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A Non-parametric Estimation of Willingness to Pay for the Marine Litter Reduction in Sri Lanka

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스리랑카 해양쓰레기감소를 위한 지불의사액추정에 대한 비모수적 접근연구

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Abstract

This study estimates the individuals' preference for marine litter reduction on the coastal beaches in Sri Lanka by using the one-and-one-half-bound dichotomous choice contingent valuation method. 600 households in Sri Lanka were surveyed how much they would be willing to pay as an additional environmental tax for marine litter reduction. The Laspeyres and Paasche non-parametric estimation method (Boman et al., 1999) was then used to estimate the willingness to pay value for marine litter reduction. The study evaluates the total economic value, including the use-value and non-use-value of marine litter reduction, and this will be an exclusive study added to the Sri Lankan literature on the economics of marine litter which tremendously assists in coastal litter management policy-making process by providing reliable quantitative estimates. The estimated results show that the residents would like to pay 2,594 LKR ($13) (95% confidence interval, 2,547 – 2,641 LKR) each year for five years period as an environmental tax for the marine litter reduction on Sri Lanka's coast.

Key words : Marine litter, WTP, Non-parametric, Dichotomous choice contingent valuation

Ⅰ. Introduction

The purpose of this study is to estimate the willingness to pay the value(WTP) of households for marine litter reduction in Sri Lanka. UN Environment(2017) has defined marine litter as "any persistent, manufactured or processed solid material that has been discarded, disposed of, abandoned in, or eventually reaches the marine or coastal environment". Marine litter is a huge problem in coastal countries and a significant threat to the marine ecosystem. International Maritime Organisation(2018) has estimated that 15% of marine litter floats on the sea's surface, 15% remains in the water column and 70% rests on the seabed. According to Eriksen et al.(2014), 5.25 million plastic particles, weighing 268,940 tons in total, are currently floating in the world's oceans. Sri Lanka's unique location in the Indian Ocean also affects the accumulation of marine debris.

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Seychelles and India-Sri Lanka regions have been identified as possible sources of low wind debris rather than medium and high wind items(Duhec et al., 2015). Similarly, Sri Lanka is affected by beach particles from diverse source countries when the Northeast Monsoon Current(NMC) and the Southeast Monsoon Current(SMC) pass through it(Mheen et al., 2020).

Marine litter has several economic impacts, especially for an oceanic island like Sri Lanka which actively engages in fishing, tourism, and trading activities. Major sources of marine litter are inland litter flown through rivers and, solid and liquid wastes dump from industries and fishing vessels(Wickramaarachchi et al., 2010). The geographical location of beaches also plays an essential role in the amount of marine debris accumulation. Fishing activities take place around the entire coast of Sri Lanka and fish consumption is the main source of animal protein for the Sri Lankan population.

According to the statistics of the Sri Lanka Tourism Development Authority(2019), the tourism industry is the third-largest foreign exchange earner in Sri Lanka. Most tourists from European countries visit Sri Lanka for coastal-related activities such as sea bathing, sunbathing, surfing, diving, whale watching, sea turtle watching, boat visits, etc.

The economic costs of marine debris include the direct and indirect costs of damage as well as the cost that is inherently linked to the benefits from marine debris control as the implementation of policy options. Among the limited literature available on marine litter or beach cleanliness, the majority of the studies have been conducted using discrete choice CVMs. Aanesen et al.(2018) have estimated the economic value of coastal recreational activities in the Arctic region using a sample of 518 respondents. Employing the discrete choice random utility method the average WTP for 50% litter reduction on beaches lies between 123.1-167.5 USD. Davis et al.(2018) compared the South-East Queensland residents' WTP for beach cleanliness using integrated choice experiment(ICE) and discrete choice experiment(DCE) approaches which found a larger positive WTP for beach cleanliness as 43.2AUD per year for 5 years period. Hanley et al. (2005) employed the choice experiment CVM to estimate the WTP for water quality improvement for the aesthetics of River Wear and River Clyde in the UK. One of the main attributes focused on in their study is sewage/litter reduction and the estimated WTP for sewage/litter reduction is £16.91. Hynes et al.(2013) have conducted a similar study to value the economic benefits of the improvements to coastal waters using a sample of beach recreationists in Ireland. It has been estimated that the annual WTP for marine debris management (collection and prevention) is €7.20 per person. Schuhmann et al.(2016) also applied the choice experiment method to find the estimated WTP for beach litter reduction is 308.13 USD, under the mixed logit model. Jin et al.(2020) applied the one and one-half-bound(OOHB) dichotomous choice contingent valuation method to estimate the household's annual WTP for submerged marine litter reduction in South Korea and Choi & Lee(2018) have estimated the annual WTP for removing microplastics in the South Korean coastline using the same WTP elicitation method. These two studies are the closest studies to this study in terms of welfare estimation. However, the uniqueness of this study is that it evaluates the total economic value including both the use-value and the non-use-value of marine litter reduction on the Sri Lankan coast.

