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Household Poverty Status and Willingness to Pay for Renewable Energy Technologies: Evidence from Southwestern Nigeria †

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Abstract: This study examined households' poverty status and willingness to pay for renewable energy technologies (RETs) in Southwestern Nigeria. Three hundred and four households in Southwestern Nigeria were surveyed. Households were grouped into poor and non-poor using two-thirds of the mean per capita expenditure (MPCE), and poverty depth and severity were calculated using the Foster–Greer–Thorbecke (FGT) poverty measure. The poverty line (two-thirds of the MPCE) for the households was calculated to be ₦80,412.57 and the poverty depth 0.0827. The results of Heckman's two-stage model revealed that age, marital status, level of education, household size, house location, income and awareness about RETs are factors influencing surveyed households' WTP and payout levels for RETs.

Keywords: willingness to pay; renewable energy; contingent valuation method; foster greer thorbecke; mean per capita expenditure

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1. Introduction

Energy is crucial in all human endeavours, such that the growth and development of any economy are hinged on it. People need energy for various purposes including lighting, cooking, transportation and even entertainment. In the quest to meet their essential energy needs, individuals, households and businesses resort to various means. Recently, a series of events ranging from severe changes in atmospheric weather, bushfires, droughts and other events have been consequences of the changing climate [1]. Climate change is a global menace that has received attention from the majority of world economies. While there are natural causes, the anthropogenic causes of climate change are more significant. These sources largely consist of the burning of fossil fuels to meet the energy demands of the growing global population. Apart from resource depletion and damage to the natural environment associated with the burning of non-renewable fuels, serious health complications and issues have been reported arising from the inhalation of fumes from fuel combustion. This has increased the mortality rate especially in countries with developing economies that have low-quality health facilities to treat the resultant illnesses.

Many countries have recorded considerable success in substituting fossil fuels with renewable sources [2,3]. However, the situation is worrisome in certain developing countries such as Nigeria. Despite the country's advantages in RETs, such as abundant solar radiation to power solar photovoltaic cells, high winds to drive wind turbines and water sources to explore hydropower, RET uptake has been low. Although the initial investment in RET can be huge for projects such as solar power systems; there has been a lack of evidence in the case of Nigeria to ascertain the factors limiting the uptake of RETs. Hence, the primary objective of this study is to investigate household poverty status and willingness to pay (WTP) for renewable energy technologies, using Nigeria as a case study.

2. Literature Review

2.1. Theory of Consumer Behaviour

This study is hinged on the theory of consumer behaviour. The theory states that a rational consumer seeks to maximise his level of utility in the consumption of goods given his budget constraints. Contextually, other factors being constant, a household willing to pay for renewable energy technology think that they are better off with its usage and vice versa [4,5]. CVM has been deemed appropriate for estimating levels of customer satisfaction especially for public goods and goods with limited private nature.

2.2. WTP—Contingent Valuation Method

The contingent valuation method seeks to create a non-existent marketplace for non-market goods, to allow measurement of people's willingness to pay (WTP) for the use of the goods or their willingness to accept (WTA) deprivation of the benefits arising from the goods due to inability to use them. While the method is also applicable for the valuation of marketable goods which are readily available in marketplaces, its application is largely seen in studying public goods including air and water quality improvements. CVM has been particularly useful when complemented by other techniques used in valuing non-market goods, such as hedonic and travel–cost approaches. Hence, the primary goal of the contingent valuation is to determine the compensating variation for the item being assessed, in this case, renewable energy technologies [6–8].

2.3. Empirical Review on Household Poverty, WTP and Renewable Energy Use

Several studies have documented the relationship between household poverty status proxied by income and WTP for renewable energies. According to the studies conducted by [9,10], income plays a significant role in a household's decision to adopt RETs and high WTP for electricity from renewable sources is common with high-income earners. Also, educational attainment directly influences WTP for energy services. Hence, highly educated individuals have a higher willingness to pay than their counterparts [10]. In previous analysis [11], age and gender were shown to have a mixed relationship with WTP for renewable energy while other studies [12,13] indicated that age, altruism, awareness and concerns for environmental issues not only affect household demand for renewable energy but also WTP for it. These previous findings suggest that socio-economic factors influence consumers' WTP for RETs.

