makers adopt sound environmental policies and advise locals on the importance of protecting the mangroves which in turn protect their livelihoods.
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JEL Classifications: Q51, Q57, 013

1 Introduction

While mangrove forests represent a small proportion of the world forests, researchers have placed them among the most important ecosystems on earth (Barbier and Sathirathai, 2004; Barbier, 2011). Mangroves typically grow in tidal coasts and act as a natural buffer zone against flooding, erosion (Prance and Tomlinson, 1987; Blanco et al., 2012). Mangroves also serve as nurseries in a vital food source for marine life while providing critical habitat for endangered species (Polidoro et al., 2010). The leaf litter of mangroves accumulates in the root where it forms a carbon reserve fifty times larger than that captured by a tropical forest (Cummings and Shah, 2018). However, the world's mangroves are found disappearing at an alarming rate, three to four times faster than land-based forests during the past 30 years due to flawed developmental activities (McNally et al., 2011). Since the mid 1900s, between 20% and 35% mangrove forests have been lost worldwide (Polidoro et al., 2010).

Around 34-42% of the world mangrove forests are located in Southeast Asia, the world's largest area of mangroves (Giesen et al., 2007). Vietnam is a tropical country with a coastline of 3,260 kilometers (Quang Tuan et al., 2017). 78% of mangroves are located in the Mekong Delta, the southern end of Vietnam and 28% of mangroves remain in the Red River Delta, in northern Vietnam (Tuan, 2016). The mangrove forests of Vietnam were reported to decline dramatically from around 400,000 hectares in 1943 to 157,500 hectares in 2005 (McNally et al., 2011). The main cause of mangrove degradation in Vietnam included the use of herbicides during the Vietnam wars from 1945 to 1975 and shrimp aquaculture, which boomed since the mid 80s (Beresnev and Broadhead, 2016; Ha et al., 2012; Lan, 2013).

The removal of mangrove ecosystems has had far-reaching economic, social and environmental impacts. Vietnam faces annual monsoon and heavy inland flooding (Francisco, 2008). As sea level rises due to climate change, the impact of the annual floods has increased over recent decades. Many regions have also suffered severe soil erosion. In Kien Giang Province, as well as the Mekong Delta, active and severe erosion was observed along 30 kilometres, i.e. 17% of the mainland coast, with a coastal retreat of around 25 metres per year at the examined site (McNally et al., 2011). Therefore, Vietnamese authorities with international assistance have implemented several major development projects to promote investment in coastal ecosystems for sustainable development and build resilience in coastal communities. These projects involved rehabilitating mangrove areas through the development of nurseries and planting activities. Special nature reserves were designed to protect the mangroves and wildlife. Furthermore, understanding the environmental and economic value of mangroves is crucial to preserving them. Environmental valuation is a tool used to estimate a marketable price for the quality of services natural ecosystems provided in the absence of a market (Champ et al., 2017). The main purpose of environmental valuation is to find best alternatives that can put the resources needed to maintain a good environment for human benefit.

Our study focuses on recognizing the values of ecosystem services in mangrove forests in Xuan Thuy National Park (XTNP) at the Ba Lat estuary, Nam Dinh province. This typical wetland is selected as the study site because of its international importance as habitat for several endangered bird species. This wetland also brings great economic worth to local community, posing trade-offs between short-term economic gains and long-term ecological, non-use benefits. Hence, a scientific assessment of the economic value of mangrove forests is critical to systematic resource management. The Contingent valuation Method (CVM) (Carson and Hanemann, 2005) is used to determine the economic value of mangrove forests and examine factors influencing willingness-to-pay (WTP) for the conservation of the mangroves and biodiversity in XTNP in the context of climate change. CVM has been used in a number of studies in Vietnam dealing with the water quality degradation in the Mekong Delta due to pesticide (Phuong and Gopalakrishnan, 2003), flood prevention program (Navrud et al., 2012), viral load testing among HIV-positive

patients (Nguyen et al., 2017), conservation of the northern yellow-cheeked gibbon in the Bach Ma National Park (An et al., 2018), etc. Only a few studies were interested in the economic valuation of mangrove ecosystem in this country. For instance, Tuan et al. (2014) used CVM with single bounded discrete choice (SBDC) question to show that the mean WTP per household was estimated at 146,700 VND per year for mangrove restoration of Thi Nai lagoon, Binh Dinh province. Factors significantly affecting household WTP were housing condition and attitude of locals toward future climate scenarios. However, WTP was not signicantly affected by most socioeconomic or subjective characteristics of the respondents. The lack of perception indicators of respondents regarding mangroves ecosystem could result in biased estimation of their WTP because mangroves play an essential role for local livelihoods. The study conducted by Pham et al. (2018) was the first one that explored the perceptions of respondents towards mangroves as significant predictors of their WTP for mangrove conservation in the Cat Ba Biosphere Reserve. Apart from socio-demographic indicators such as gender, education level, occupation, other explanatory variables influencing the WTP include respondents' volunteer experience in mangrove conservation activities and attitudes toward climate change impacts. The estimation using the single bounded CVM yielded a mean WTP of 192,780 VND per household.

Our study aims to contribute first to the literature on economic valuation of mangrove ecosystems by using double-bounded discrete choice (DBDC) question. Responses to a SBDC question only reveal if each respondent's WTP value is less than ("no" response) or greater than ("yes" response) the bid amount they received. In a DBDC question, respondents randomly receive an initial bid. If they answer "yes" to the initial bid amount, they receive a higher bid; if they answer "no," they receive a lower bid amount. The DBDC question is a repeated dichotomous choice where a response is required for every bid amount, which is essentially a payment card where respondents indicate their WTP each bid amount, not just the maximum they would pay. This alternative specification of dichotomous-choice questions was proposed to increase estimation efficiency by Hanemann et al. (1991). Compared to SBDC question, adding additional bid amounts in DBDC question reduces the range into which the unobserved values reside. To our knowledge, our study is the first one that relies on DBDC CVM to examine how socio-economic,

demographic and subjective characteristics of respondents influence their WTP for mangrove restoration in Vietnam.

