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Utilization of Soft Energy: Approach to Eco-Development in Rural Bangladesh

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Abstract *–This study has given efforts to detect socio-economic-demographic characteristics to provide the utilization of soft energy and estimates truncated mean willingness-to-pay (WTP) for the economic valuation of soft energy. A contingent valuation survey was carried out according to the NOAA guidelines to fulfill the research objectives. The survey involved 307 villagers from twenty villages of Pabna district. The zero-inflated ordered logistic model was employed to detect the significant determinants of WTP for soft energy utilization. The model results showed that age, family composition, years of schooling, monthly income, social mobilization, and payment are the important contributors in determining WTP for the utilization of soft energy. The lower value of the truncated mean of monthly WTP (Tk. 2177.60 or US$: 25.69) compared to general mean WTP does not necessarily imply low demand for soft energy, as the findings from E(WTP) illustrate potential demand for soft energy in rural Bangladesh.*

Keywords – *contingent valuation, eco-development, energy economics, low carbon society, soft energy*

1. INTRODUCTION

It is predicted that from 2011 to 2030, global energy consumption will rise by 36% at a 1.6% growth rate, where fossil fuel-based hard energy has a greater contribution (88%) to total energy supply [1]. More utilization of hard energy accumulates major greenhouse gases (carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)) concentration to nature [2]. Global CO_2 emission was 19,074.50 million tons throughout the world in 1981, and it has continued to increase 34,032.70 million tons in 2017 [3]. This trend will rise by 85% within 2040 [4]. Bangladesh is not free from such circumstances as it largely depends on hard energy (furnace oil: 20.44%, diesel: 7.80%, power import: 4.07%, coal: 2.04%, hydro: 1.88, natural gas: 62.20% and other: 1.60) for power generation and transmission [5].

In Bangladesh, power generation is mostly dominated by indigenous natural gas (62.20%), which is now showing a depleting trajectory because of its faster rate of utilization by 300% from 1990 to 2019 [6]. Bangladesh has been experiencing a severe energy crisis for about three decades and is third among the top twenty countries where people lack electricity [7]. The energy crisis is terrible in rural Bangladesh. Only around 30% of rural households have interrupted access to grid-connected electricity [8], while about more than 75% of the total population (equivalent to 164.20 million in 2012) in the country live in the village. Almost 58% of rural families in the country are basically "energy poor" (*i.e.*, utilization of modern energy services per capita is very low), with a shortage of access to reliable and basic hard energy facilities [9]. In recent years, quick rental power plants have been established to minimize the immediate power shortage, responsible for raising the price of electricity in the country [10]. Like the shortage of access to grid-connected electricity, rural households have almost no natural gas access through pipelines for cooking. Environmentally friendly eco-development (desirable and soft change for a human social group, which is held to be not only better, but in economic and ecological equilibrium) practices, policies, and programs are highly required to overcome this situation. Economically equitable, socially ennobling, and environmentally balanced issues for sustainable rural development, low carbon growth, proper use of soft energy, and long-term adjustment of climate change are the main features of eco-development.

Rural Bangladesh is a source of soft energy (energy from renewable resources) such as biomass resources (*e.g.*, animal manure, crop residues, and kitchen and green wastes), harnessing solar power, hydro-potential, and wind. Soft energy guided eco-development ensures a low carbon society, job creation, and electricity demand in rural Bangladesh. The absence of appropriate design and mismanagement of eco-development may hamper the initiatives and activities for green growth, low carbon society, and renewable energy in rural Bangladesh and fail to meet goal 7 (affordable and clean energy) of SDG. There is no provision of existence value soft energy (the main building block of eco-development) in rural Bangladesh. Consequently, agencies, NGOs, and the government have least success to create a resource base for renewable energy. The above statement provides a background to the origin of thoughts and motivation to carry out this research.

To a certain extent, the existence value of soft energy, government, and institutional support to implement, but little is aware of the intensity of social preferences in this field. What are the rationales behind

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the *WTP* for soft energy instead of hard energy (energy from relatively inconsequential fossil fuels)? How much are village people willing-to-pay (*WTP*) for the utilization of soft energy? This paper may be the first attempt to answer these questions using a contingent valuation (*CV*) approach. Based on the research questions, the objective of this study has two folds: to grab those affecting household preference (socio-economic-demographic characteristics) for the provision of the utilization of soft energy; and to quantitatively estimates the non-use value of soft energy by assessing how much the rural households are willing-to-pay for it.

This study addresses new insights to the existing literature on the non-use value of soft energy by providing empirical evidence in the context of basic or explorative research. The study's findings can be used in cost-benefit analysis in a larger field of soft energy since the study considers a pecuniary value to the household preferences for science by using effective methods suggested by welfare economics. Indeed, the major advantages stemming from soft energy cover the creation of knowledge outputs, externalities, capital formation, the cultural impact of the outreach, and service provision only to capture the use-value or option value. The non-use value's benefits should also be considered to estimate the overall economic value [11]. It seems to examine *WTP* for scientific discovery.

