Use of Renewable Resources and Sustainable Livelihood in Indian Sunderbans: An Attempt through Contingent Valuation Method

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Abstract

The people in the Sunderbans regions of West Bengal are mostly dependent on extraction of renewable resources like fishery and forestry to maintain their livelihood in a sustained manner. The degree of dependency, the awareness about sustainability of renewable resources and the knowledge base for sustainable livelihood can best be examined if we conduct a valuation exercise to conserve the two main renewable resources of this region. The Contingent Valuation Method (CVM) has been applied for both forestry and fishery in the Indian Sunderbans. It has been found that the willingness to pay (WTP) for conserving fishery in the Sunderbans is higher than forestryas fishery is the primary occupation in that area.In fact the WTP for conserving forestry is also reasonably high. It reflects that the people of the Sunderbans are quite aware about conservation of forest resources from the point of view of long run benefit for both fishery and forestry as their livelihood are associated with these two occupations.

Keywords: *Sustainability, Fishery, Forestry, Contingent Valuation Method, Willingness to Pay*

JEL Classification: *Q20, Q22, Q23*

1. Introduction

West Bengal is one of the very few states in India that has every type of climate-zones. Sunderban is blessed with mangrove forestry as well as ample amount of fishery due to abundance of these resources in this region. The Sundarbans is an intricate web of tidal waterways, seawater, rivers, creeks and mudflats, formed by the gradual deposition of alluvial silt, at the merger of the Ganga and Brahmaputra and Meghna rivers in the Bay of Bengal (Roy Chowdhury and Vyas, 2007). The Sundarbans, has been named after the *sundari* (*Heritierafomes)* and the *bani* (*Avicenniaofficinalis*) mangroves. Itis a unique ecosystem—the largest delta and estuarine mangrove forest in India, and a habitat of the Royal Bengal Tiger.

The Sundarbans have a total area of around 10,000 sq. km of which the area of Indian Sundarban region is about 4,263 sq. km (WBFD 2003) and the rest is in Bangladesh. The Indian part of Sundarban is divided into: (i) Sundarban Tiger Reserve (STR) covering an area of 2600 sq. km. and (ii) Reserve Forest Area covering an area of 1600 sq. km (WBFD 2003). The Indian Sunderbans is situated in the north-east coast of India (Latitude 21° 32.-22° 40.N, Longitude 88° 22'- 89°0.E). The Indian component constitutes of 106 islands, of which 56 are inhabited, located in 13 blocks in South 24

Parganas District and six blocks in North 24 Parganas District, with a population of more than 4 million. All these islands are separated from each other by a network of tidal channels or small rivers (known as '*khari*' in Bengali). The main occupational groups in the Sundarbans are fishers, the *bowalis* (wood cutters*/golpatta*collectors), and the crab and shell collectors (UNDP 2002). Fishing is one of the primary sources of livelihood of the local, forest-dwelling population, as few people have access to agricultural land. Sunderbans National Park has been the largest mangrove swamp in the world. This evergreen land of mangroves has been awarded as a "UNESCO World Heritage Site". The National Park of Sunderbanis surrounded by a buffer zone of 885 square kilometers. This also mainly consists of mangrove forests. The core area of the park has its own natural boundaries with the river Matla on its West, the river Haribhanga on its East, with Netidhopani and Gosba in the North.Sunderbans has been the nursery for almost 90% of the aquatic species of eastern coast of India. Jhingran (1977) recorded a total of 172 species from a variety of sources and also mentioned that the diversity of the Hooghly-Matlah estuary increases along an increasing salinity gradient. Apart from fish species, there are 20 identified species of Prawns and 44 species of crabs including two edible ones. Government of West Bengal has also been helping the fishermen of Sunderban with various infrastructural facilities, for example, five fishing harbor has been built in Frazerganj, Diamond Harbour, Kakdwip, Sagar and PatharPratima. All these have generated more than 50,000 employment opportunities.

The mangrove forest of Sundarban is valuable because of its rich biodiversity, which are commercially exploited particularly, the Non Timber Forest Produce (NTFPs), which is one of the epitomes for the livelihoods of many forest fringe dwellers (Bhattacharya and Hayat, 2004). The NTFPs collected from mangrove forest of Sundarban includes tannin bark; Nypafruticans (Golpata), natural honey and bee wax; fuelwood and small poles. Participatory Forest Management system has been in operation for the management of Sundarbans. Forest Protection Committees (FPC) and Eco Development Committees (EDC) have been formed in the fringe areas of Sundarban to protect a sizeable portion of mangrove forest. Every forest visitors need to take the permission of the existing committees before going into the forest and collecting any type of NTFPs. The above discussion, so far, makes it clear why people of Sunderban depend on fishery and forestry for their livelihoods.