3. Methodology

3.1. Sampling Method and Data Collection Technique

The three hundred and four samples were recruited by convenience sampling. This was necessary due to the COVID-19 pandemic at the time this study was conducted, making face-to-face data collection impossible. Online questionnaires were sent to participants and follow-up questions were also presented to test the veracity of their responses. About four hundred responses were received, of which only three hundred and four were complete and had the required variables for analysis after cleaning. Although the sample may not be entirely representative of the population due to its limitations, it gives an indication of the situation in the country.

3.2. Foster–Greer–Thorbecke (FGT) Poverty Measure

The Foster–Greer–Thorbecke (FGT) poverty measure was used in this study to determine poverty status among households in the study region. According to the literature [14], the model is as follows:

$$P_\alpha = {}^1/_n \sum_{i=1}^{h} (Z - Y_i/Z\,) \tag{1}$$

where:

Y_1 is the expenditure per household head equivalent of ith household, Z is the poverty line, n is the number of households; h is the number of the sampled population below the poverty line and α is an aversion to poverty, a coefficient reflecting different degrees of importance according to the depth or severity of poverty. A poverty threshold was obtained using two-thirds of the mean consumption per adult equivalent in the households. This threshold was used to separate poor households from the non-poor. The headcount index (P_0) measures the proportion of the population that is food poor; the poverty gap index (P_1) measures the extent to which individuals fall below the poverty line as a proportion of the poverty line; the squared poverty gap (P_2) is poverty severity, which averages the squares of the poverty gaps relative to the poverty line.

3.3. Contingent Valuation Method

According to the literature [15], the contingent valuation technique is a simple and adaptable non-market approach, often known as the expressed preference model. According to researchers [16], it is widely used for cost-benefit analyses and environmental impact evaluations of non-market resources. This approach, however, was used to determine the value of renewable energy and other non-market resources [17] as it allows for a direct evaluation of WTP. Consumers were explicitly requested to indicate their WTP for RETs using this technique. The contingency valuation method (CVM) is mathematically stated as follows:

$$WTP_i = \sum_{hi=1}^{T_i} \delta h_i \; Ph_i \tag{2}$$

where: WTP_i represents the average payout level of households in the region I; δh_i represents the payout level for a household's h_i; Ph_i represents the frequency of the payment value of a household's h_i; and T_i represents the number of samples from the surveyed population.

3.4. Heckman's Two-Stage Model

Heckman's two-stage model was devised by James Heckman, who received the Nobel Prize in Economics in 2000 for the concept [18]. Heckman's two-stage approach may successfully rectify the selectivity deviation, which is a one-of-a-kind problem [19]. Furthermore, this model can be used to examine the factors influencing households' WTP and payout level [20].

Model selection: The renewable energy technologies payment activities of households studied in this paper were divided into two stages. The first stage is the behavioural decision stage when households decide whether to pay for RETs. Households who do not have the willingness to pay were not carried forward to the next phase of the study, and the households who had the willingness to pay entered the second stage. The second stage is the payout level of the decision-making stage, which refers to the payout level of the households who are willing to pay for RETs. Hence, this paper employed Heckman's two-stage model to analyze the factors influencing households' WTP and their payout level, respectively. The model is expressed as follows and contains the two-stage models Model 1 and Model 2.

Model 1 is a Probit model, which mainly examined the impacting factors for households who are willing to pay for RET. Following [21], the specific model is shown below:

$$E\left(\frac{Y}{M}\right) = \mathrm{P}(Y = 1/M) = \Phi(\mu_0 + \mu_1 M) = \mu_0 + \mu_1 M_1 + \mu_2 M_2 + \mu_3 M_3 + - - - - - - - - + \mu_n M_n + \theta \tag{3}$$

where:

Y is the endogenous variable while M_n are the exogenous variables.
Y = WTP for RETs (Yes = 1, No = 0)
M_1 = Age in years
M_2 = Gender (Male = 1, female = 2)
M_3 = Educational level (Secondary = 1, Tertiary s= 2)
M_4 = Household size in numbers
M_5 = Marital status (Single = 1, Married = 2)
M_6 = Awareness about RETs (Yes = 1, No = 0)
M_7 = Monthly income in Naira
μ = Parameter estimate
θ = error term