The second paper contribution is to introduce questions about how respondents evaluate the causes of mangrove degradation and perceive the potential benefits occurring from its restoration. This second contribution is in line with the recent paper of Pham et al. (2018) which showed the importance of introducing perceptions of respondents towards mangroves when assessing significant predictors of WTP for mangrove restoration. Therefore, by proposing a more accurate assessment of WTP using DBDC questionnaire and introducing stakeholders' knowledge and interest as potential determinants of WTP, our paper aims to provide a more comprehensive understanding of WTP for mangrove restoration not only in XTNP, but also in Vietnam.

The paper is organized as follows. Section 2 introduces the background of the mangrove ecosystem of XTNP. Section 3 presents the methodology used in the paper. Section 4 summarizes the main features of data. Results are presented and discussed in section 5. Section 6 draws some conclusion.

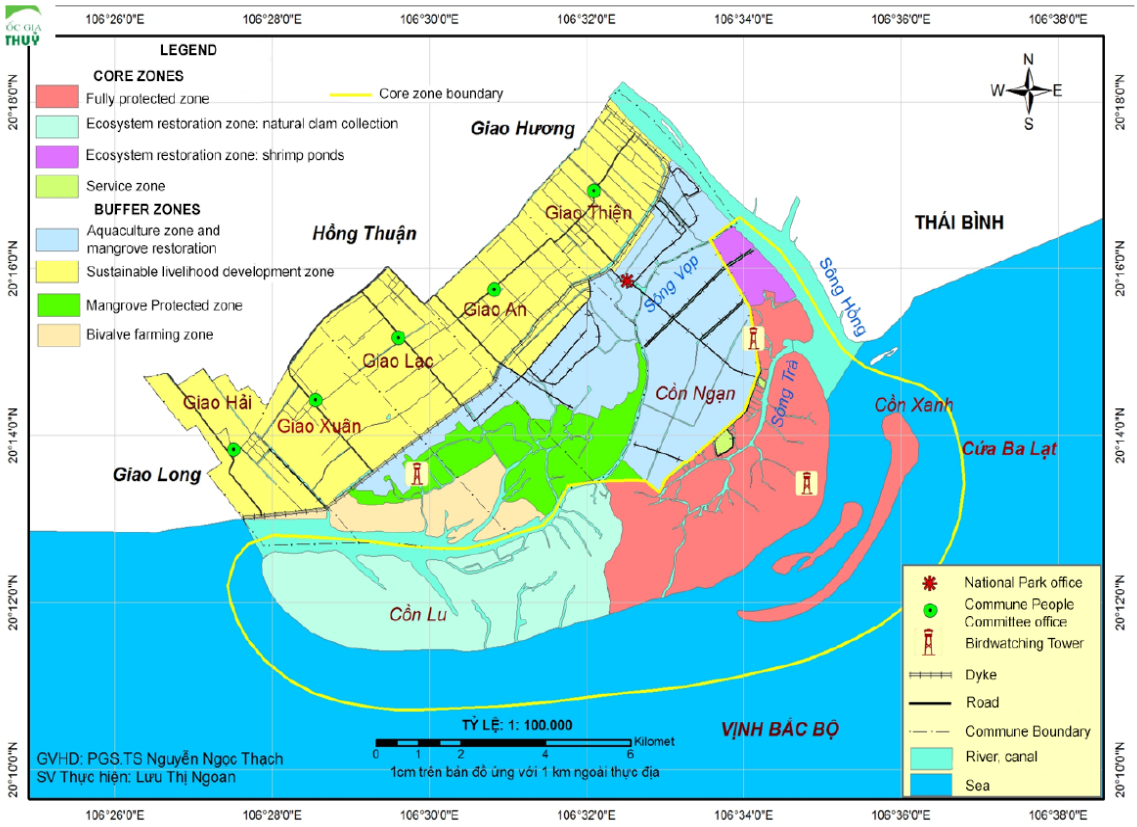
2 The mangrove ecosystem of Xuan Thuy National Park

XTNP, the first Ramsar site in South-East Asia approved by the Bureau of the Convention on Wetlands of International Importance, is located in Nam Dinh province, in Red River Delta, Northern Vietnam (Thanh and Yabar, 2015).[1] The park occupies 7,100 hectares of core zone which is strictly protected and 8,000 hectares of buffer zone where human activities are regulated to reduce adverse impacts on the core area (Pham Hong and Mai Sy, 2015). This study was conducted in 5 communes in the buffer zone: Giao Hai, Giao Xuan, Giao Lac, Giao An and Giao Thien (see Figure 1).

Today, XTNP is internationally-recognized as a migratory bird habitat, many of them are named in the Red List of Endangered species such as the Black-faced Spoonbill, Spotted Green-

[1]The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Figure 1
Map of Xuan Thuy National Park and survey sites in 2008
Source: Management Board of Xuan Thuy National Park (2014)



shank and Spoon-billed Sandpiper. Besides, the coastal wetland is protected by over 3000 hectares of mangroves and has over 500 aquatic species, 120 species of plant, and 10 mammal species (Leslie et al., 2018). This Ramsar site provides invaluable green economy services including food, eco-tourism, protection from floods and storms for 48,000 local inhabitants in the buffer zone (Thanh and Yabar, 2015).