If we select a subset of the vast literature on forestry and environment at the international level we find that authors like Angelson and Wunder (2003) have searched the reasons for the poor economic condition of forest dependent people. Cavendish (2000) has tried to link CPR with sustainable livelihood. At the national level the important works regarding common property rights (CPR), poverty and forest degradation are by Jodha(1986), Reddy and Chakravarty(1999), Adhikary(2005) etc. Major works on mangrove-fishery linkages at the international level are by Ruitenbeek (1994), Grasso (1998), Gupta (2005) etc. Most of these works focus on the benefits and costs associated

with mangroves. In the context of the literature on participatory management of forestry we find that there are two major works that are frequently cited in the literature at the international level. These are the works of Adhikary (2002) and Olson (1971). West Bengal is the pioneer in the concept of Joint Forest Management (JFM). It was formally introduced in India through a resolution in 1990 to address the problems and constraints of government management of forests. This has been mentioned in details in the work of Saxena (1999). The other form of participatory forest management is Community Forest Management (CFM). For the state of West Bengal one can refer to the works of Malhotra and Deb (1992), Guha, Pradhan and Mandal (2000) etc to have an idea about the position of JFM/CFM in the southern part of the state.

In spite of the existence of vast literature on forestry; participatory forest management and fisheries at the international level and also at the national level, specific works on the Sunderban of West Bengal are relatively few, regarding the valuation of resources. This lacuna in the literature on economic analysis of dependency on natural resources in the areas of Sunderbans has been the biggest motivation behind this work. It naturally becomes very interesting to see how the people, who earn their livelihoods from these natural resources have been valuing these resources and how far they are able to make a contribution for protection as well as further improvement of these resources. This work tries to find out an analysis of such resource extraction in the form of a comparative analysis between two natural resources: forestry and fishery for the Sunderban area of West Bengal. Such an attempt has never been made before.

The remaining part of the present paper is organized in the following manner. Section 2 deals with the objectives and hypotheses of the study. In the next section, that is, Section 3 considers the data base and survey design of the study. Methodology, econometric specification and the results of the study are shown in section 4. Finally the concluding remarks are made in section 5.

2. Objectives and the Hypotheses of the Study

The major objectives of the present paper can be summarized as follows:

1. To see how the people of the Sunderbans are valuing the major natural renewable resources on which they are mainly dependent for their survival.
2. To examine the determinants of willingness to pay (WTP) for conservation along with proper use of natural renewable resources in the Sunderban area of West Bengal
3. To link the valuation analysis with that of sustainable livelihood of the stakeholders in the study region.

To achieve these objectives, the following hypotheses have been considered in the present study

1. The bids of the respondents regarding WTP in case of ‘single-bounded dichotomous choice closed-ended referendum’ has been considered in terms of dice throwing.
2. Conservation and use of renewable natural resources in our study region implies

overall conservation of renewable resources in the backward areas not only as a 'use value' but also as a 'non-use value'.

3. Estimation of WTP can be considered both in terms of a logit model (with single-bound closed ended referendum for choosing the bids) and OLS method (with open ended referendum). So two WTPs for two different methods are to be estimated.
4. Estimation of WTP depends mostly on socio-economic variables and also on various dummy variables.

3. Data Base and Survey Design

The study is confined to collection of primary data forthe rainfed areas of the coastal zone of the stateof West Bengal, that is, Sunderbans which is backward in nature as well.For our field survey in Sunderbans, we have considered that the main source of livelihood is fishery and next comes forestry.

For the collection of primary data, we have followed partly stratified and partly random sampling techniques. For the selection of blocks or villages we have followed stratified sampling. The stratification is done in a manner so that we have blocks of South 24 Parganas district where the stakeholders are dependent on fishery or forestry or both. First, to conduct the study on valuation of forestry we have selected the blocks on the basis of their dependency on forests. Then we have selected villages in the forest-fringe areas of the blocks. We have selected two villages like Jhorkhali 4 (of Basanti block) and Pakhirala (of Gosaba block) for our purpose on the basis of consultation with the local Panchayat members of the two blocks. We have also stratified the sections of the villages for our survey on the basis of dependency on forests in terms of consultation with the Panchayat members. Then we have selected 150 families each from the two villages so that the total size of the sample for conducting our study for valuation of forestry becomes 300. Second, we have focused on valuation of fishery. It is to be noted that people in the same family of the Indian Sunderbans people are dependent not only on forestry but also on fishery. In fact, the villages that we have considered for forestry are such examples. In fact, for the Sunderbans as a whole fishery is the primary occupation. Actually there are some blocks in this region where majority of the people are dependent on fishery. Namkhana is such a block. So for valuation of fishery we have considered the same sample for the blocks of Gosaba (150 families from village Jhorkhali) and Basanti (150 families from village Jhorkhali) and 300 more families from Namkhanablock (consisting of 100 families from Bijoybati village, 50 villages from Amarabati(east) village, 50 families from Amarabati(west) village and 100 families Budkhali village). The villages in Namkhana block again are selected on the basis of discussion with the Panchayat members and also the stratification within a village is done on the basis of consultation with them. The families from each village are selected randomly. So for fishery we have all total sample size of 600. We have also considered this sample for our socio-economic study.

In the Sunderbans we have selected three blocks for survey, namely Basanti, Gosaba and Namkhana. Basanti and Gosaba are very close to the forestry as well as rivers of Sunderban and people of these blocks are dependent on both forestry as well as fishery for their livelihood. However, in Namkhana block our main focus has been on fishery only as forests are far from this block and the people of this block are mainly dependent on fishery for their livelihood. So, for the fishery part of our study we have surveyed 600 houses in Sunderban, 300 houses, 150 each, from Basanti and Gosaba and 300 houses from Namkhana. However, for forestry we have surveyed only in the Basanti and Gosaba blocks implying that we have surveyed only 300 households.