Model 2 is a multiple linear regression model, which mainly examined the factors influencing the households' payout level. According to the literature [22], the implicit model is expressed as:

$$T = \varphi_0 + \varphi_1 M_1 + \varphi_2 M_2 + \varphi_3 M_3 + - - - - + \varphi_n M_n + \varepsilon\lambda + \delta \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where:

T is the endogenous variable while Ms are the exogenous variables.
T = Payout level in Naira
M_1 = Age in years
M_2 = Gender (Male = 1, female = 2)
M_3 = Educational level (Secondary = 1, Tertiary = 2)
M_4 = Household size in numbers
M_5 = Household location (Rural = 1, Urban = 2, Peri-urban = 3)
M_6 = Marital status (Single = 1, Married = 2)
M_7 = Monthly income in Naira
φ = Parameter estimate
δ = error term

4. Results and Discussions

This section is divided into three parts. First, we report the socio-economic characteristics of respondents in the Southwestern part of Nigeria. The second part concentrates on their poverty status and WTP for renewable energy services. Lastly, we examine the factors influencing a household's willingness to pay for RETs.

4.1. Sample Characteristics

In Table 1, the descriptive statistics of the socioeconomic characteristics of the surveyed households in Southwestern Nigeria are profiled. The results revealed that most of the respondents are young, with a mean age of 29 $\pm$ 7 years. This indicates that the surveyed households have young household heads, which has many economic implications. About 54 per cent of the sampled households were headed by a female which contradicted previous findings [23,24] reporting that male-headed households dominate the Nigerian population. This result may be attributed to the limitations of the study which adopted a convenient sampling method through online means. The findings relating to average years spent in formal education show that the majority (about 97 per cent) of respondents have tertiary education. As indicated in Table 1, the average household size was 5 members per household, which is similar to the figures reported in a previous study [24]. About three-quarters of the sampled population were married while only one-quarter were single.

Table 1. Socio-economic characteristics of households in the region.

Variable	Description	Southwestern Nigeria (n = 304)
Age	Age of household head (years)	28.62 (6.77)
Gender	Gender of household head (1 = Male, 2 = Female)	1.54 (0.50)
Educational level	Level of education of respondent (Secondary = 1, Tertiary = 2)	1.97 (0.16)
Household size	Number of household members	5.37 (2.35)
Occupation	Primary occupation of respondents (Civil service = 1, Farming = 2, Trading = 3, Others = 4)	2.72 (0.88)
Marital status	Marital status of respondents (Single = 1, Married = 2)	1.73 (0.44)
Social group	Respondents belong to a social group like cooperative societies (Yes = 1, No = 2)	1.26 (0.44)
Household location	The location of the household of respondents (Rural = 1, Urban = 2, Peri-urban = 3)	2.51 (0.80)

Source: Authors' Survey, 2021.

4.2. Household's Monthly Expenditures

Table 2 presents the household's average monthly expenditure on food, non-food and energy. Of the three items, households expend the least amount on energy while the highest expenditure is on food items. The distribution of households' income on these items with the highest expenditure given to food is reasonable given that many have opined that food is the most important of the three basic needs of man—food, clothing and shelter. Although the maximum amount spent by a particular household on non-food items was the highest of the three categories of needs, the lowest amount spent on these items revealed that households place a higher premium on food.

Table 2. Distribution of Household's Average Monthly Expenditure in Naira.

Item	Mean	Std. Dev.	Min	Max.
Food	66,513.16	61,462.48	10,000	800,000
Non-Food	53,505.59	80,184.31	800	890,900
Energy	17,693.13	22,899.74	600	300,000

Source: Field Survey, 2021.

4.3. The Poverty Line

In constructing the poverty line, two-thirds of the mean per capita expenditure (MPCE) was used. The MPCE was calculated as the summation of households' total expenditure on food and non-food items divided by the sample size as shown in Table 3. Following this process, ₦80,412.57 was determined as the poverty line such that households living below this value per month were categorised as being poor, and non-poor if otherwise, as shown in Table 4. However, this value is higher than was reported in a previous study [24] carried out in the Southwestern region. This can be attributed to the nature of the two studies; the earlier study [24] considered the food security status of households and thus used only food expenditure, whereas the current study considered expenditure on both food and non-food items.