Despite a high biodiversity, XTNP is under serious threat from the degradation of its mangrove forests. According to a report by Vietnam Netherlands Water Partnership On Water for Food and Ecosystem (2008), the period 1986- 1998 indicated a dramatic reduction in the area of the mangroves by nearly 70%, mainly due to intensive shrimp farming. The park officers face challenges to prevent illegal human activities such as bird trapping, fishing, cutting mangroves for wood in the core zone because the wetlands still play a major part in local livelihoods and income.

Moreover, the low-lying island has a highest elevation of about 0.5 and 0.9 m above sea level making thousands of locals extremely vulnerable to any storm that hits the coast, particularly in monsoon season (Nhuan et al., 2009). In addition, erosion is happening very rapidly here in which land is being lost up to 14.5m per year. Therefore, the implementation of economic instrument is necessary to value mangrove biodiversity of XTNP for effective management of this wetland.

3 Methodology

This section introduces the main features of the methodology used in this paper. The focus is first to put on questionnaire design and survey methodology. Then, we describe the estimation techniques used to assess the mean WTP and study its determinants.

3.1 Questionnaire design and survey methodology

Questionnaire design From a theoretical point of view, total economic value of an ecosystem service has two major components: use values and non-use values (Albani and Romano, 1998). There are consumptive uses from natural resources that humans can directly benefit from such as fish or water. There are also non-consumptive uses from these natural resources, for instance, recreation, the matter of knowing these resources are existing for ecosystem functioning, or available for future generations, etc. These non-consumptive uses cannot be transacted in marketplaces. Environmental economists find ways to measure the values that humans derive from these ecosystem services for project implementation purposes and policy development. The CVM is a widely used survey-based approach to place monetary values on environment goods and services not bought or sold in the marketplace (Carson, 2000). The goal of the CVM is to improve the the reliability of the estimate results of non-use values. The CVM builds a hypothetical market using a survey questionnaire to form a scenario that allows respondents to state their WTP in return for improved environmental quality (Aizaki et al., 2015).

To guarantee the applicability of the questionnaire in our study, focus group discussions were held with village heads of the five studied communes, and with XTNP's management board.

The scenarios for the mangrove rehabilitation project was also informed by baseline studies and expert's opinions about how we can improve the current situation.

This survey has three main sections. The first section of the questionnaire was designed to understand respondents' perception about mangrove ecosystem services, their perception of global climate change, and biodiversity protection. A major part of this section was to explain the biodiversity of XTNP and the threats to biodiversity. In doing so, respondents were provided with adequate information to decide their valuation on the basis of direct benefits and other non-use benefits that can be gained from the mangroves. Our enumerators therefore proposed the following scenario to survey residents. According to the Tran et al. (2016), a climate change scenario is forecast that by 2030, XTNP would experience a sea level rise of 20 cm and the mangroves would be severely affected. Our enumerators clearly stated the vulnerability of XTNP that were informed by research studies. Pictures of coastal erosion and biodiversity degradation were shown as an visual aid to help respondents understand how vulnerable XTNP would be to sea level rise in the coming decades. The scenario supposed a local project would be carried out from now to 2030 and require all locals to donate money for protecting mangroves and biodiversity in XTNP. Respondents were then asked the amount of cash they would be willing to contribute in a lump sum payment for the project.

In the second section, respondents were asked the elicitation questions that were the WTP questions. Based on the existing literature review, there are two formats to elicit individual preferences: (1) *open-ended* format : respondents are asked directly what their WTP is, no bid value being suggested ; (2) *close-ended* format: a bid value is proposed to respondents and they can choose whether or not to accept it. In order to determine optimal bid design, a pre-test survey with an open-ended format had been conducted with 20 households in the buffer zone prior to the main survey. In the pre-test survey, household members were invited by the management board of XTNP to take interview with our enumerators at the park office. This pre-test survey ensured that the lowest bid rate and the highest bid value used in the close-ended format of the formal survey were applicable and made economic sense. The results showed that the lowest bid value is 50,000 VND and the highest bid value is 2,000,000 VND.

Our study relied on DBDC contingent valuation methodology. Each respondent was required to answer "yes" or "no" to two sequential bid rates. A respondent accepted the initial bid rate would be proposed a corresponding higher bid rate. If the initial bid rate was refused, a lower bid rate would be proposed subsequently. Therefore, there are four possible responses: (Yes, Yes), (Yes, No), (No,Yes), (No, No) (Hadker et al., 1997; Tseng and Chen, 2008).

The questionnaire was designed so that the information respondents presented on willingness or unwillingness to pay was true and accurate as far as their knowledge was concerned. If people replied that they were willing to pay, then our enumerators recorded that. If this was no, there were follow-up questions to ask why respondents were unwilling to pay. This procedure made sure respondents understood the scenario presented to them and avoided the hypothetical bias that would affect the validity of the results. Reasons for refusing any payment for mangrove conservation included : a) the government should be responsible for conservation, b) the project cannot succeed in preserving biodiversity, c) the funds contributed by respondents might not be used for the right purpose, d) respondents have not made up their mind yet. It is worth noting that respondents with these answers would be removed from the valuation analysis (the protest bid).

Finally, information on demographic and social economic conditions of the survey site was collected for statistical purposes and used as explanatory variables in the regression analysis, in a third section. Enumerators asked respondents questions about their employment status, age, marital status, educational level, etc.

Survey method The survey was conducted in the five communes constituting the buffer zone, i.e. Giao Thien, Giao An, Giao Xuan, Giao Hai and Giao Lac in March and April 2017. In doing so, our study aims to provide an initiative for local engagement in biodiversity conservation. According to Giao Thuy District's Statistical Yearbook in 2015, there are total 12,972 households in the five surveyed communes. To determine a statistically visible sample size for the CVM in this study, the following formula was used to select the total number of surveyed households, or

n:

$$n = \frac{N}{1 + N * \varepsilon^2} \tag{1}$$

where N is a total number of households in the area, and ε is desired margin of error (Tuan et al., 2014). In this study, the error was fixed at 5%, and, consequently, the survey sample size at 350 households.