Table 1: Division of Households of sample survey in case of the Sunderbans

District	**Block**	**No. of Households**
South 24 pgns	Basanti	150
South 24 pgns	Gosaba	150
South 24 pgns	Namkhana	300

Source: Field Survey

We have conducted household survey to get data on various socio-economic aspects of the families of the respondents (like number of family members, age-sex composition, educational status, income earned from different sources, landholding, livestock holding etc)

In the Sunderbans we find that almost 62% of the respondents are Male and rests are female. Next, we have categorized the respondents in different income groups for both the areas. We have classified the entire income range in different groups like Rs. 0-2500, Rs. 2501-5000, Rs. 5001-10000, Rs. 10001-20000 and more than 20000 then, frequency of people falling in each group with their percentages are shown in tables 2.

Table 2: Different Income Groups of Respondents with Frequency and Percentage in the Sunderbans

Blocks	Basanti (150)		Gosaba (150)		Namkhana (300)	
Income Groups (Rs.)	Frequency	%	Frequency	%	Frequency	%
0-2500	23	15.33%	20	13.33%	36	12%
2501-5000	81	54%	86	57.33%	125	41.7%
5001-10000	34	22.67%	39	26%	118	39.3%
10001-20000	10	6.67%	4	2.67%	18	6%
More than 20000	2	1.33%	1	0.67%	3	1%

Source: Field Survey

In table 2 for all the three blocks we have seen that a huge proportion of respondents belong to the income group of rupees 2501-5000 per month, followed by the income

group of 5001-1000. In Basanti and Gosaba around 70 % of the households earn below 5000 rupees per month. Namkhana has 53.7% households in this category. So, Namkhana is in a comparatively better position compared to the other blocks. However, for all the three blocks households having monthly income more than 10000 are very few in number in our sample.

4. Valuation of the Major Renewable Resources in the Study Area: Methodology and Results

The present study focuses on extraction of renewable resources in the Sunderbans and its linkages with sustainable livelihood. To understand the implications of extraction of renewable areas in the backward regions of West Bengal one should focus on the valuation of these resources. Valuation of the renewable resources are done by using Contingent Valuation Method (CVM) as the this is the most common approach to conduct any valuation exercise. Our results have strong implications for sustainable livelihood in the study area in the sense that high willingness to pay (WTP) to conserve the resource means the stakeholders has the knowledge base to conserve these resources due to the fact that they are dependent on the specific resources for their livelihood.

In the Sunderbans the main renewable resources that are extracted and also on which the stakeholders are dependent for their livelihood are fishery and forestry. We have considered in this paper first the valuation of forestry in the Sunderbans and then we have compared it with that of fishery. The purpose behind considering the valuation of forestry first is though fishery is the primary occupation in the Sunderbans conservation of forestry helps to promote fishery in the long run. This is because the forests in this area are in the form of mangrove swamps and they are the nursery grounds for various fish stock.

a) Valuation of Forestry: Methodology

The sampling procedure is already discussed in section 3. We just mention that we have followed stratified random sampling for our study. It has been observed that the response rate is 100% which is high. A higher percent of response rate in our study can be considered an unconventional but good outcome in a developing country.[1]

The CVM is based on closed-ended bidding game of dichotomous choice (DC). For the above kind of analysis it is important to determine the bid first and then to determine how these bids are to be shown to the respondents.[2] The bids that we have considered for

[1] We attribute this high response rate to the "*face-to-face in-person interviews*" that we have conducted, as suggested by the NOAA (1993) panel. One more reason for such high response rate could be the fact that the degree of forest dependency is very high, almost 100%, for the people of our surveyed areas. So, regarding uptiftment of forestry, they might be very eager.

[2] One can refer to Saha(2015) and Chatterjee (2017) for a similar type of bidding procedure. However, the present bidding strategy is different from the bidding strategy followed by Saha(2015), rather it is close to the work of Chatteerjee (2017). In our case and also in Chatterjee (2017) anchoring has been done in

forestry in the Sunderbans are Rs.2, Rs.5, Rs.8, Rs. 10, Rs. 15 and Rs.25 (in terms of per month). Here the bids are determined after discussing with the local people through pilot surveys which gave us an idea of the maximum and minimum amounts that we should put forward to the respondents as bid amounts.[3] The next step is to identify the "valid" responses out of 300 respondents. For this we have followed a strategy in the final survey. We have categorized the respondents in three bid groups, namely, *low, medium and high*. We have applied single-bound dichotomous choice CV method. The *low* bid group implies bids of Rs.2 and Rs.5 per month. For *medium* bid group the bid amounts are Rs.8 and Rs.10 per month. For *high* bid group the bid amounts are Rs.15 and Rs.25 per month. This process of offering bids, amounts of bids and accordingly grouping of respondents in three bid groups, just described, is same for both forestry and fishery

We now explain how bids are selected in a closed ended referendum under single-bound dichotomous choice CVM. *First* of all, a dice has been thrown to each and every respondent. If the outcomes are "1" or "6" for a particular respondent, then the respondent is considered to fall under *low bid group*. Next, again the same dice has been thrown for the *second time* to the respondent and if the outcomes are "odd numbers", that is, if the outcomes are any one of the three possible odd numbers -1, 3, 5, then the respondent has been categorized to accept the bid of Rs. 2, if the outcomes are 'even numbers', that is, 2, 4 or 6, then the respondent has been offered the bid of Rs. 5. In this case the respondent has been asked whether he or she willing to accept the bid Rs. 2, if the answer was 'YES', then we consider the bidding amount to be Rs.2. If the answer is NO we consider the respondent as a *protest bidder*.[4] This is also true for the bidding amount Rs.5.