To this end, this study attempts to estimate the WTP value of Sri Lankan households for marine litter reduction by employing CVM. The remainder of the paper is organised as follows: Section 2 elaborates on the measurement method employed in this study, and the questionnaire and survey design. Section 3 explains the WTP elicitation method and Section 4 discusses the results of the study. The derived estimation would help marine litter management-related policy-making decisions in the country.

Ⅱ. Materials and Methods

1. Survey and Data Collection

The National Oceanic and Atmospheric Administration(NOAA) panel concluded that CVM can produce estimates reliable enough to be the starting point of administrative and judicial processes. Further, it mentioned that if the respondents are familiar with the assessed commodity, and use professional surveyors for the interviews, the validity and the accuracy of contingent valuation studies can be improved (Arrow, et al., 1993).

A focused group interview was performed with 15 representatives from the households in the study areas – a minimum of two households from each coastal district. It was realized that the participants well-understood the hypothetical market scenario. The explanation of the hypothetical scenario was slightly revised according to their responses. The pre-test surveys were then performed with 36 households – six households from each coastal district. The bid values were then modified based on their responses in which bid ranges are referred to the standard error of ±10%. Two separate questionnaires were developed with lower-bound and upper-bound bid questions. The main survey was conducted in November 2021 by experienced interviewers belonging to a professional market research institute. The selected sample of 600 households were residents of the six coastal districts, aged between 20 and 65 who have the capability of making financial decisions for a family and bearing the burden of taxes.

The questionnaires consisted of four sections. In the first section, five respondent selection questions check the suitability of respondents to participate in the survey. According to the respondent selection criteria, the respondent should be aged between 20 and 65, should be the head of the household or the spouse, there should have a monthly income, and should be a resident of one of the districts selected for the survey. The second section of the questionnaire was allocated to find the respondents' attitude towards marine litter status in Sri Lanka, followed by questions to discover the level of awareness of the marine litter problem, to obtain details about recent beach visits, and their attitudes on beach litter management in Sri Lanka. The third section is the distinguishing part of the lower-bound and upper-bound questionnaires which explains the hypothetical market scenario and presents the WTP questions (see Appendix A for the WTP questions). Finally, the survey ended with the socio-economic questions.

A view card was used to explain the hypothetical scenario to the interviewees. First, the current status of marine litter in Sri Lanka was explained to the interviewees. Regarding marine litter reduction in Sri Lanka, the status quo was defined as no proper policy action being practically implemented against the problem. The suggested hypothetical scenario for the reduction in the

marine litter was developed concerning the practicality to the Sri Lankan context, with the assistance of economists. The scenario was based on the implementation of a government program for continuous removal of marine litter on beaches in addition to taking actions on reduction of litter generation sources such as banning manufacturing/importing single-use plastic items, etc. This program would involve several aspects such as conducting regular and continuous beach cleanups by employing the cleaning staff of the urban councils in each coastal district, installing garbage traps in river mouths, and continuous cleanups of river basins and waterways directly connected to the ocean. The implementation of this program would require the support and commitment from each local and government authority responsible for waste management in Sri Lanka. The financing of the proposed project would be achieved through an environmental tax collected from the residents of Sri Lanka, between the years 2021 and 2025. The income gained from the tax would help the government to fund the program to achieve the planned objective. The proposed scenario would be implemented only if the public benefits from the project exceed the costs.

Several actions can be implemented at the national, regional, and international levels to manage marine litter. Banning disposal items such as single-use plastic items, imposing laws on waste management, environmental taxes, incentives and refunds can be seen as national-level actions for marine litter management. Sri Lanka introduced environmental taxes by the Environmental Conservation Levy Act No.26 of 2008 as another strategy to reach sustainable development. The environmental tax has a plausible connection with the marine litter removal programs because it is the main source of additional payment for the project implementation costs. Moreover, tax is the most widely applied payment method in CV studies because it is more familiar to the people, they feel more obliged and it is very realistic than other payment methods. Therefore, an annual environmental tax was chosen as the payment vehicle in this study.