2. LITERATURE REVIEW

The dumped household organic waste creates emission from methane and enhances the greenhouse gases (GHGs) in rural Bangladesh. Emissions of GHGs lead to unprecedented transformations in the earth's climate, and long-term environmental changes [12]. Energy is consisting of the exploitation of energy sources, energy conversion, and power generation. Organic waste and solar will be a potential source of electricity generation and develop an eco-development mechanism. Eco-development is the best platform for climate change mitigation. The provision of soft energy in eco-development has no insoluble problems, but hard energy options involving reliance upon fossil fuels and uranium can, on the one hand, lead to short term benefits while, on the other, they store up great difficulties in energy supply for the future [13]. Eco-development provides external benefits and is essential to assess green growth practices to justify climate change mitigation actions in the energy sector [14].

Domestic soft energy implementation has gained momentum in China, India, Nepal, Vietnam, Cambodia, Japan, South Korea, and Thailand [15]. From 2007 to 2012, the number of soft energy usage households has increased in China and India. In China, the number of households increased from 26.50 to 42 million, and in India from 4 to 5 million [7]. Soft energy could provide an alternative energy source essential to mitigate energy shortage and ensure long-range energy planning [1]. Turkey utilizes greenhouse heating for improved agricultural productivity by biogas, solar, and ground source heat pump hybrid system. Bangladesh is endowed with a plentiful supply of soft energy. Out of the various renewable sources, solar and biomass, and to a limited extent, wind and hydro-power are effectively used [16]. Installation and utilization of soft energy at household levels are determined by income, level of education, occupation, gender, age, household composition, social mobilization, institutional support, and religious status are the important determinants of utilization of soft energy at household level [17].

The *CV* technique is suitable for a quantitative approach for presenting consumer preferences and choice of a good and service. The *CV* technique elicits tangent stated preference over different hypothetical alternatives and has significant advantages over the *WTP* [18]. The *CV* and *WTP* have successfully applied to environmental and resource economics, energy economics, health economics, and ecological economics [19]. The measure of *WTP* is essential to evaluate the economic efficiency of soft energy. For proper implementation of soft energy in India through eco-development mechanisms people are prepared to pay for low carbon growth [20]. Based on a random effect meta-analysis of 30 studies [21] makes a summary of *WTP* for renewable energy use and develops a *CV* questionnaire to get respondents' perception on soft energy and its effectiveness.

Many studies have focused on the effectiveness of soft energy-related eco-development for low carbon society, energy efficiency and uninterrupted energy supply, country experience, and soft energy determinants. However, very few studies covered the effectiveness of soft energy in rural Bangladesh. This study may be the first attempt to explore the factors related to implementing soft energy in rural society, examine its effectiveness, and develop appropriate soft energy policies.

3. THEORETICAL MOTIVATION

The Eco-Development

Traditional development models delude low-income countries on two major counts. Firstly, low-income countries hold out material improvements attained through economic growth lead to develop expropriation of existing natural resources and overexploitation of labor; secondly, most of the poor countries are mollified by antidotal aid aim to combat disease, disaster, malnutrition, food insecurity, and illiteracy. These traditional models always ignore flows of non-existent natural resources that have more significant potential for overall well-being.

The improved society belonging to Northern nations is generally known as a consumer society. This society motivates low-income countries towards growth and creates inequality within and between nations [22]. A number of poor nations are now exploiting for their growth and generating the selfsame dividend society.

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The degraded resources and pushed their frontiers too far and fell into bureaucratic disorder. Thus, it can be said that bureaucratic disorder, resource degradation or depletion, and frontiers' mismanagement are significant outcomes of growth in selfsame dividend society [13]. Parasitic selfsame dividend society is treated like a shadow of modern consumer society. This society always tries to maintain the rate of consumption without consideration of the environment, ecosystem, biodiversity, and nature. It is essential to introduce an alternative attitude to development (highlighted more in regional human progress than national economic growth) in low-income societies or nations to mitigate this unusual practice's intensity. Eco-development can ensure regional human progress, equity, environmental balance, diversified culture, and social harmony through mutual respect, collective beliefs, and cooperation [23].

Two terms economic and environmental prospects constitute eco-development. It describes soft change for a human social group and works for better economic, social, and ecological equilibrium [24]. It works against resource depletion and advocates a balance between human and natural resources like air, land, wind, water, and forestry. It is the best fitting approach to optimize the balance between the number of populations, locally available resources, and culturally desired lifestyles [25]. It offers a rational, humanitarian, and democratic foundation for the government [13]. Proper utilization of eco-development can meet our fundamental rights, such as clothing, shelter, nutrition, and decent life [26]. Eco-development brings numerous benefits, and it can be directed by organizational, and political, operational, and administrative points of view [27]. Establishing an ideological commitment, sharpening political and administrative integrity, and attaining international parity are induced mostly by the organization [38]. Likewise, alleviate poverty and hunger, develop low carbon society and green growth, eradicate disease and misery, clean up urban squalor, balance the number of humans with existing resources, conserve resources and protect the environment are associated with political, operational and administrative initiatives [28].

A higher degree of jointness of economic and environmental issues through the eco-development model can align resource conservation and protection of the habitat, offering human well-being, and construct a better future for our grandsons. Eco-development is essential to utilize resources properly in the terrestrial platform, solar incidence, oxygen, carbon dioxide, and water. Eco-development has a greater relationship platform with such resources for energy conversion. Reference [13] notes that "empirically the pursuit of eco-development rests on a recognition of the constraining influences of the law of entropy, most particularly the long-term consequences arising from the disordering of earthbound energy resources". Wise and proper use of these resources can protect the ecological system and less emission and develop a low carbon society. Among all resources, renewable resource is suitable for generating soft-energy in terms of its origin, features, applicability, and future.