Table 3. Mean per Capita Expenditure and Poverty Line.

Estimate	Food	Non-Food	Total
Total expenditure	20,220,000	16,265,700	36,485,700
Mean per capita expenditure (MPCE)	66,513.16	53,505.59	120,018.75
Two-third of the MCPE	44,563.82	35,848.75	80,412.57

Source: Field Survey, 2021.

Table 4. Households' Poverty Headcount, Gap and Severity.

Poverty Status	Estimate	Poverty Line
Head count P_0	0.2993	80,412.57
Poverty gap P_1	0.0827	80,412.57
Poverty severity P_2	0.0351	80,412.57

4.4. Household's Poverty Status

Table 5 presents the distribution of households into poor and non-poor following the analysis above. About 30 per cent of the households in the region are poor. This implies that these households spend below ₦80,412.57 on food and non-food items per month. This result is similar to reports [24,25] that more households in the region are food secure than are food insecure.

Table 5. Distribution of Household's Poverty Status.

Poverty Status	Frequency	Percentage
Poor	91	29.93
Non-Poor	213	70.07
Total	304	100.00

Authors' Survey, 2021.

4.5. Poverty Headcount, Gap and Severity

The poverty incidence shown by the headcount in Table 4 shows that 29.9 per cent of the sampled households are poor. By indication, these are the households whose monthly spending falls below the poverty line of ₦80,412.57. The poverty gap of 0.082 shows that households in the region that are poor will need to raise their monthly expenditure by 8.2 per cent to reach the poverty line. However, poverty severity in the region is very low at 3.5 per cent.

4.6. Reasons for Households' Lack of Usage of Renewable Energy in the Study Area

Table 6 presents the reasons highlighted by households for their lack of usage of renewable energy. The high set-up costs of solar, hydro and portable wind turbines in the region are the most important reasons why households have not embraced renewable energy technologies. Of the sampled households, 83.55 per cent lack knowledge about renewable energies. Almost 60 per cent of the households highlighted the intermittent supply of power from renewable sources as a reason for continuing to use non-renewable sources. While this problem of intermittent power supply from wind and sun has been reported in the literature [2], experts have shown that renewable energies can still meet daily energy needs. The fact that RETs are not common in the region was not highlighted as a major reason for the low uptake.

Table 6. Reasons for Households' Lack of Usage of Renewable Energy.

Reasons	Percentage	Rank
High installation cost	91.45	1
Lack of knowledge	83.55	2
High maintenance cost	76.97	3
Intermittent supply	57.57	4
Not common in the locality	28.62	5

4.7. Factors Influencing Households' WTP for RETs

Table 7 shows the estimated results of the factors influencing households' WTP for RETs. The variance inflation factor enabled us to check for multicollinearity among the dependent variables. Hence, all the variables in the model passed the minimum requirement for inclusion in the analysis. The results in Table 7 show a Pseudo R^2 of 0.2627 implying that the model is of good fit, which is further strengthened by the Likelihood Ratio (LR) test statistic of 4.78 significant at 1 per cent. Using these estimates, we accept the alternative hypothesis that the joint effect of all the explanatory variables has a significant effect on a household's WTP for RETs.

Table 7. Estimates of the Factors Influencing WTP for RETs.

Variable	Coefficient	Standard Error	*P* > /*z*/
Constant	1.8615	1.0223	0.069
Age	0.0503 ***	0.0017	0.000
Gender	−0.2843	1.9511	0.884
Marital status	0.8300 *	0.4833	0.086
Income	0.0044 ***	0.0014	0.003
Level of education	0.0699 **	0.0298	0.019
Household size	0.7896 ***	0.1497	0.000
Awareness	0.2283 ***	0.0237	0.000
LR Chi^2	4.78		
Prob Chi^2	0.0001		
Pseudo R^2	0.2627		

The asterisks (*, **, ***) denote a statistically significant level at 10%, 5% and 1% respectively.