2. Method of Elicitation

Referendum or dichotomous choices(DCs), open-ended questions, and bidding games are some of the existing elicitation methods, and referendum format and open-ended questions are broadly used in CV literature. The referendum style of asking valuation questions has been recommended by NOAA(1993) panel on contingent valuation and CV practitioners for a long time and it is the most popular WTP elicitation method nowadays. In this study, one and one-half-bound dichotomous choice contingent valuation method (hereafter, OOHB method) was utilized as the WTP elicitation method to assess the economic value of marine litter reduction on coastal beaches in Sri Lanka. Thereafter, the Laspeyres and Paasche estimation method suggested by Boman et al.(1999) was employed to estimate the lower and upper limits of WTP.

The OOHB method was proposed by Cooper et al.(2002), and the model was used as follows; The bid amounts range from 500-5000LKR. First, the respondent was asked whether s/he would be willing to pay the lower amount. If the respondent said ‘yes’ to the initial lower-bound bid amount, then the respondent was asked the second WTP question by adding 500 LKR to the initial bid value. If the respondent said ‘no’ to the initial

lower bid amount, there was no follow-up question. There were three expected answers to the lower-bound WTP questions: (yes, yes); (yes, no), or (no). Another randomly selected household was asked whether s/he would be willing to pay the upper amount.

When the respondent is questioned about the WTP for marine litter reduction, they think whether the benefit or the utility of eliminating beach litter is higher than the presented bid amount. According to Hanemann(1984), a yes-answer to a suggested bid A_i for an environmental change z^0 to z', where z is a vector describing the environment before and after the change in the indirect utility is as follows:

$$V(z',\ Y - A_i;B)+\varepsilon^i \geq V(z^o,Y;B)+\varepsilon^o \quad \cdots\cdots\cdots\cdots (1)$$

Where, $V(\ )$ is the indirect utility function, Y is the individual's net income, B is a vector of household characteristics, and ε^i(i=1,0) are identically and independently distributed random variables.

The probability that an individual accepts A_i follows directly from the indirect utility function and can be written in two ways:

$$\text{Prob}\{\text{individual accepts}\}=F_\eta(\Delta V(\cdot))=1-G(\cdot) \quad \cdots\cdots (2)$$

Where, $F_\eta(\cdot)$ is the cumulative distribution function of $\eta = \varepsilon^o-\varepsilon^i$, $\Delta V = V(z^i,Y-A_i;B)-V(z^o,Y;B)$, and $G(\cdot)$ is the cumulative distribution function of WTP(Kristrom, 1990).

It is assumed that zero responses are not uncommon in referendum-style contingent valuation studies and these zero responses are often excluded from most of the non-parametric applications in the literature(Kristrom, 1997).

3. Non-parametric Approach

It is not feasible to correctly draw up the probability distribution of practical applications (Watanabe, 2010). The parametric approach has the risk of mis-specifying the distribution function which causes inconsistencies in the maximum likelihood estimates of the parameters in F_η. Criado et al.(2013) emphasized that the mis-specification tests generally reject the parametric specifications in favor of more flexible counterparts, but they do not guarantee improved out-of-sample performance for the preferred model. Therefore, the non-parametric approach has been developed for contingent valuation studies as a method that do not depend on the probability distribution(Watanabe, 2010).

In discrete choice CVM surveys, it assumes that the *k-1* bid offers are selected from $A_1,A_2,\ldots,A_{k-1}$ and are administered into *k-1* sub-samples having corresponding probabilities $p = (p_1,p_2,\ldots,p_{k-1})$, where $A_i < A_{i+1}$ and $p_i \geq p_{i+1}$. It implies that the corresponding probabilities are monotonically decreasing when A_i increases(Boman et al., 1999). However, sometimes the proportion of "yes" responses are increasing as A_i increases ($p_{i+1} > p_i$). In this case, Ayer et al.(1955) introduced a theorem to obtain a monotonic regression by replacing the proportions p_i and p_{i+1} with $(k_i + k_{i+1})\ /(n_i+n_{i+1})$, and the procedure is repeated until getting a monotonic sequence of probabilities. This theorem is also known as the pool-adjacent-violator algorithm(Kristrom, 1990). This method provides several points on a function of an unknown WTP in a sample $p(A)$ which is generally known as the survival function(Boman et al., 1999). It is required to have more information on the behavior of (A) to calculate the mean WTP. Hence, Kristrom(1990) and Boman et al.(1999) utilized linear interpolation. A value A_0 must be determined that makes $p(A) = 1$. The assumption is that the distribution of WTP cannot take negative values, that is, $p(0) = 1$. If

WTP takes negative values regardless of this assumption, linear extrapolation can be utilized to find A_0 (Boman et al., 1999). <Table 1> summarised the mean WTP and the variance of mean WTP formulas suggested by Boman et al.(1999).