Similarly, when the dice has been thrown in the front of the respondent for the *first time* if the outcomes are 2 or 5 then the particular respondent is categorized as a part of *medium bid group*. In the next step again, just described above, the dice has been again thrown for the *second time* and if the outcomes are any of the three possible 'odd numbers', then the respondent has been offered to accept Rs. 8, otherwise Rs. 10, in case the outcomes are any of the three possible 'even numbers' of the dice. Here also we find that if the answer is YES for any of the two bids as mentioned above then we can determine the bidding amount. If the answer is NO for each of the above-mentioned two bids, then we again consider the respondents as *protest bidders*.

Lastly, if the outcomes from throwing dice for the *first time* are "3" or "4" to any respondent, then the respondent has been categorized in the *highest bid group*, that is, in the group of bids Rs. 15 or Rs. 25. Then again, the above-mentioned process has been followed after throwing the dice for the *second time*. In this way a particular bid has been

offering bids in terms of a dice throwing first and then the bids are offered again by throwing a dice for the second time.

[3]The amounts of bids are different in case of valuation of fishery. The sample size for fishery is also 600.

[4] Protest bidders are those who do not prefer the stated programme and therefore provide zero WTP value.

shown to a particular respondent from different events when the events are mutually exclusive, equally likely and independent. So, for a particular respondent, we have thrown a dice twice, firstly, for randomly selecting the bid-group for each and every respondent and, secondly, for randomly selecting the amount of bid that was offered to the respondent.[5] In this way a particular bid has been shown to a particular respondent from different events when the events are mutually exclusive, equally likely and independent. For the open-ended segment of our study we have directly asked the respondents about their maximum willingness to pay (Max WTP).

Our present survey reflects that 119 respondents out of 300 respondents are not willing to accept the bids and thus we will consider 181 respondents as *"willing"* respondents and 119 respondents as *"non-willing"* for our further analysis. Here 119 *"non-willing"* participants are considered as *"protest bidders"* (Bateman et al, 2002). It has been seen that these bidders give "zero WTP values" but still have preference to participate in the programme and enjoy the benefits of it. So we cannot omit those respondents. The respondents have responded to the offered bids in terms of either "YES" or "NO" to a concerned bid.

The bidding process as described above is "single bounded dichotomous choice" bidding process. The theoretical rationale for this type of bidding process can be explained briefly in terms of a random utility model.

This model closely replicates the choices individuals face in a market situation. The respondent is presented with a specific monetary value (e.g. Rs. X) for a policy change and he/she is asked to make a judgment of accepting or rejecting the offer. The size of X is randomly varied across the sample of a study.

The DC elicitation method provides us only limited amount of information about the WTP value of the respondents, namely, "YES" or "NO" answer to a particular bid and nothing more.

If Bid Amount (X) > WTP, then the response is "NO"

If Bid Amount (X) ≤ WTP, then the response is "YES"

We next focus on the Random Utility Version of the model. An individual respondent will respond with "YES" if his/her utility from the additional forestry conservation measure is larger than or equal to her utility compared to status quo position; and NO, otherwise.

$(U_1 - U_0) \geq 0$, the individual will accept to pay the bid X (1)

$(U_1 - U_0) < 0$, the individual will reject to pay the bid X (2)

The utility U of the individual is not directly observable (hence the differences are also not directly observable). However, its determinants are observable. Under the two differentscenarios, one with the acceptance and other with the rejection of the bid, the

[5] This procedure of throwing a dice twice before offering a particular bid to the respondent was followed for bringing simplicity in the survey process.

following specification of the utility function can be put forward:[6]

$U_1(1, y - X;\ S) = V(1, y - X;\ S) + e_1$ (3)

$U_0(0, y;\ S) = V(0, y;\ S) + e_0$ (4)

Where, $V(.)$ is the utility function without random element and $U(.)$ is the utility function with random element. It is to be noted that in equations (3) and (4) we find Y = total income; 1= acceptance of the bid; 0 = rejection of the bid; S = other socio-economic features; e = random error component due to the limited knowledge of the utility model of the individual by the analyst.

From equations (3) and (4) we can write

$\Delta U = \Delta V - e$ (5)

Where $(U_1 - U_0) = \Delta U$, $(e_0 - e_1) = e$ and $[V(1, y - X;\ S) - V(0, y;\ S)] = \Delta V$, given equation (5), the inequalities (1) and (2) can be written as,

$\Delta V \geq e \rightarrow$ Acceptance of X (6)

$\Delta V < e \rightarrow$ Rejection of X (7)

There are two types of models for estimating the mean WTP value from the DC bids – the probit and the logit model. Here we have considered a logit model (logistic distribution of the error term) for our purpose.[7]

The probability that the individual agrees to accept the bid is therefore:

$P(acceptX) = P\ (Y = 1) = P(e \leq \Delta V) = F(\Delta V)$(8)

Where Y is the observed dichotomous variable, acceptance = 1, refusal = 0.