Every society can convert renewable resources into soft-energy such as solar power, tidal and wind offshoots, hydro and vegetable, alcohol, or biomass. On the contrary, hard energy options like fossil fuels, uranium, gas, and coal from the non-renewable can, on the one hand, lead to short-term benefits while, on the other, they accumulate great difficulties in energy supply for the future. For better policy options, it is essential for valuing soft energy through *WTP* in rural Bangladesh.

There are a large number of valuation approaches to environmental goods and services. The most common are the contingent valuation approach, conjoint analysis, opportunity cost method, pairwise comparison approach, benefits transfer approach, hedonic pricing approach, and travel cost method [12], [29]. Existing studies suggest that *CV* is the best fitting approach for valuing soft energy [30]. Since the estimation process of the existing value of soft energy is still in infancy, this study decided to consider the *CV* approach rather than adopting any of the approaches mentioned above because of their limited capacity to value in the soft energy context. The following section will cover the nature of *CV* for valuing the soft energy in rural Bangladesh.

The Contingent Valuation Method

The traditional theory of demand and welfare economics state that the value of a good arises from its use or utility. Nevertheless, the sixties environmental economists' forum argued that there might be a value arising from non-use of the pure existence of environmental goods [31]. According to [32], non-use value can be classified into three main categories: the bequest or altruism value, the option value, and the existence value. The quasi-option value is another form of non-use value, which is closely associated with the option value. The option value is applicable when predicting a little use of good in the future but not use it at the current time. If it is not possible to predict the use or irreversibility of good at present, then quasi-option value is more applicable [33]. The nature and feature of existence value are different from a bequest, option, and quasi option values. The existence value generates from the utility and perception of the existing good, even without any expectation or unpredictable use [34]. The existence value stated preference data, and contingent valuation is highly correlated with each other and essential to measure the non-use valuation of environmental goods and services through willingness-to-pay (*WTP*).

Stated preference data and *CV* appear to date back to the early 1960s when Davis (1963) conducted a study that highlights the value to retreaters of the Marine (United States) woods [35]. During the 1980s and 1990s, the *CV* method became more popular for valuing environmental goods. [36] Provide guidelines of the *CV*

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method, which were supported by an authoritative panel of experts (six distinguished economists and survey researchers, including two Nobel laureates) of the National Atmospheric Administration (*NOAA*). The *NOAA* panel concluded that *CV* could be useful for supporting the non-market valuation of environmental goods, services, government regulatory actions, provision of public goods, health care service, and cultural economics [35]. The *NOAA* supported guidelines for the *CV* have then been broadly refined, adapted, and implemented to the non-market valuation essential for changing scenario and policy formation.

The stated preference data involve exploring an individual's *WTP* for good by developing a set of questions followed to the *CV* method in terms of stated choices or preferences directly to the individual [37]. In a CV, a respondent is asked to imagine some situation that is typically outside the respondent's experience, speculate on how s/he would act in such a situation [38]. More specifically, a respondent should be asked to state only '*yes*' denoted by 1 or '*not*' denoted by 0 to the proposed payment for existing environmental goods or services. The superscript 0 presents the current scenario, and 1 refers to an improved scenario. The *CV* is a helpful approach to develop a questionnaire and measure *WTP* or shadow price (maximum bid that a respondent is ready to accept and would like to pay for environmental goods or services) [39]. In this viewpoint, Equation 1 can also be written as:

$$CV_t = e_t \int_{q^0}^{q^1} \pi(F^1, x, U_t^0)dq \quad (1)$$

WTP is elicited through the *CV* method because of the unobserved nature of the shadow price function $\pi_t(F,x,U_t) = -\delta e(F,x,U_t)/\delta x$.

According to the random utility model, if respondent's income in the utility function is Y_i and the bid value for any environmental goods is h_i for the individual *i*, a respondent will be willing to pay h_i (because of rises utility or satisfaction from x^0 to x^1) if

$$U_1(y_i - h_i, z_i, \varepsilon_i) > U_i(y_i, z_i, \varepsilon_i) \quad (2)$$

Equation 2 implies that respondents will participate in a bidding game for *WTP* if they are better off with the payment and provide the facility for the goods or services [37],[40]. This proposition gives the probability of a respondent who has a positive attitude towards those goods or services, written as:

$$\Pr(\textit{positive attitude}) = \Pr\{U_1(y_i - h_i, z_i, \varepsilon_i) > U_i(y_i, z_i, \varepsilon_i)\} \quad (3)$$

The utility function of an individual is strongly and additively separable into a deterministic and random component [49] and can be written as:

$$U(y_i, z_i, \varepsilon_i) = U(y_i + z_i) + \varepsilon_i \quad (4)$$

Assume that the deterministic or non-stochastic segment of the utility function is $U_i = \alpha_i z_i + \beta(y_i - h_i)$ and the stochastic segment is the error term (ε). The utility difference is measured as:

$$U_i^1 - U_i^0 = (\alpha_i z_i + \beta h_i) \quad (5)$$

$$\Pr(\textit{positive attitude}_i) = \Pr(\alpha_i z_i - \beta h_i + \varepsilon_i) > 0 \quad (6)$$