Multi-stage sampling was used to select villages and households. At the first stage, two villages were selected by random sampling from the list of villages in each commune. At the second stage, 350 households were surveyed by convenience sampling, i.e. surveying any household in each village without any prior notice given their proximity to enumerators. In the main survey, enumerators were sent to conduct face-to face interviews instead of phone or email survey.

3.2 Econometric modelling

Nonparametric estimation Non-parametric and parametric estimation methods were used to measure mean WTP for surveyed households. As WTP is not observable, non-parametric method allows the researcher to consider WTP as a random variable with a particular cumulative distribution function that defines the probability of the WTP being less than a certain threshold. This distribution can be estimated using Kaplan-Meier survival estimator as shown by Turnbull (1976). Then, the mean WTP for mangrove conservation can be seen as the probability of total number of households accepting bid values. The general formula is:

$$\text{Mean WTP} = \Sigma(t_j * f_j)$$

where t_j shows the different bid values and f_j is the change in density (Carson and Hanemann, 2005). In this method, the estimation results completely depend on the statistical characteristics of the observations.

The Kaplan-Meier-Turnbull estimator can be used to compare survival curves across values of a given covariate when this latter is discrete. Testing a difference between the estimated survival functions is then possible using statistical test. However, this test does not provide

strong evidence that the considered covariate influences survival because other factors may be correlated with both this covariate and with survival. Thus, the effects of the covariates cannot be modelled explicitly using this estimator.

Parametric estimation There are four potential outcomes per respondent in a DBDC questionnaire, as mentioned before: (Yes, Yes), (Yes, No), (No, Yes) and (Non, No). For each outcome, there is an interval at which WTP belongs. So,

$$\begin{cases} \text{(Yes, Yes)} & \text{indicates that} \quad WTP \geq b^U \\ \text{(Yes, No)} & \text{indicates that} \quad b \leq WTP < b^U \\ \text{(No, Yes)} & \text{indicates that} \quad b^L \leq WTP < b \\ \text{(No, No)} & \text{indicates that} \quad WTP < b^L \end{cases} \tag{2}$$

where b, b^L, and b^U are known values. In contrast to the SBDC model, which results in only one minimum or maximum value for each respondent's WTP, the DBDC methodology allows the construction of a bounded interval, or minimum or maximum bound, of each respondent's WTP, and is shown to improve the asymptotic efficiency of parameter estimates (Hanemann et al., 1991; Nayga et al., 2006).

From the knowledge of the b, b^L, and b^U values and the answer, it is then possible to build the following probabilities:

$$\begin{cases} P^{YY} & \equiv \text{Prob}[(Yes, Yes)] & = \text{Prob}[WTP \geq b^U] & = 1 - G(b^U) \\ P^{YN} & \equiv \text{Prob}[(Yes, No)] & = \text{Prob}[b \leq WTP < b^U] & = G(b^U) - G(b) \\ P^{NY} & \equiv \text{Prob}[(No, Yes)] & = \text{Prob}[b^L \leq WTP < b] & = G(b) - G(b^L) \\ P^{NN} & \equiv \text{Prob}[(No, No)] & = \text{Prob}[WTP \leq b^L] & = G(b^L) \end{cases} \tag{3}$$

where $G(.)$ is the cumulative distribution function of a known statistical distribution such as logistic, normal, or Weibull.

The format of Eq. (4) is used to display the WTP function:

$$\log WTP = X\beta + \varepsilon \tag{4}$$

where X is a vector of explanatory variables, including initial bid (in logarithm), β, a vector of parameters to be estimated, and ε, the error term.

For a sample of n independent observations, the log-likelihood can be expressed as follows

$$\ln L = \sum_{i=1}^{n} \left[d_i^{YY} P_i^{YY} + d_i^{YN} P_i^{YN} + d_i^{NY} P_i^{NY} + d_i^{NN} P_i^{NN} \right] \tag{5}$$

where d_i^{AA} indicates whether respondent i answered (A, A) with $A = Y, N$ (dichotomous variable). Estimates of parameters β can be recovered by maximizing the log-likelihood given in Eq. (5).

4 Data

4.1 Individual characteristics

Table 1 shows the socio-demographic characteristics of the respondents. In this study size, the number of female participants (52.3% of the 350 respondents) is slightly greater than the number of males, reflecting gender balance in the survey. The respondents aged over 45 account for almost 60% of the total sample, dominating the age distribution of respondents in the sample. This indicates that while younger generations are leaving villages for work, the middle-aged and elderly (over 45) tend to work in the villages. Married individuals make up 92.8 percent of the sample. Most respondents in the survey (94.5%) reported that they were born in Giao Thuy District. The survey indicates a sample with a low education level, given that 92% of the respondents could complete high school. In this study, there are four main categories of jobs: farmers working in the aquaculture or agriculture sector, business owners, and hired employees at public or private sectors. These main labor force groups account for 89.5% of the total sample.

The remaining sample consists of students, retirees, housewife, and unemployed. Over one-third of the respondents (38%) has a monthly household income of lower than 3 million VND (about 129 USD), followed by 28.8% receiving between 3 and 6 million VND (about 129-258 USD), and 22.7% in the range between 6 and 10 million VND (about 258–430 US$). And only 10.5 % of respondents has a monthly income of over 10 million VND (about 430 USD). Furthermore, the majority of respondents (81.3%) said that their household's income partially or totally depent on the mangrove ecosystem. Average household size in the sample is about 3.71 and can represent normal family size in Nam Dinh Province. The largest household has 10 people and the smallest household has 1 person. Finally, less than one-third (28.5%) had their field of career or study very related to environment and biology and more than one-half (53%) showed strong interest in environmental conservation activities.