Assuming that the random variable e follows a logistic probability distribution we can write:

$P(acceptX) = F(\Delta V) = 1\ /\ [1 + exp(-\Delta V)]$(9)

When the individual accepts to pay the proposed bid X, its means that the maximum Willingness to Pay (WTP) is greater than the proposed bid X. The probability of acceptance, given a bid X, is the probability of individual $WTP \geq X$. Therefore we can write:

$P(acceptX) = P(WTP > X) = 1\ /\ [1 + exp(-\Delta V)]$(9.1)

This means that the probability the WTP is less than or equal to X is:

$P(WTP \leq X) = G(X) = 1 - 1\ /\ [1 + exp(-\Delta V)]$(10)

Where, G(X) is the probability distribution of the WTP.

The mean of the WTP distribution is commonly assumed to be indicators of the individual WTP.

The mean of the maximum WTP can be calculated using the formula that relates the

[6] This part briefly describes the theoretical methodology of Harou, Markandya, Bellu and Cistulli(1998) and naturally the methodology part is similar to the work of Saha(2015)

[7]The choice of the model depends on the probability distribution of the error term where probit is used if the error term follows a normal distribution and logit is used if the error term follows a logistic distribution. However, most of the studies that used DC format follow the logit model since the difference between the two is minor and the logistic function is simpler to deal with.

mean of a random variable to its probability distribution:

$E(WTP) = \int_0^\infty \{1 - G(X)\} dX (11)$

We now want to consider the econometric specification of the DC model for a closed-ended referendum. The purpose is to derive the mean WTP for the forestry of the Sunderbans. To estimate the WTP we have used a logit model and we have derived the values for the DC bids used for the respondents.

The logit model[8] used for the study contains the following variables.

Dependent Variable: $\ln \frac{P_i}{1-P_i}$

where p_i as the probability of WTP amount greater than or equal to an assigned bid.

$\ln \frac{P_i}{1-P_i}$ is the log odds ratio.[9]

The independent variables used in this model are described in terms of table 3.

Table 3: Description of independent variables of the model

dc bid	Bids vector of Rs. 2, Rs.5, Rs. 8, Rs.10, Rs.15 and Rs.25
Income	Total monthly income from all sources
family size	Household Size
Age	Age of the respondent
eduyrs	Total years of education of the respondent
Sex	Dummy Variable. 0 for Males and 1 for Females.
Caste	Dummy Variable. 0 for General Caste, 1 for OBC, 2 for SC and 3 for ST
dom animals	Dummy variable. 0 for having no animal and 1 for having any.

The independent variables are the socio-economic variables and are more or less common for the CVM studies. We have used several socio-economic aspects as independent variables by using dummy. It has been done because in a poverty-stricken, backward area it is expected that these aspects can play an important role in the response of the respondents. The estimated results of the logit model along with Marginal effects are shown in terms of table 4.

b) Valuation of Forestry: Results

The results related to valuation of forestry in terms of logit model are reported in Table 4. From table 4, we find that age and sex are insignificant but others are significant. Among the significant variables, dichotomous choice bid has a negative sign before it, indicating

[8] Most of the variables used in this model have been selected after going through the literature on CV technique.

[9] The ratio of probability of willingness to pay (P_i) and non-willingness to pay (1- P_i). It is to be noted that as Piincreases the log-odds ratio increases.

the fact that for a unit change in the bid, the probability of willingness to pay or the log-odds ratio falls. The negative coefficient for the bid-vector can be explained on the basis of the fact that as bid value rises the probability of YES (or acceptance) decreases. The negative sign of caste signifies the fact that people of general caste are more willing to contribute and as we move from general caste community to OBC, SC and ST respectively, this willingness to contribute decreases. This is also quite expected because, generally, people of so-called lower castes (SC, ST) are very poor. Income has a positive impact on WTP because it is expected that with an increase in income, people of Sunderbans would want to pay more for conserving the source of their livelihood. This result is irrespective of all types of income groups.

Table 4: Results of the Logit model in case of Forestry (Indian Sunderbans)

Variable	**Coefficient**	**Marginal Effects(dY/dX)**
dc bid/ close-ended bid	-0.000733*** (-8.83)	-0.0000671*** (--6.21)
Income	0.000176*** (5.89)	0.0000220*** (3.31)
family size	0.008567*** (9.32)	0.0016475*** (5.33)
Age	0.146683 (1.19)	0.002398 (0.78)
eduyrs	0.958134** (2.08)	0.184256** (1.99)
Sex	0.945677 (1.47)	0.181860 (1.03)
Caste	-0.004522*** (-5.09)	-0.000231*** (-3.43)
dom animals	0.227459** (1.97)	0.437421** (1.83)
Constant	-5.832970*** (-7.98)	
Log-likelihood	-228.5120	The terms in the parentheses for both coefficient and marginal effects are the t-values
LR chi-square	312.98	
Prob> chi-quare	0.000	
Pseudo R^2	0.5012	
Total no. of observations	300	
*** denotes significant at 1 % levels ** denotes significance at 5 % levels		