The common objective *CV* approach is the derivation of measures designed to determine the amount of money where participants are willing to forfeit to obtain benefits from the undertaking of some specific action, and such measures are known as *WTP* [41]. Based on the existing literature, the study argues that the management of eco-development is not only to the government's actions and efforts. It also requires collective efforts or actions which need data from different stakeholders to measure *WTP* for proper management of soft energy. Improper application of *CV* and its guided questionnaire may hamper the whole survey and data collection process. The *CV* guided questionnaire should design to give background information on the problem, describe the "good" in question, elicit *WTP*, and collect information on the respondent, such as age, income, level of education, marital status, religious status, gender, social mobilization, and household composition [35]. Asking about the *WTP* for improving eco-development in the energy sector is never easy. Every researcher should follow a few characteristics of *NOAA* guidelines for conducting the *CV* survey. A successful *CV* study has six components which are essential to measuring *WTP*: define market scenario (*i.e.*, the information to be conveyed to a respondent), choice elicitation method (*e.g.*, direct question, bidding game, payment card, and discrete choice or referendum or single-bounded dichotomous choice), design survey administration (*e.g.*, mail, internet, telephone, and in-person), design sampling (*i.e.*, the first is to choose the group from which to draw the sample, and the second is to draw the random sample), design of experiment and, estimate *WTP* [42].

The *NOAA* guidelines suggest that a single referendum method is the best method to ask respondent '*yes*' or '*not*' to base bid or payment value to elicit *WTP* for a particular environmental good or service [43]. The follow-up question's bid level should be greater than the base payment offered if the answer to the base payment question is '*yes*'; otherwise, the follow-up procedure is not continued. The bidding game method is more efficient then the single referendum method [44]. Besides, the single referendum elicitation format is highly vulnerable to anchoring effects [45]. For the proper empirical investigation, and questionnaire development, the CVM requires Focus group discussion (FGD), survey, and sampling. The following section covers the brief discussion of FGD, the CV questionnaire, and sampling techniques.

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4. METHODS

Focus Group Discussion (FGD) and Variable Selection

Customization is an issue in the selection of the pecuniary attribute and its level. Under this process, it should attempt to make the choice alternative more realistic by relating the pecuniary attribute and its level. There is a rule of thumb that each higher pecuniary alternative directly relates to its actual level proposed by FGD. The visibility levels could be set 15% higher than the proposed or actual level [46]. This study organized four FGDs, which consists of (7-8) participants of each occurred on 23-26 December 2019 at Char Dulai, Ataikanda, Hatgram, and Bonogram in Sujanagar, PabnaSadar, Bhangura and Chatmohar sub-districts under Pabna district of Bangladesh. The first objective of *FGD* was to set a base price for the service of soft energy, and it was fixed at Tk. 3,000 per month, and it will be 36,000 per year. The value presented in local currency (BDT: Bangladeshi Taka), equivalent to US$ using a conversion rate of BDT equivalent to US$ using a conversion rate of BDT 1 to US$ 0.012 corresponding to March 2020. The second objective was to detect the desirable services from soft energy for rural households. The entire participants preferred solar pumps for irrigation, power generation from solar panels for the operating fridge, watching television, lighting room, charging electronic gadgets, roadside solar lamps, and waste-based biogas transmission facilities for cocking.

In this study, the monthly payment attribute for the utilization of soft energy is selected based on the findings from FGD. The reviewed literature helped us select variables (*e.g*., age, monthly income, household composition, education, and social mobilization) and develop the questionnaire. According to a systematic review of factors affecting the utilization of soft energy in rural Bangladesh, lack of social mobilization could be facilitators or barriers to utilizing soft energy in Rural Bangladesh [47]. More specifically, other studies found that lack of social mobilization becomes a barrier to developing a low carbon society through soft energy [48]. Besides, another two studies suggested that age, income, household size, and education level in the Philippines, Japan, South Korea, and Taiwan play a significant role in developing soft energy [49],[50].

The CV Questionnaire

This study carried out a *CV* survey to fulfill its objectives (identify the independent variables potentially affecting respondents' *WTP* for the service of soft energy, and measure the expected *WTP* as a provider of scientific discovery) that comes from the methodological insights of the *CV* related literature.

The pre-test was conducted to validate and understand the experimental setup where twenty-five respondents (seven farmers, four small traders, three rickshaw pullers, five service holders, four community leaders, and local government representatives, and two fishers) took part in the pre-test. These fifteen respondents were omitted from the main survey results. The pre-test results' assured that the proposed attributes and their associated levels were significant and relevant in terms of validity of respondents' experiment and understandability.