4.2 Local awareness about mangrove restoration in XTNP

Table 2 shows respondents' perceived benefits for local communities from mangrove ecosystems. Over 60% of respondents believed that the mangroves in XT help mitigating flooding, storms and soil erosion. The results also indicate that a major number of the respondents have realized the vital roles of mangrove ecosystems in their livelihood, including a necessary supply of aquatic products, raw material for production and consumption. Table 3 displays the local perception of mangrove degradation. Human activities such as aquaculture, fishery, etc. (40%) were perceived to be the major threat to mangrove forests. Table 4 shows reasons for protection in Ba Lat estuary. First, respondents were given clear demonstration of how the mangroves in Ba Lat estuary has changed from time to time and were provided with various scenarios of the mangroves in the context of climate change . Respondents were asked to rate the importance of reasons to protect the mangroves, on a scale from 1 to 5, with "1 = Not at all important", "2 = Not so important", "3= Neutral" , 4= important", and "5= very important". Respondents were also left with the choice of not being able to evaluate. These results suggest the two most important reasons are preventing the coastlines against floods, erosion, salinization and providing benefits for future uses. Conserving biodiversity is the third most important reason for mangrove rehabilitation.

Table 1
Socio-demographic characteristics of the respondents

	Category	Frequency	Percentage
Gender	Female	183	52.3
	Male	167	47.7
Age	18-25	29	8.382
	26-35	54	15.6
	36-45	57	16.5
	46-55	76	22
	>= 56	130	37.6
Marital Status	Married	324	92.8
	Single	25	7.2
Born in Giao Thuy district	Yes	328	94.5
	No	19	5.4
Education	Below high-school	320	91.9
	High-school or above	28	8.1
Career	Farmer/Fisherman	224	64.5
	Business owner/Self-employed	27	7.7
	Public sector employee	16	4.6
	Private sector employee	44	12.6
	Students	7	2
	Retired/Housewife	27	7.8
	Unemployed	2	0.6
Household Size	1	21	6.1
	2	63	18.3
	3	65	18.8
	4	90	26.1
	5	73	21.1
	6	26	7.6
	7	4	1.2
	9	2	0.6
	10	1	0.3
Monthly Income of household (million VND)	Low income (Up to 3)	132	38
	Lower middle (Between 3 and 6)	100	28.8
	Upper middle (Between 6 and 10)	79	22.7
	High income (Over 10)	34	10.5
Environmental work	Not at all	181	52.1
	Slightly related	67	19.3
	Very related	99	28.5
Passion for environmental protection	No	30	8.6
	Like a little	133	38.3
	Like a lot	184	53
Mangrove dependency	Yes	65	18.7
	No	282	81.3

Table 2
Perceived benefits from mangrove forests

Benefits from mangrove forest	Percentage
Aquatic products, raw material for production and consumption	42.6
Recreation, tourism	7.1
Prevention of storms, floods, tides, and coastal erosion	61.1
Underground water protection, preventing salinization	7.4
Climate regulation, carbon dioxide absorption	17.7
Preserving silt, sea encroachment	11.7
Habitat for fish and animals	22.6
Biodiversity	10
Cultural values	0.9
Other	10
Do not know	16

Table 3
Perceived causes of mangrove degradation

Reasons	Percentage
Human activities: aquaculture, fishery, etc.	40.9
Pollution	13.40
Climate change	18.60
Other	5.70
Do not know	2.00

4.3 Bid responses

The interviewers randomly selected 350 respondents. Answers from 226 respondents were used in estimating WTP after excluding protested zero-bids: 70 respondents who were not willing to pay to protect mangroves, and 54 who answered they were not sure. Table 5 gives the main reasons for respondents' being willing or unwilling to pay. The most important reason for WTP for mangrove restoration is that mangrove restoration is a good program for their own benefit (70.4%). About 57.5% of the respondents believed that their contributions now would bring benefit for future generation. On the other hand, the main reason for not being willing to pay for the restoration of mangroves was household income constraints, accounting for 37.9% of the negative responses; followed by the statement that the project is likely to fail (11.3%). 9.3 %

Table 4
Perceived motives for mangrove conservation

Reasons	Not at all important	Not so important	Neutral	Important	Very important	Can not evaluate
Providing wood, fish and raw materials	8.3	11.1	20.6	46.9	10	3.1
Providing recreation	4	12.3	20.3	52	10	1.4
Preventing floods, erosion, salinization	0	0	2.6	15.4	81.4	0.6
Conserving biodiversity	3.1	10.3	14.6	58.6	11.4	2
Benefits for future uses	2.3	6.6	9.7	52.4	28.4	0.6

of the respondents did not agree to pay because they thought that only those who had direct benefit from the program should finance. About 29.8% of respondents provided other answers not listed in the questionnaire such as the need for more information, depending on other people's contributions, etc.

Table 6 shows how bid rates were presented to respondents. For each respondent, the interviewer made a random selection of A, B, C or D options. If the respondent did not accept the first bid rate in column 2, the interview was followed up with a proposal of smaller bid rate (initial bid divided by two) as shown in column 3. If the first bid rate was accepted, the second bid rate was doubled, as shown in column 4.

Table 5
Reasons for being willing to pay and for not being willing to pay.

Reasons	Percent
Respondent's reasons for being willing to pay	
The program is good for my own sake	70.4
The program is good for the next generation	57.5
The program is necessary for preserving culture, beliefs	5.8
The program is good for the whole society	34.1
Others	9.7
Respondent's reasons for not being willing to pay	
My family has no money to contribute	37.9
The biodiversity in this area does not mean much to my family	4.8
I am afraid my family contribution shall not be used properly	6.5
I do not believe in the success of the project	11.3
Biodiversity conservation is the sole responsibility of the local authority	0.8
It is the beneficiary who should finance	9.7
Others	29.8

Table 6
Bid options proposed to respondents.