Source: Author's Estimation

From the table we can see that larger the family size higher is the number of working members who are dependent on forest.[10] So, the variable family size has a positive sign before its coefficient. Income has a positive impact on WTP because it is expected that with an increase in income, people of Sunderbans would want to pay more for conserving the source of their livelihood. On the other hand, people with lower income are more dependent on forest than others and would require a continuous flow of services from the forest ecology to maintain their livelihood, so they would naturally like to pay for resource usages from the forest. However, their payments might be lower compared to the other groups of respondents. People of high income group are more educated and hence they understand the necessity of preserving the forest because they are also dependent on forestry in various ways. So, their probability of accepting a bid is supposed to be high. The coefficients of dc bid, income and family size are highly significant (at 1% level of significance).Education has a positive sign and is significant at 5% level. Domestic animal is used as a dummy of economic asset. The coefficient having a positive sign indicates the fact that in the presence of domestic animal, people are in a better economic condition than others. Also the fact that people having livestock get their fodder from the forestry and use forest as the grazing land for free of cost may have contributed to the positive sign of this coefficient. Hence, their WTP is quite high which justifies a high value of the coefficient for domestic animals which is highly significant with a positive sign. The insignificance of sex and age implies that irrespective of these two factors, people of Sunderbans depend on forestry for their livelihood. The goodness of fit of the model used is usually judged by the value of pseudo-R^2. In our model the value of pseudo-R^2 is 0.5012. So, our model gives a good fit. It is important to examine whether some degree of multicollinearity is present in the model as it is common in any cross section data. The variance inflationary factor (VIF)[11] andthe tolerance[12] for the model show that the models do not suffer from severe multicollinearity problem as the value of 'mean VIF' is 4.36 which is well below the value of 5.[13] The marginal effects for the logit equation have also been estimated. It shows the rate of change in the probability of willingness to pay due to change in the value of an independent variable X_j

[10]This dependency is not only in terms of working as foresters but also the fishermen (if any in the family) are dependent on forests as mangrove forests of the Sunderbans are nursery grounds for fish. The honey collectors are also very much dependent on forests. So it is expected that all the stakeholders will opt for forest conservation in the Sunderbans.

[11]Variance inflationary factor (VIF) measure how much the variance of the estimated regression coefficients are inflated as compared to when the predictor variables are not linearly related. This is used to describe how muchmulticollinearity (correlation between predictors) exists in a regression/logit analysis.When there is no collinearity, VIF will be 1.

[12] 1/VIF is known as tolerance.

[13] As 'the rule of thumb', if 1<VIF<5, it implies variables are moderately correlated and if 5<VIF<10, then the variables are highly correlated.

(j=1, 2… n). This is also shown in table 4. Here, we find that as income changes by one unit, holding other factors constant, the probability of WTP also rises; same explanation applies in case of variables like years of education, family size and domestic animals. The opposite explanation applies to the variables like dichotomous choice bid and caste.For these variables, one unit of change causes the probability to accept an assigned bid fall.

Our next task is to estimate the WTP in the case of closed-ended referendum under dichotomous choice model. The mean WTP of our model is Rs. 13.72 per month, with lower bound of Rs. 9.28 and upper bound of Rs. 21.92. These are shown in table 5.

Table: 5: Estimation of Mean WTP for Forestry in Indian Sunderbans (DC model under Closed-ended Referendum)

Measure	WTP	LB	UB
Mean	13.72	9.28	21.92
Achieved Significance Level for testing H_0: $WTP <= 0$ vs. H_1: WTP>0 LB: Lower bound; UB: Upper bound			

Source: Author's Estimation

Though the mean WTP, in general, appears to take a low value, given the backwardness of our study area and also given the fact that a large portion of the respondents that have been considered for our study lie below the poverty line, the mean WTP figure of Rs. 13.72 per month to conserve the forests in the Sunderbans is quite reasonable. We can thus say that the closed-ended WTP is Rs.13.72 per month. In other words, one can say that the forest-dependent communities are willing enough for conservation and further development of the forestry in the Indian Sunderbans.

So far we have discussed closed ended referendum; we now want to examine the determinants of WTP under open ended referendum. Here we consider WTP for forest conservation when open ended bids are offered by the respondents. In this case we use OLS regression techniques to determine the WTP and the regression result is summarized in table 6.

Table 6: Regression Results of Open-ended Referendum (Forestry in the Indian Sunderbans)

Variables	Coefficients	t values
Constant	-4.88734***	-5.93
Income	0.070345***	15.42
family size	-0.392501 ***	-3.99
Age	0.072453	1.31
eduyrs	0.496623**	1.99
Sex	0.489942	1.01

Caste	-0.754033***	-8.98
dom animals	0.764483***	7.29
Dependent Variable: max wtp (Open ended maximum WTP)		
N = 300 F = 112.33 Prob> F = 0.000 Adjusted R^2 = 0.4798		
*** denotes significant at 1% level,** denotes significant at 5% level		

Source: Author's Estimation

From table 6 we find that the variables which are significant in logit model are also significant here, with same signs (except for family size) before their coefficients.[14]Other variables have same sign, that is, as income rises, WTP also rises. Educated people want to pay more and people of General caste are showing higher tendency to pay. Again Sex and Age are insignificant. We have used simple OLS estimation for the open-ended part. The value of adjusted R^2 implies the fact that around 48% of the variation in dependent variable is explained by the independent variables included in the model (adjusted with respect to degrees of freedom). So, in terms of cross-section data one can say that it is a well-fitted model. Also, the t-values suggest that most of the parameter estimates are significant at 1% level. It is only years of education which is significant at 5% level. From table 6, the open–ended (maximum) mean WTP has been calculated to be Rs. 12.09 per month. If we consider the simple average of dichotomous choice WTP and open–ended WTP we find that the value of *'true WTP'* for conservation of forestry in the Indian Sunderbans is Rs.12.90 (approximately Rs.13) per month.