The common objective of the *CV* survey is the derivation of measures designed to determine the amount of money where participants are willing to forfeit to obtain benefits from the undertaking of some specific action and such measures are known as *WTP* [51]. The study assumes that initiative towards soft energy is not only to the actions and efforts of the government. It also requires collective efforts or actions requiring data from different households to elicit *WTP* for proper empirical investigation. Improper application of the *CV* survey may hamper the whole survey and data collection process. This study was strictly followed by *NOAA* guidelines to develop and design questionnaires to avoid such a situation. The questionnaire has three sections. Section one highlighted the background knowledge, information, and awareness of respondents about soft energy. Open-ended and binary choice questions were included to identify the respondents' preference, desire, ability, and interest in soft-energy service. Besides, a brief description of the importance of soft energy was also included in this section. Section two contained personal information such as respondents' age, monthly income, household composition, years of schooling, and social mobilization provision. Section three has included questions to elicit the *WTP* through the bidding game method. The *WTP* is elicited in two ways [33]. First, respondents are asked about their willingness to offer a single lump-sum payment with three possible alternative answers: '*yes*', '*no*', and '*do not know*'. Second, the *WTP* is asked in the form of an annual fixed contribution for 10 years. The study allows second options for soft energy because rural people of Bangladesh cannot pay more at a time and do not prefer long term contracts.

Respondents who completed the first session of the questionnaire were proceeding to the bidding game. Seven trained data collectors and professional interviewers conducted all survey interviews. Before starting the *CV* survey, the assigned data collectors meet face-to-face with the respondents and explain the imagery scenario of the proposed service from soft energy and the bidding game rules. The interview of respondents was taken care of for a long time. The data collectors did not indulge in any personal and irrelevant gossiping to avoid anchoring or influencing the respondents' answers. Besides, respondents' strategic behavior was tackled by ensuring the questionnaire's anonymity to reduce suspicious related to highly sensitive information [52].

Sampling

This study has chosen twenty villages of all sub-districts under Pabna district purposely for sample selection, but

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the representative households were randomly sampled. For sample random samples (*SRS*), the minimum acceptable sample size, n, was determined by applying the following formula.

$$n \geq \frac{q}{pa^2}[\emptyset^{-1}(1-\frac{\alpha}{2})]^2 \qquad (7)$$

Estimated probabilities at a 95% level of accuracy and *Z*2 (calculated by Microsoft Excel) determine sample size 307 in the study area. Four villages (Chardulai, Dulai, Kumuria, and Vhabanipur) of Sujanagar sub-district, three villages (Ataikanda, Atguriapara, and Shanirdear) of PabnaSadar sub-district, three villages (Nayabari, Masundia, and Kaitola) of Bera sub-district, two villages (Hotgram, and Nowbaria) of Bhangura sub-district, two villages (Bagpur, and Kabarikhola) of Shanthia sub-district, one village (Dhanuaghata) of Faridpur sub-district, one village (Voroymary) of Ishwardi sub-district, two villages (Bonogram, and Jogtala) of Chatmohar sub-district, and two villages (Gokulnagar and Shibpur) of Atghoria sub-district were selected for sample selection.

All heads of households (permanently live in these villages and have land, and business, occupation) got eligibility to be respondents. The head of the household (father or elder son or in certain case mother) is defined as the person making the major economic, social, and household decisions irrespective of age [53]. Out of estimated 338 respondents, 307 (90.82%) respondents were agreed to participate in the *CV* survey, and the rest 31 (9.17%) respondents were refused the request to participate in the survey and conjoint experiment. Among all respondents, 157 (51%) were farmers, 7 (2%) were fishermen, 106 (35%) were businessmen, small traders, and shopkeepers and the rest 37 (12%) were service holders. For the proper empirical investigation, *the author conducted FGD* and pre-test along with other data collectors. The household surveys were conducted in twenty villages in all sub-districts of Pabna district from 11 to 29 January 2020. On average, two days were spent in each village to collect data.

Framework for Measuring WTP

A zero-inflated ordered logistic regression model and a standard multinomial logistic model are used to examine the independent variables affecting respondents' *WTP* [33]. The first regression model is suitable for annual fixed contribution to soft energy, while the second regression model is applicable in a single lump-sum payment for utilization of soft energy. In the study, this study applied a zero-inflated ordered logistic regression model because of consideration of annual fixed contribution to soft energy at the village's household level. Besides, *WTP* flows a discrete ordered variable, including the zero value. As demonstrated by [54], the traditional ordered logistic regression model has a narrow scope in explaining zero observations. Existing studies suggest that a zero-inflated model by applying a double combination of a split logit model and an ordered logit model is the best-fitted model to overcome this situation [33]. For simplification, suppose a group of respondents is categorized into '*no*' or zero preferred option (they are not willing to pay), and '*yes*' or 1 preferred option (they are willing to pay) and their functional form of *WTP* is written as *WTPi* (*i=0,1,…,N*). Under this procedure, it is possible to examine the binary decision to be positive or negative towards *WTP* in the first stage. Besides, it is also possible to examine the probability of falling in one of the bid categories conditional on being *WTP* [58]. The binary decision to pay is structured with a logit model is given as follows:

$$P_i^* = X_{1i}\gamma + u_i \qquad (8)$$

The observed binary variable for being *WTP* (P_i) relates to the latent variable (P_i^*) and can be written as:

$$P_i = \begin{cases} 1 & if\ P_1^* > 0 \\ 0 & otherwise \end{cases} \qquad (9)$$

Probability of paying is the combination of Equations 8 and 9 and can be expressed as:

$$\Pr(P_i = 1) = \wedge(X_{1i}\gamma) \qquad (10)$$

and its likelihood function is given by:

$$L(\gamma / P_i, X_{1i}) = \prod_{P_i=0}[1-\Pr(P_i=1]\prod_{P_i}\Pr(P_i=1) \qquad (11)$$