<Table 1> Mean and Variance Formulas

Measure	Mean	Variance
Upper WTP	$\mu_p = \sum_{i=0}^{k-1} \pi_i = (\lvert A_{i+1}\rvert - \lvert A_i\rvert)$	$var(\mu_p) = \frac{\sum_{i=0}^{k-1}(A_{i+1} - \mu_p)^2 (p_i - p_{i+1})}{n}$
Intermediate WTP	$\mu_I = \sum_{i=0}^{k-1} 0.5(A_i + A_{i+1})\ (p_i - \hat{p_{i+1}})$	$var(\mu_I) = \frac{\sum_{i=0}^{k-1}(A_{i+1} - \mu_I)^2 (p_i - p_{i+1})}{n}$
Lower WTP	$\mu_L = \sum_{i=0}^{k-1} \pi_{i+1} = (\lvert A_{i+1}\rvert - \lvert A_i\rvert)$	$var(\mu_L) = \frac{\sum_{i=0}^{k-1}(A_{i+1} - \mu_L)^2 (p_i - p_{i+1})}{n}$

Ⅲ. Results

<Table 2> exhibits the representativeness of the characteristics of the 600 sample of households with the population characteristics of the country. There is an extremely small difference in the percentages of males and females in the sample and the population. There are no differences between the district values in the sample and the population.

However, it can be seen that the average annual household income of the sample is comparatively higher than the population. There may be two causes for this discrepancy between two income values: (i) population statistics were given for 2016, and the survey was conducted in 2021. Hence, there may be an increase in average annual household income during five year time, (ii) the average monthly household income in 2016 is 62,237 LKR which is an average of the monthly income values from urban, rural, and estate sector populations (88,692; 58,137; 34,804 LKR respectively). The average monthly income value of the sample (93,450 LKR) lies between the 95% confidence interval limits of the 2016 mean annual household income of the urban population (79,590~ 97,793 LKR) (Department of Census and Statistics, 2017).

<Table 2> Sample characteristics

Variable	Sample	Population
Gender		
Female	51%	51.6%
Male	49%	48.4%
District		
Gampaha	27.7%	27.7%
Colombo	27.9%	27.9%
Kalutara	14.7%	14.7%
Galle	12.8%	12.8%
Matara	9.8%	9.8%
Hambantota	7.2%	7.2%
Household income	1121400	746844

The presented bid values were ranging from 500 to 5,000 LKR. When a higher bid was offered, the

proportion of negative responses was high and vice versa. Totally, 15.3% of the respondents in the 600 household sample stated “yes” when the lowest bid was offered, while 6% stated “no” when the highest bid was offered. Accordingly, the proposed distribution was biased towards the lowest bid, indicating that the WTP was improbable to be an overestimate. The probabilities of accepting the offered bids were indicated in <Table 3>.

Watanabe(2010) highlighted an issue in DBDC surveys that the answer to the second bid question is not independent of an answer to the first bidding question, which affects the assurance of the consistency of the mean WTP estimator, and this problem is also relevant to the OOHB CV surveys. As a solution, he suggested considering that both lower bid and upper bid are virtually offered at the second stage regardless of the answer at the first stage. This means that BIDH is actually offered to a respondent at the first stage, but at the same time, BIDL is virtually offered to a respondent at the second stage who stated “yes” at the first stage. Even though the respondent does not directly answer the second question, it is logically assumed that the respondent will say “yes” for BIDL as it is lower than the BIDH. In the same way, BIDL is actually offered to a respondent at the first stage, but at the same time BIDH is also virtually offered to a respondent at the second stage who stated “no” at the first stage, and it is locally assumed that the respondent will say “no” for BIDH. This procedure enables the probability distribution of BIDL and BIDH in the second stage(Watanabe, 2010).