We have tested for anchoring bias (called the convergent validity test) by comparing the two mean WTPs and have conducted the paired-t test for this purpose.The null hypothesis here refers to the difference of two mean WTPs (open ended and dichotomous choice) is zero against the hypothesis it is not. Here the difference between "two WTPs" is -1.63 and the value of paired t- statistic is – 4.84 with 299 degrees of freedom. It is significant at 1% level. So, two mean WTPs are significantly different. It implies that anchoring bias exists in our CVM exercise for forestry in the Sunderbans. This anchoring bias may be due to the fact that the people of the Sunderbans are not highly educated and also they do not have the proper perception about the issue of sustainability of mangrove forests. From our study we find that in the Sunderbans the 'true WTP' for conserving forests is approximately Rs. 13 per month.

c) Valuation of Fishery: Methodology and Results

We now focus on the valuation of fishery in the Sunderban region of West Bengal. As already mentioned in section 3 of this study that the sample procedure that we have

[14]The only reason before the family size may be due to the fact that large family size can cause relatively less per-capita income and hence reduces the maximum WTP to conserve forests in the Sunderbans.

followed here is 'stratified random sampling' from six villages under three blocks like Gosaba, Basanti and Namkhana and the total number of families that we have surveyed for CVM in the context of valuation of fishery is 600. The methodology for CVM is same as the one that we have mentioned in the context of valuation of forestry in the Sunderbans. The only difference is that here we have considered the bid amounts to be higher as fishery is the main occupation in the region and a reasonable portion of the fishermen or persons associated with fishery lies well above the poverty line.

From our pilot survey we have observed that people of the study area were more dependent on fishery than on forestry. In Namkhana block we do not find forest dependent people, but there are people dependent on fishery. In Basanti and Gosaba blocks only we find forest dependent people, but still they consider fishery as their primary occupation. This is the reason why we have 600 sample size for fishery and 300 for forestry. We have observed from our pilot survey that the people are more happy and enthusiastic regarding their willingness to pay for the development of fishery than that of forestry. So, deliberately we have kept our bids lower for forestry sector than that for fishery sector, because people here depend on fishery throughout the year. Many people earn their living from fishery and activities associated with fishery like business of boat, net, etc. So, they are willing to pay a higher amount of money for the improvement of fishery sector. This is the reason for selecting different bids for the two separate sectors, of course, after discussing with Panchayat members and conducting mock-meetings with the people of surveyed area during pilot survey. The bids to conserve fishery in the Sunderbans are of the amounts Rs. 10, Rs.20, Rs. 30, Rs.40, Rs.60 and Rs.80 (all are expressed in terms of per month). We do not go into the details of the bidding game as it is exactly similar to the bidding game that we have considered in case of forestry in the Sunderbans. We just report here he major results of the study.

Our present survey reflects that 113 respondents out of 600 respondents are not willing to accept the bids and thus we will consider 487 respondents as *"willing"* respondents and 113 respondents as *"non-willing"* for our further analysis. As mentioned earlier in case of forestry in the Sunderbans,in case of fishery the 113 *"non-willing"* participants are considered as *"protest bidders"*. It has been seen that these bidders give "zero WTP values" but still have preference to participate in the programme and enjoy the benefits of it. So we cannot omit those respondents. The respondents have responded to the offered bids in terms of either "YES" or "NO" to a concerned bid. To estimate the WTP we have used a logit model and the results of our logit model are stated in terms of table 7.

Table: 7- Results of Estimated Logit Model (Fishery)

Variable	**Coefficient**	**Marginal Effects(dY/dX)**
dc bid/ close-ended bid	-0.0088345*** (-5.93)	-0.002103*** (-3.21)
Income	0.0189853***	0.004520***

	(7.67)	(4.55)
family size	0.6784312*** (8.21)	0.161531*** (4.98)
Age	0.2398614 (0.56)	0.056395 (0.22)
eduyrs	0.0098724 (1.21)	0.002350 (0.91)
Sex	1.9856435 (0.98)	0.472772 (0.47)
Caste	-0.7235735*** (-4.98)	-0.172279*** (-3.31)
dom animals	0.342986*** (4.55)	0.081663*** (3.29)
Constant	-6.776123*** (-5.60)	
Log-likelihood	-189.9867	The values in the parentheses for both coefficient and marginal effects are the t-values
LR chi-square	287.97	
Prob> chi-quare	0.000	
Pseudo R^2	0.4934	
Total no. of observations	600	
*** denotes significant at 1 % levels ** denotes significance at 5 % levels		