Let *WTPi* be an outcome variable measuring the level of the proposed bids and take on integer values from 0 to J. The variable *WTPi* takes the value of zero for those respondents who chose the '*no*' option (P_i=0). Positive values can only be observed conditional on P_i=1. The joint likelihood of observing the entire sample takes the following form:

$$L(\theta / WTP_i) = \prod_{P_i=0}[1-\Pr(P_i=1)]\prod_{P_i=1}\Pr(P_i=1)\Pr(WTP_i / P_i=1) \qquad (12)$$

The conditional density $P_r(WTP_i/P_i = 1)$ can be perfectly handled by an ordered logit model [55]. In our proposed model, each respondent presents the strength of his preferences in terms of the level of bid chosen. Although the choices or preferences will vary continuously in the traditional utility theory, the expression of respondents' preferences is given in a discrete outcome on a scale with a limited number of choices. Hence, our proposed model is constructed around a latent regression of the following form:

$$WTP_i^* = X_{2i}\beta + \varepsilon_i \qquad (13)$$

The variable WTP_i coincides to the latent variable (WTP_i^*) according to the following rules:

$$\begin{aligned} WTP_i &= 1 && if && WTP_1^* \leq \tau_1 \\ WTP_i &= j && if && \tau_{j-1} < WTP_i^* \leq \tau_j && j = 2,\dots,J-1 \\ WTP_i &= J && if && \tau_{j-1} < WTP_i^* \leq \infty \end{aligned} \qquad (14)$$

The conditional distribution of WTP_i given P_i=1 and X_{2i} and the likelihood function of this sub-sample are given by the following form of equations:

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$$\Pr(WTP_i = j / P_i = 1) = \wedge(\tau_j - X_{2i}\beta) - \wedge(\tau_{j-1} - X_{2i}\beta) \quad (15)$$

$$L(. / WTP_i, X_{2i}) = \prod_{j=1}^{J} [\wedge(\tau_j - X_{2i}\beta) - \wedge(\tau_{j-1} - X_{2i}\beta)]^{WTP_{ij}} \quad (16)$$

Equation 12 should get top priority to estimate. From the statistical view point, it expresses the joint distribution of the random variables WTP_i and P_i conditional on the independent variables contained in X_{1i} and X_{2i} with the variance-covariance matrix of the bivariate distribution of the error term $\xi \equiv [u_i \ \ \varepsilon_i]'$ defined by the following matrix:

$$V(\xi) = \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon u} \\ \sigma_{\varepsilon u} & \sigma_u^2 \end{bmatrix} \quad (17)$$

In this model, X_{1i} includes the explanatory variables which determine the '*yes*' or '*no*' decision towards *WTP* (the participation Equation 10) and X_{2i} which influence the level of the bid chosen (the level Equation 15). Naturally, X_{1i} is an informative set contained in X_{2i}, and in that sense,$X_{1i}$and $X_{2i}$are identical where covariance between u_i and ϵ_i take zero value. In this viewpoint, the study estimates Equations 10 and 15 separately. More specifically, the study estimates Equation 10 using the entire sample and Equation 15 is using to estimate the sub-samples. This procedure is essential for answering the first research question of the study.

The regression model in Equation 13 is suitable for estimating the existence value of all environmental goods [56]. We apply this model to provide an answer to the second research question. Suppose the outcome variable of interest towards utilization of soft energy, S_i (i= 0,1) is binary. S_i = 0 identifies respondents who would not be *WTP* for the service from soft energy whereas, S_i= 1 describes respondents willing to pay for the proposed bid. Each respondent has an indirect utility function of the form V (M; Y_i; Z_i). During the survey, each respondent has options: to answer '*no*' which implies that respondent has no interest in soft energy and under this scenario, all of his income (Y_i) remains same, and to choose '*yes*' which implies that respondent has an interest in soft energy and under this scenario, all of his income has reduced. Following the latter option, it is possible to write the respondent's indirect utility function as follows:

$$\delta V_i^* = V(1; Y_i - A; Z_i) - V(0; Y_i; Z_i) + \nu_i \geq 0 \quad (18)$$

Empirically, the probability of offer (A) from respondents is approximated with a binomial model given as follows:

$$\Pr(S_i = 1) = \wedge(\delta V_i^*) = \wedge(\alpha + A\beta_1 + Y_i\beta_2 + Z_i\beta_3) \quad (19)$$

It is possible to get the expected value of *WTP* by numerical integration after completion of the estimation process of Equation 19. The truncated mean *WTP* (integrating from 0 to maximum bid) is the most appropriate method because it satisfies theoretical constraints (the upper limit of the *WTP* is not infinity but something less than income) [57]. By using this method, the value of the maximum bid (A) has to be assigned to all recorded *WTP* above (A). The mathematical form of truncated mean *WTP* can be written as:

$$\begin{aligned} E(WTP) &= \int_0^{Max\,A} \wedge(\delta V_i^*(A))\,\delta A \\ &= \int_0^{Max\,A} [+\exp(-(\hat{\alpha} + A\hat{\beta}_1 + Y_i\hat{\beta}_2 + X_i\hat{\beta}_3))]^{-1}\,\delta A \quad (20) \\ &= \int_0^{Max\,A} [1 + \exp(\hat{\alpha} + A\beta_1)]^{-1}\delta A \end{aligned}$$

5. RESULT

Descriptive Statistics of the Variables

Based on the collected data obtained from surveys in twenty villages of Pabna district, basic descriptive statistics of major variables are calculated (see Table 1 for more details).