Options	Initial bid or b	Lower bid or b^L	Upper bid or b^U
A	100,000	50,000	200,000
B	300,000	150,000	600,000
C	500,000	250,000	1,000,000
D	1,000,000	500,000	2,000,000

Table 7 displays the distribution of the answers of respondents in (Yes, Yes), (Yes, No), (No, Yes), and (No, No) for each bid option, and for all options without distinction between them. No clear pattern appears when reading this table except that, when the initial bid rate increases, the percentage of respondents accepting both the first and second bid rates decline from 44.3% to 11.1% , and, conversely, the percentage of respondents refusing both the first and second bid rates increase from 18% to 44.4%.

Table 7
Distribution of responses by bid option

Bid options	Yes-Yes	Yes- No	No- Yes	No- No
A: (100.000; 50.000 ; 200.000)	44.3% (27)	29.5% (18)	8.2% (5)	18.0% (11)
B: (300.000; 150.000 ; 600.000)	26.9% (14)	36.5% (19)	13.5% (7)	23.1% (12)
C: (500.000; 250.000 ; 1.000.000)	19.0% (12)	30.2% (19)	15.9% (10)	34.9% (22)
D: (1.000.000; 500.000 ; 2.000.000)	11.1% (7)	28.6% (18)	15.9% (10)	44.4% (28)
All options combined	25.1% (60)	31.0% (74)	13.4% (32)	30.5% (73)

[*Note*: Frequency counts are in parentheses.]

5 Results

5.1 Non-parametric estimation

The Kaplan-Meier Turnbull nonparametric approach was used to estimate the proportion of respondents willing to pay falling into the intervals defined by the different monetary thresholds (Turnbull, 1976). The change in density occurring in each interval was used to determine the lower bound estimate for the mean of WTP by multiplying the density estimated to be in each interval and the lower endpoint of the interval. Table 8 shows then that about 13.1 % of the respondents fall into the interval 0 to 50,000 VND, and about 7.4 % were willing to pay over 2,000,000 VND, and that the median falls into the interval 300,000-500,000 VND. The nonparametric estimate of mean WTP is 511,090 VND (22 USD) per household. As emphasized by Carson and Hanemann (2005), this value provides a lower-bound to mean WTP for mangrove preservation in XTNP.

5.2 Parametric estimation

The empirical interval regression model based on Eq. (4) is as follows:

$$\begin{aligned} \ln \text{WTP} = \quad & f(\text{Initial Bid, Gender, Age, Household size, Education,} \\ & \text{Income, Knowledge, Passion}) + \varepsilon \end{aligned} \tag{6}$$

Table 8
Turnbull estimation results

Lower bound (t_j)	Upper bound	Probability of being greater than upper bound	Change in density (f_j)	Mean WTP
0	50,000	0.869	0.131	0
50,000	100,000	0.81	0.059	2950
100,000	150000	0.745	0.065	6500
150000	200,000	0.596	0.149	22350
200,000	250000	0.596	0	0
250000	300,000	0.596	0	0
300,000	500,000	0.476	0.12	36000
500,000	600,000	0.263	0.213	106500
600,000	1,000,000	0.263	0	0
1,000,000	2,000,000	0.074	0.189	189000
2,000,000	∞	0	0.074	148000

where $\ln$ WTP is the WTP for mangrove preservation (in logarithm). The definitions for all explanatory variables used in Eq. (6) are presented in Table 1. Results of estimation by maximum likelihood of the corresponding model with different assumptions about the cumuluative distribution function $G(.)$ are reported in Table 10.

We first tested if the introduction of the individual characteristics in addition to initial bid, was statistically meaningful. We performed a likelihood ratio test comparing the estimated model with a model where the values of the parameters associated to individual characteristics were all fixed to zero. The p-value for log-logistic (0.014), log-normal (0.009), and Weibull (0.003) clearly indicate the rejection of the null hypothesis that all the latter parameters are equal to zero.

Although the estimated coefficient of an independent variable does not directly measure the marginal effect of that variable on WTP, the sign of the estimated coefficient does indicate the direction of the effect, as emphasized by Knapp et al. (2018). The estimation results were found to be highly consistent in three model specifications. Table 10 indicates that the signs and significance of the parameters in the three specifications are relatively similar. As expected, we found a significant negative impact of the initial bid on WTP. This result corroborates the observation

Table 9
Description of variables.

	Variable	Description	Value
1	Probability	The probability of a respondent being willing to pay for mangrove forest restoration	1 =Yes WTP 0 = No WTP
2	Bid	Bid levels (thousand VND) [a]	Option A (100; 200; 50) Option B (300; 600; 150) Option C (500; 1,000; 250) Option D (1,000; 2,000; 500)
3	Age	Age of respondent	Numeric variables
4	Gender	Gender of respondent	1 = Male 0 = Female
5	Education	If respondents were educated to high-school level or above	1 = High-school or above 0 = Otherwise
6	Hhsize	Number of members of each households	Numeric variables
7	Knowledge	Respondent has knowledge about benefits of mangroves	1 = Yes 0 = No
8	Passion	Respondent is interested in activities for environmental conservation	1 = Yes 0 = No
9	Income	Total household income per month (million VND)	1 = Up to 3 2 = Between 3 and 6 3 = Between 6 and 10 4 = Between 10 and 15 5 = Over 15

[a] 1 USD is equivalent to 22,300 VND.

made when reading Table 7. Characteristics of respondents such as gender, age, household size and education did not appear to have an impact on WTP. Only respondents belonging to upper middle and higher income classes seemed ready to pay for mangrove restoration.