According to the estimation results, the median WTP for marine litter reduction on the Sri Lankan coast, at = 0.5 is 1,500 LKR ($7.5) in Figure1. <Table 4> illustrates the upper, intermediate, and lower measures of mean WTP estimates, variance and the 5% confidence interval levels that were calculated using the equations depicts in <Table1>. The mean WTP estimates under the linear logistic model and the spike model using the parametric approach were 2,613LKR and 2,585LKR respectively(Hasini, 2022). The difference between the parametric and non-parametric estimates is about 9 LKR. The mean WTP estimate via the non-parametric approach is higher than the mean WTP estimate via the parametric approach because the probability distribution was constrained to have

<Table 3> Probabilities of "yes" answers

First bid (LKR)	Proportion of Yes (YY+YN+Y+NY)	Total Respondents	Probability (Yes)	Interpolated Acceptance Probabilities
0			1	1
500	60	100	0.60	0.60
1100	47	100	0.47	0.54
1700	96	200	0.48	0.48
2300	69	200	0.35	0.43
2900	48	100	0.48	0.38
3000	23	100	0.23	0.37
3500	33	100	0.33	0.33
3800	15	100	0.15	0.31
4200	18	100	0.18	0.28
5000	23	100	0.23	0.23

positive support by assuming that π =1 at A = 0, restricting negative WTP(Kristrom, 1990).

<Table 4> Mean and variance of WTP

Measure	Upper WTP (LKR)	Intermediate WTP (LKR)	Lower WTP (LKR)
Mean	3,197	2,594	1991
Variance	8,259	8,562	9,472
5% CI (Lower)	3,151	2,547	1,941
5% CI (Upper)	3,243	2,641	2,040

Ⅳ. Discussion and Conclusions

Marine litter is one of the most world-spread environmental issues that severely affects the marine environment. It requires policy actions, especially for developing countries, to mitigate this environmental problem. The Coast Conservation Authority, Sri Lanka Coast Guard, and the Central Environmental Authority are some of the main legal authorities in Sri Lanka to protect the coastal environment and it requires to have the government, public, and industrial support to properly implement the existing policies on litter management in the Sri Lankan coast. This study provides an economic estimation of an individual's preference for marine litter reduction in Sri Lanka which can be included as a quantitative measure in the coastal litter management policy-making procedure. The studies assessing the economic value of marine litter reduction are lacking within Sri Lankan literature, despite significant attention paid to beach recreation. Therefore, decision-makers would benefit from possessing reliable estimates of the economic values that country residents place on litter-free beaches. This study utilized Boman's Laspeyres and Paasche(Boman et al., 1999) non-parametric approach to analyze the data. OOHB method was employed as the WTP elicitation method and focused explicitly on beach litter because submerged marine litter in Sri Lanka has not yet been appropriately quantified. This study covers only six coastal districts in western and southern provinces which provides a range of recreational, commercial, and other benefits to the entire nation including, tourism, fisheries, coastal agriculture, marine wildlife, etc. In addition to that, over 40% of the Sri Lankan population is residing in these six coastal districts and it has been found that the coastal belt along the selected districts was highly polluted with small and large marine litter. 600 households were randomly selected for the interviews, using a stratified random sampling method. Due to the good awareness of the marine litter problem, the number of zero responses is relatively low in this study.

The results of the study revealed that Sri Lankan residents have a strong preference to reduce marine litter along the Sri Lankan coastline. The estimated median WTP for marine litter reduction is 1,500 LKR($7.5), while the mean WTP is 2,594($13). A primary concern when measuring WTP in a CVM study is how to deal with protest zero bids which are No-No-No and No_No responses to the WTP questions. Desvousges et al.(1987) have discovered using the probit model that the probability of zero bids decreases with education, risk of exposure, and increases with greater knowledge of the issue, as findings of their experiment to discover the determinants of non-zero bids and Musser et al.(1992) have discovered using the logit model that respondents with higher education levels, age, and income were less likely to register protest zero bids and believes by the respondent that the development is "good", it decreases the probability

of a protest zero bid(Halstead et al., 1992). 93 respondents in the sample rejected paying a single rupee for marine litter reduction and 38.7% of them stated a valid reason that the cost is too high for their household to afford. On the flip side, 507 respondents (84.5%) of the sample expressed their WTP for an annual environmental tax. The reason for bearing an extra burden was explained by the respondents who expressed their willingness to pay for the marine litter reduction. 32% of them (162 respondents) considered marine litter reduction as a legacy for future generations. 154 respondents (30.4%) contemplated the protection of the scenic beauty of Sri Lankan beaches, and 23.3% (118 respondents) considered the environmental tax as a better approach to pollution prevention. Moreover, the majority of the respondents(74% of the sample) strongly agreed with the statement that “marine litter reduction is very important for Sri Lanka’s coastal tourism industry”.

Future studies can be focused on evaluating the benefits of marine litter reduction to the country's tourism industry and fisheries industry of the country. However, it needs to ensure that the findings can be applied island-wide by expanding the survey to the other provinces with government sponsorship, segmenting the respondents into diverse groups, and analyzing results according to various categories such as the income level, geolocation of the residents, etc. to obtain differentiated implications for several categories.

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