Table 1. Brief descriptive statistics of the variables.

Variables	Mean	Minimum	Maximum	Standard deviation
Age (years)	35.42	25	75	13.13
Monthly income (Tk.)	22,617	5,000	75,000	1243.14
Education (years of schooling)	5.33	0	17	5.09
Household composition (family member)	5.03	4	11	2.79
Bidding price for '*yes*' case	2,357.07	2,500	1,800	27.34

(Source: Authors' calculation based on survey data, 2020)

A total of 307 villagers participated in the survey, where a major portion was covered by male respondents (98%) and the rest 2% was covered by females. About 203 (66.12%) respondents argued that soft energy could play an important role in developing a low carbon society and ensuring energy efficiency, but 104 (33.87%) respondents were not interested in paying for service from soft energy due to low income, faith and trust, and effective utilization of collected funds. All respondents strongly agreed that they did not get access to the national grid for electricity. Table 2 depicts the summary statistics (SED) of the study. The average age

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and monthly income of the respondents were calculated at 35 years and Tk. 22,617 respectively. About 133 (43.32%) respondents passed secondary school certificate (SSC) examination, higher secondary certificate (HSC) examination, and above, 98 (31.92%) respondents had completed primary education, and the rest of 76 (24.75%) respondents were illiterate. The average year of schooling was estimated at 5.33. The entire respondents believed that social mobilization could enhance the rural energy sector by soft energy. The monthly minimum bid was fixed at Tk. 1,800, and 182 (59.28%) respondents gave consent to pay this minimum amount or soft energy. Besides, the monthly maximum bid was fixed at Tk. 2,500, and 53 (17.26%) respondents agreed to pay this amount for soft energy. The monthly mean bidding price was calculated at Tk. 2,357.07 or US$: 27.81. The majority of the villagers have five family members.

Results of Models and the Truncated Mean WTP

Table 2 outlines the estimates of ordered logit model conditional on the sub-sample of respondents (Equation 15) and marginal effects of minimum and maximum paying groups for soft energy.

The signs, significance, and magnitudes levels of the estimates suggest that respondents' preferences were robust. All estimated coefficients are statistically significant at 1%, 5%, and 10 % levels. The negative sign of monthly income is negatively correlated with the level of *WTP* for soft energy. Economic theory, the structure of the question, and the household levels collected data can assist us in interpreting this surprising result. Economists argue that giving hypothetical services as a function of income is non-linear but has a U-shaped pattern-people in the lowest and highest income groups. This relationship persists even when accounting for additional services associated with income [58]. Likewise, the negative sign of payment derived from bid price is negatively associated with the *WTP* for soft energy. The higher price can shrink the scope of soft energy utilization and vice-versa, which can be supported by the traditional theory of demand. Finally, the Taos (τ) parameters refer to the thresholds used to differentiate the adjacent levels of the outcome variable (*WTP*). The significant signs of all Taos confirmed the justification of maximum and minimum bid for soft energy. Moreover, the likelihood ratio tests in the models confirmed that the explanatory variables' variation explains a good proportion of the variability in the outcome variable. Summing up, our empirical analysis did not show significant differences between the independent variables associated with the outcome variable (*WTP*).

The estimated results of the logit model for all samples are presented in Table 3. As expected, the estimated coefficient on the bid was found negative and statistically significant. Monthly income has significantly impacted on the probability of '*yes*' for *WTP* and the positive sign. The goodness of fit (McFadden *R2*) ensures that 34.1% of observations were correctly allocated to predict either '*yes*' or '*no*' indicating a good fit to the collected data.

Like the sub-sample case in Table 2, all sample cases' SED characteristics play a significant role in utilizing soft energy in rural Bangladesh. The payment stands out as the major burden affecting the probabilities to prefer soft energy. The preference is more sensitive to a higher payment for service from soft energy than a lower payment. This result confirmed the findings of previous studies [59],[60], and it was also consistent with the self-reported reasons why respondents did not prefer the provision of soft energy. The value of McFadden R2 (goodness of fit) of all models imply that the total variation in the outcome variable can be explained by the variation of all variables of the models.

This study further explored the distribution of respondents' mean *WTP* for soft energy utilization at the household level. The result of the truncated mean *WTP* from Equation 20 was calculated by the significant coefficients of intercept ($\hat{\alpha}$ = -0.003) and the monthly payment (A= -0.327) of the logit model for all samples, monthly mean bidding price 27.81$ and 0 for no interest to pay for soft energy. The mean bidding price was placed at the upper limit and 0 was placed at the lower limit in the integral. The estimated value of truncated mean *WTP* is given as follows:

$$E(WTP) = \int_{0}^{2357.07} [1 + \mathrm{e\,xp}(-0.003 - 0.327\mathrm{A})]^{-1} \delta A$$

=Tk. 2177.60 or US$: 25.69

The lower value of truncated mean WTP compared to general mean WTP does not necessarily imply low demand for soft energy, as the findings from E (*WTP*) illustrate potential demand for soft energy in rural Bangladesh and ensure eco-development. The empirically tested evidence generated by this study supports the findings of [47],[50].