The results reveal two additional important facts. First, the passion of respondents for environmental protection activities was found to have a positive impact on respondent WTP for mangrove restoration, implying that the interest in improving climate scenarios led to a respondent being willing to pay more. This finding is consistent with Pham et al. (2018) that volunteer experience in conservation activities has a positive influence in explaining WTP for mangrove rehabilitation project. Second, the respondent's knowledge about the benefits of mangroves allowed respondents to better appreciate mangroves, modifying Pham et al. (2018) the perceptional determinants of WTP for mangrove restoration.

The results of the interval regression estimation provide estimates of the mean and median values of WTP as by-products. Table 11 reports the estimated values of truncated mean, adjusted truncated mean, and median WTP for the three specifications.[2] Confidence intervals can then be computed using nonparametric bootstrap technique.[3] For instance, maximizing the likelihood function under the assumption of a log-logistic distribution results in estimates of 619,908 VND (26.63 USD) for the truncated mean WTP, 639,967 VND (27.49 USD) for the adjusted truncated mean, and 358,559 VND (15.41 USD) or the median WTP. Here, the estimation results were also found to be highly consistent for the three specifications. Estimated confidence intervals for each of the three measures: truncated mean, adjusted truncated mean, and median, overlap. The total non-use value from the restoration of the mangrove ecosystem in Ba Ria estuary can then be calculated by multiplying mean WTP per household (619,908 VND) by the total number of households (10,465) living in the in Ba Ria estuary in 2015. Table 11 displays the computed

[2]Details about the computation of these estimates are given in Aizaki et al. (2015). Truncated (at maximum bid) mean estimates are computed to avoid (i) having infinite value when the estimated value of initial bid parameter is lower than one, or (ii) getting some portion of the respondents who have an estimated WTP greater than their income. The adjusted truncated mean makes use of the normalization proposed by Boyle et al. (1988). This normalization allows to set the value of the cumulative distribution function of WTP as soon as WTP is greater than the maximum bid, to one.

[3]The bootstrap method resamples the data at our hands and repeatedly estimates the model with the bootstrapped data to formulate an empirical distribution of the associated WTP. See Hole (2007) for more details. The number of bootstrap replications can be chosen following Davidson and MacKinnon (2000).

results for mean WTP, their confidence intervals and total non-use value of mangroves across the three models. In the log-logistic specification, the total non-use value was estimated at approximately 6.487 billion VND which is equivalent to about 277,100 USD per year.

Table 10
Maximum likelihood results

Variable	Log logit	Log normal	Weibull
Constant	14.913(1.489)***	8.919(0.835)***	10.867(1.005)***
Log(bid)	-1.237(0.101)***	-0.74(0.056)***	-0.868(0.069)***
Gender	-0.103(0.279)	-0.114(0.163)	-0.048(0.169)
Age	-0.005(0.01)	-0.003(0.006)	-0.003(0.006)
Household size	-0.053(0.096)	-0.032(0.057)	-0.02(0.056)
Education	0.279(0.433)	0.134(0.256)	0.145(0.288)
Income: Lower middle	0.205(0.348)	0.139(0.204)	0.191(0.218)
Income: Upper middle	0.528(0.375)	0.365(0.221)*	0.333(0.228)
Income: High	0.794(0.476)*	0.481(0.276)*	0.568(0.305)*
Knowledge	0.677(0.383)*	0.385(0.227)*	0.44(0.229)*
Passion	0.812(0.277)***	0.508(0.163)***	0.555(0.17)***
Observations	227	227	227
Log likelihood	-306.067	-305.199	-300.864
LR test statistics (p-value)	0.014	0.009	0.003

[*Note:* Standard errors are in parentheses, and *: p<0.1; **: p<0.05; ***: p<0.01.]

Compared with other mangrove valuation studies in Vietnam, our non-parametric and parametric estimates of mean WTP per household (511,090 VND and 619,908 VND, respectively) are much higher than those of Tuan et al. (2014) (131,670 VND and 146,700 VND, respectively) and Pham et al. (2018) (only parametric mean WTP was reported at 192,780 VND). The discrepancy could be mainly attributed to the lump sum payment for each household in our hypothetical scenario whereas the annual payment per household was requested in other studies.

Table 11
Mean WTP

	Log logit	Log normal	Weibull
Truncated Mean WTP	619,908.457[a]	607,333.742	592,294.639
	[506,422; 701,113][b]	[515,877; 689,005]	[497,088; 675,590]
	6,487,342,003[c]	6,355,747,610	6,198,363,397
Adjusted truncated Mean WTP	693,966.997	672,705.172	628,172.846
	[547,087; 803,778]	[553,183; 794,871]	[517,606; 741,085]
	7,262,364,624	7,039,859,625	6,573,828,833
Median WTP	358,559.672	346,233.245	391,307.789
	[274,635; 444,357]	[274,715; 429,994]	[308,592; 476,886]
	3,752,326,967	3,623,330,909	4,095,036,012

[a] Computed mean WTP in VND.
[b] 95% confidence intervals are computed with 299 bootstrap replications.
[c] Computed total non-use value of mangroves in VND

The DBDC format in our CVM survey is also noteworthy, producing a better data set and more precise results of WTP estimates. Furthermore, the environmental context of XTNP with more endangered bird species, higher biodiversity values and greater threats of climate change possibly resulted in an increase in yes responses, raising the demand for mangroves forest rehabilitation.