The coefficient of age is positive and significant at 1 per cent. This implies that older household heads have a higher likelihood of being willing to pay for RETs. As many health issues are associated with old age, they will be willing to pay more for RETs which are cleaner energy sources than conventional sources such as firewood. Conventional sources of energy have been reported to have serious health implications through inhalation of fumes during combustion. Marital status is positive and significant at 10 per cent. Thus, married household heads have a higher likelihood of being willing to pay for RETs than single counterparts. This may largely be attributed to the shared responsibilities which come with marriage. The coefficient of monthly income is positive and significant at 1 per cent. Income is an indicator of purchasing power and thus, higher-income earners have higher purchasing power. The direct relationship between income and WTP has been reported by several authors in the literature [7,26]. Household size is positive and significant at 10 per cent. The positive relationship is contrary to previous reports [7] suggesting that because of the attendant cost of meeting other basic needs of a larger household, WTP for new or improved energy sources or RETs will not be a priority. Awareness of RETs is also significant at 1 per cent. Knowledge and awareness of modern RETs is vital for improving their uptake. WTP increases when households become more aware of the benefits of using the new technologies as opposed to the conventional technologies.

4.8. Factors Influencing the Amount Households Are Willing to Pay for RETs

Table 8 shows the estimated results of the factors influencing the amount households are willing to pay for RETs. The R^2 value of 0.5150 implies that about 52 per cent of the variation in the dependent variable is explained by the explanatory variables included in the model. The P>F value is significant at 1 per cent, which shows that the model is a good fit. Using these estimates, we accept the alternative hypothesis that the joint effect of all the explanatory variables has a significant effect on the amount households are willing to pay for RETs.

Table 8. OLS Estimates of the Factors Influencing the Amount Willing to Pay for RETs.

Variable	Coefficient	Standard Error	*p*-Value
Constant	0.1637	0.13825	0.237
Age	0.5576 **	0.2799	0.048
Marital status	10.3134 ***	0.7230	0.000
Level of education	0.1428 ***	0.4361	0.001
Household size	0.5063 ***	0.1325	0.000
House location	0.5509 *	0.4022	0.082
Income	0.6421 **	0.2818	0.024
Gender	0.1226	0.2459	0.619
R-squared	0.5160		
Adj. R^2	0.5030		
RMSE	4.8279		
$P > F$	0.0000		

The asterisks (*, **, ***) denote a statistically significant level at 10%, 5% and 1% respectively.

The result shows that age, marital status, level of education, household size, location and income are positive and significant at different levels. The coefficient of age is significant at 5 per cent, which implies that an increase in age by one year will increase the amount households are willing to pay for RETs by 0.56. The coefficient of the level of education is significant at 1 per cent. This shows that household heads with higher levels of education are willing to pay more for RETs. This is in tandem with other findings [23] reporting that higher educational status predisposes households to higher income, so they can easily afford basic needs especially as these relate to improved quality of life. Marital status is significant at 1 per cent, which implies that married household heads are willing to pay a higher amount for RETs. This may be because of an increase in the sources of income available to the household. The coefficient of monthly income is significant at 5 per cent. Because income is an indicator of purchasing power, an increase in monthly income increases the amount households are willing to pay for RETs. The location of the household is significant at 1 per cent, which indicates that households in urban and peri-urban centres are willing to pay more for RETs. However, household size is positive and significant at 1 per cent, contrary to previous findings [23] that household size is negatively related to household poverty status. However, the positive relationship between the amount willing to pay and household size can be attributed to additional benefits (which may be in form of finance) available to the household by having an additional family member especially one that is gainfully employed.

5. Conclusions

This study examined household poverty status and willingness to pay for renewable energy technology, using evidence from Southwestern Nigeria in the form of primary data collected from 304 households using online means. Despite the popularity and improved uptake of renewable energy technologies in developed economies, Nigeria still lags behind in this respect. Low levels of income and high poverty levels have been reported as possible causes of this. In this study, age, marital status, level of education, household size, house location, income and awareness about RETs have all been shown to influence WTP and the amount that households are willing to pay for modern RETs. However, level of education is the most influential predictor. Based on the findings of this study, it is recommended that the government and other concerned stakeholders should invest in educating the public about the national and global benefits of transitioning to renewable energies in an atempt to mitigate the impact of climate change. This study was limited in the way the data was collected. The questionnaire was administered through various social media channels mainly because of COVID-19 in the study area and the high cost of administering the questionnaire. Thus, no proper sampling could be undertaken. However, the data was thoroughly cleaned before analysis was carried out.

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