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Table 2. Regression results of sub-sample survey.

Variable	Model 1 (*no* for *WTP*)		Model 2 (*yes* for *WTP*)		Marginal effects for model 2			
	Coefficient	*P*-value	Coefficient	*P*-value	j=Tk.1,800	*P*-value	j=Tk. 2,500	*P*-value
Age	0.217*** (0.322)	0.000	0.035*** (0.032)	0.000	0.002*** (0.423)	0.000	0.007 (0.452)	0.109
Monthly income	-0.032* (0.089)	0.102	-0.001*** (0.424)	0.000	0.128*** (0.067)	0.000	-0.241 (0.976)	0.190
Household composition	0.002 (0.471)	0.213	0.217* (0.521)	0.104	0.243 (0.001)	0.218	0.562 (0.037)	0.065
Education	0.001 (0.560)	0.110	0.235*** (0.472)	0.001	0.187 (0.732)	0.107	0.289 (0.064)	0.287
Social mobilization	0.325 (0.007)	0.132	0.017** (0.532)	0.042	0.010*** (0.200)	0.000	0.459*** (0.004)	0.000
Monthly payment	-0.092*** (0.452)	0.000	-0.019** (0.002)	0.033	0.395 (0.127)	0.164	0.137 (0.485)	0.340
Constant	-0.098 (0.035)	0.163	-0.007 (0.452)	0.214				
τ_1	-2.47** (0.009)	0.021	0.531*	0.102				
τ_2	-2.09*** (0.031)	0.000	0.836***	0.000				
Observations (*n*)	104		235		182		53	
McFadden R^2	0.271		0.421					
Log likelihood	-472.302		-501.923					
Likelihood ratio test	24.985		33.001					

Note. Robust standard errors in parentheses. ***,**,* denote significance at the 1%,5%, 10% level
(Source: Authors' calculation based on survey data, 2020)

Table 3. Regression results of all sample surveys.

Variable	Coefficient	*P*-value	dy/dx	*P-value*
Age	0.201*** (0.020)	0.000	-0.007*** (0.013)	0.000
Monthly income	0.235* (0.437)	0.102	0.034* (0.125)	0.104
Household composition	0.197*** (0.493)	0.001	0.005*** (0.054)	0.003
Education	0.055** (0.250)	0.035	0.012** (0.067)	0.023
Social mobilization	0.189** (0.594)	0.023	0.011*** (0.025)	0.000
Monthly payment	-0.327** (0.008)	0.031	-0.016*** (0.090)	0.000
Constant	-0.003*** (0.005)	0.000		
Observation	307			
McFadden R^2	0.341			
Log likelihood	-579.761			
Likelihood ratio test	57.285			

Note. Robust standard errors in parentheses. ***,**,* denote significance at the 1%,5%, 10% level
(Source: Authors' calculation based on survey data, 2020)

6. CONCLUSION

The objective of soft energy is to ensure a low carbon society and efficient utilization of energy. The economic case for soft energy includes the cost of energy, eco-development, green growth, and building well-being and resilience. However, in rural Bangladesh, the effectiveness of soft energy remains far from satisfactory due to the lack of awareness or social

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mobilization and not the consideration of households' ability to pay for the provision of soft energy under the existing market scenario condition.

Bangladesh is one of the most electricity deprived nations [47]. Despite the large potential for soft energy sources in Bangladesh, their contribution to the power generation remains insignificant. The existing so-called service from soft energy does not meet the demand for energy and goal seven of SDG because of its shorter coverage facilities, inappropriate policy framework, and institutional support. Adequate use of soft-energy is considered an indispensable component of a sustainable energy system. Age, monthly income, household composition, and years of schooling were found to be important contributors to improve the utilization practice of soft energy because they are affecting households' preference for the provision of the utilization of soft energy. Lower payment for soft energy utilization does not necessarily indicate low demand for soft energy. Values of truncated mean *WTP* for the provision of soft energy make a guarantee that it creates well-being for households and brings a substantial amount of revenues from the sector of soft energy. The interest of rural households towards soft energy can be increased if soft energy payment is cost-effective based on our proposed socio-economic-demographic factors. Hence, any policy aiming to undertake soft energy service is needed to consider these factors for effective management and implementation of soft energy and eco-development. The study findings can serve as policy inputs to the soft energy sector and eco-development and pave the way for undertaking similar projects.

NOMENCLATURE

e_t =expenditure function
F = bid value vector
x = current situation of environmental goods
U_t = level of satisfaction
Z = vector of SED characteristics
α = vector of coefficients of SED
p = true choice proportion of accuracy
q = not true choice proportion of accuracy
$\emptyset^{-1}(1-\frac{\alpha}{2})$ = inverse cumulative distribution function
P_i^* = latent outcome
X_i = vector of exogenous variables
γ = vector of parameters
u = error term
$\wedge(.)$ = logistic cumulative distribution function of u_i
WTP_i^* = propensity to be willing to pay
X_2 = vector of exogenous variables
ϵ_i = random disturbance term
τ_1 = unknown thresholds
WTP_{ij} = indicator variable (1 and 0)
M = binary variable
Y_i = income
Z_i = vector of exogenous variables
δV_i^* =latent variable
$\hat{\alpha}$ = estimated adjusted intercept

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