6 Conclusion

This research is motivated by the idea that mangrove ecosystem restoration can generate a variety of benefits to human such as carbon sequestration, erosion control, water purification, flood prevention, wildlife habitat, etc. However, many of these benefits are not valued by markets. In addition, mangroves are one of the most threatened ecosystems in Vietnam, and yet there exists few quantitative information on the value of mangroves in Vietnam. This paper used CVM with DBDC questionnaire, to assess the economic value of mangroves at XTNP in the context of

climate change. Specifically, it explored the determinants of WTP for improved management of mangroves. Mean WTP was first estimated using either nonparametric or parametric methods. The parametric model gave an estimate of 619,908 VND per household, while the non-parametric model produced a lower bound for mean WTP of 511,090 VND per household. These results suggest that the total non-use value of mangrove in XTNP is estimated at 6.5 billion VND, with a lower bound of 5.3 billion VND. Second, factors affecting people's WTP were found to be income, perception of mangrove benefits and concern for the environment. People with high income, having good understanding of the mangrove benefits or showing strong interest in environmental conservation activities would likely to pay more. The findings provide decision-makers with the true cost of converting mangroves to short-term profitable alternatives, while taking into account indirect economic, ecological and social benefits of mangroves. The study also sets out important policy guidelines including strengthening the role of the mangroves via mass media, especially newspapers and television to raise public awareness of mangrove value. In addition, locals should be given environmental training programs that encourage them to adopt sustainable behaviors and engage their interests in conservation activities.

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Appendix

This session provides a sample of questions on WTP developed as part of the household questionnaire survey.

Future climate scenario

Climate change is a major challenge for coastal areas in Vietnam. According to the future climate change scenario that the Ministry of Natural Resources and Environment released in 2016, the average temperature in Ba Lat estuary would increase by about 0.6°C by 2030 compared to the period of 1986-2005. Meanwhile, maximum rainfall per day would increase from 20 to 30 ml and sea level would likely rise by an additional 20 cm in Ba Lat estuary. Climate change and sea rise could result in a large area of the mangrove degraded, which in turn lead to severe losses of biodiversity. According to the board of directors at XTNP , if appropriate preservation measures are not taken, biodiversity value of the park would be declined by about 5% each year in comparison to the present.

Supposed a project is conducted from now to 2030 to implement new measures for planting, protection of the mangroves, protecting birds and biodiversity in the mangrove forest. This project would raise awareness and capacity of the locals on planting, mangrove rehabilitation as well as provide training courses, seminars on the mangroves. It is noted that the project would help develop alternative livelihoods for the locals and encourage communities to actively participate in the conservation. The exploitation of natural resources for fisheries would be reduced and replaced by eco-tourism services, hence offering new opportunities for economic development as well as conservation of natural biodiversity resources. Local authorities would play a role in mobilizing financial resources necessary to fund the project. If this project is supported by the majority of the locals, all households living in 5 communes including Giao Thien, Giao An, Giao Lac, Giao Xuan and Giao Hai would make a lump sum payment to the Fund for Biodiversity Conservation (Fauna and Flora) of the Mangroves in Ba Lat estuary.

1. Please tell us, are you ready to make a financial contribution to the Fund for the Conser-

vation of Fauna and Flora Diversity of the mangroves in Ba Lat estuary?

☐ Yes ☐ No ☐ Not sure

2. (If YES) Please tell us the reason

   ☐ For my own sake

   ☐ For the next generation

   ☐ Preservation of culture, religion

   ☐ For the benefit of society

   ☐ Other (please specify) .....

   → Go to question 4

3. (If NO or NOT SURE) Please tell us the reason

   ☐ My family has no money to contribute

   ☐ The diversity of species in this area does not mean much to my family

   ☐ I am afraid my household contribution shall not be used properly

   ☐ I do not believe in the success of the project

   ☐ Biodiversity conservation is the sole responsibility of the local government

   ☐ The person who is beneficiary should finance

   ☐ Other (Please specify) .....

   → Go to question 7

Applicability of the WTP

We know that this is just a survey for research purposes, so your WTP answers may not reflect the real payment. In surveys, people sometimes response that they are willing to pay a larger amount than they will actually do. For example, 70% of respondents say they are willing to pay the money. Nevertheless, when the project is actually implemented, only 50% of the households contribute to the fund. Therefore, we would

like you to answer as if this is a real payment, i.e. imagine that you are required to contribute to the funds for implementing the project on request of local authorities and most people agree to make financial contributions.

4. Are you willing to pay <**first bid**> to implement the project?

   ☐ Yes ☐ No → go to question 6 ☐ Not sure → go to question 6

5. (If YES) If your contribution is <**second higher bid**>, would you be willing to pay the amount for the implementation of the project?

   ☐ Yes → go to question 9 ☐ No → go to question 7 ☐ Not sure → go to question 8

6. (If NO or NOT SURE) If the contribution is <**second lower bid**>, would you be willing to pay the amount for the implementation of the project?

   ☐ Yes → go to question 9 ☐ No → go to question 7 ☐ Not sure → go to question 8

7. Please tell me the reason you are not willing to contribute this sum

   ☐ It is not necessary to contribute so much money

   ☐ The biodiversity in this area does not mean much to my family

   ☐ I do not believe in the success of the project

   ☐ I must spend money on more important things

   ☐ My household does not have enough money to contribute this much

   ☐ Other (please specify) .....

8. Could you please show the reason that you are not willing to contribute this sum? (*the interviewer should not give a clue*)

   ☐ I must discuss with other family members / I have no right to decide

   ☐ I wait to see whether others contribute or not

☐ Other (please specify) .....

9. Assuming that the project is not implemented, how will biodiversity be affected in the mangroves in Ba Lat estuary by 2030?

   ☐ Very much

   ☐ Much

   ☐ Average

   ☐ Little

   ☐ Not affected

   ☐ Do not know

10. When the project is implemented, how better will the biodiversity of the mangroves in Ba Lat estuary than that when the project is absent?

    ☐ Very much

    ☐ Much

    ☐ Average

    ☐ Little

    ☐ Not different

    ☐ Do not know