Source: Author's Calculations

The signs of the coefficients are as expected. Bids have a negative sign, implying a higher bid has a lower probability to be accepted. Positive sign before variable income implies people with high income are aware about protection and use of fish where as poor people with lower income may want to pay for improvement of fishery as they are dependent on it. Family size, like that of forestry in the Sundebans, has a positive sign. So, larger family, for the sake of its livelihood from fishery is aware about its improvement. Variables like age, years of education and sex are insignificant from the point of view of impact of these variables on probability of willingness to pay or the log-odds ratio. The goodness of fit of the model used is again judged by the value of pseudo-R^2. In our model the value of pseudo-R^2 is 0.49. So, our model gives a good fit. The variance inflationary factor (VIF) and the tolerance for the model show that the models do not suffer from severe multicollinearity problem as the value of 'mean VIF' is 4.11 which is well below the value of 5. The marginal effects model for the above logit equation has also been estimated which shows the rate of change in the probability of willingness to pay to conserve fishery due to change in the value of an independent variable X_j (j=1, 2… n). The interpretations of the marginal effects are similar to that of normal logit model analysis performed for forestry in the Indian Sunderbans (as shown in

Table 4). Hence we do no repeat our interpretation of the marginal effects.

Table 8: Estimation of Mean WTP (fishery)(DC model under Closed-ended Referendum)

Measure	WTP	LB	UB
Mean	28.98	16.11	35.92
Achieved Significance Level for testing H_0: $WTP <= 0$ vs. H_1: WTP>0 LB: Lower bound; UB: Upper bound			

Source: Author's Estimation

The mean WTP under closed-ended referendum is Rs. 28.98 per month, with lower bound of Rs. 6.28 and upper bound of Rs. 35.92 (as shown in table -8). The figure is quite high and we can say that the fishery-dependent communities are willing enough for conservation and further development of the fishery in the Indian Sunderbans as it is their main source of livelihood.

The regression result for open-ended referendum to determine the maximum WTP has been shown in table 9.

Table 9: Regression Results of Open-ended Referendum (fishery)

Variables	Coefficients	t values
Constant	-3.595673**	-3.41
Income	0.034213***	9.85
family size	-0.2672501***	-2.65
Age	0.004198	0.45
eduyrs	0.601753	1.03
Sex	0.682198	1.41
Caste	-0.983501***	-5.33
dom animals	1.337623***	6.23
Dependent Variable: max wtp (Open ended maximum WTP)		
N = 600 F = 112.33 Prob> F = 0.000 Adjusted R^2 = 0.6076		
*** denotes significant at 1% level,** denotes significant at 5% level		

Source: Author's Estimation

From table 9 we find that the variables which are significant in logit model are also significant here, with same signs before their coefficients. High value of adjusted R^2 implies the fact that more than 60% of the variation in dependent variable is explained by the independent variables included in the model (adjusted with respect to degrees of freedom). So, in terms of cross-section data one can say that it is a well-fitted model. In our OLS model, the mean WTP (open ended) is Rs.31.80 per month. If we consider the simple average of dichotomous choice WTP and open–ended WTP we find that the value of *'true WTP'* for conservation of fishery in the Indian Sunderbans is Rs.30.39 (approximately Rs.30) per month.

We have already mentioned earlier that the primary means of sustaining livelihood in the

Sunderban areas is fishery (as it is the primary occupation) and hence its WTP figure is quite high (equals Rs..30/- per month). The secondary occupation in the Sunderban areas is collection of forest products and hence its WTP is relatively low (Rs. 13/- per month). The relatively higher figure of WTP in the Sunderbans for forestry is not only because of the fact that people in this region are relatively well off but also people of this region want to conserve mangrove forests in this region not only for forestry itself but also for sustainable management of fishery resources.[15]

5. Concluding Remarks

In this paper we have started from a socio-economic analysis for some selected areas of the Indian Sunderbans to analyze the level of backwardness in this area. The people in the Sunderbans are mostly dependent on extraction of renewable resources like fishery and forestry to maintain their livelihood in a sustained manner. The degree of dependency, the awareness about sustainability of renewable resources and the knowledge base for sustainable livelihood can best be examined if we conduct a valuation exercise to conserve the two main renewable resources of this region. The Contingent Valuation Method (CVM) has been done for both forestry and fishery in the Indian Sunderbans.

In this study we have observed that as the people of the Sunderbans are heavily dependent on mangrove forests for their livelihood. They are very much willing to conserve the forests as well as the fishery base of the region. This is reflected from the high willingness to pay by the people for these two renewable resources in this region. Fishery is the main source of livelihood in this region. It can be in the form of employment in the aquaculture shrimp farms or in the form of shrimp fry collector (mainly by the women) or in the form of estuary/marine fishermen. Conventional wisdom suggests that expansion of aquaculture fish farm destructs mangrove forests. However, our analysis suggests that the people of the Sunderbans are quite aware about conservation of forests (as reflected in terms of reasonable figure for WTP to conserve forestry) along with expansion of aquaculture shrimp farm and traditional fishery (as reflected in terms of high WTP for fishery). The government should thus take more initiative to improve the condition of the stakeholders in this region by promoting conservation of forests. Such a policy will help both the foresters and the fishermen in the long run in the sense that in the Sunderbans forests are nursery grounds for fishery. In the short run, however, the government can promote various measures for sustainability of fishery as extraction of fish resources is the primary occupation in this region.

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[15]It can be mentioned that in the context of dryland areas of West Bengal scarcity of water resources, especially scarcity of drinking water, is an important issue. Chatterjee (2017) has shown that the WTP for conserving drinking water is Rs. 7.91 per month. See also Chatterjee (2014).

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