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Willingness to Pay for Pome Modern Treatment Technologies For Environmental Sustainability by Smallholder Oil Palm Farmers in Agbo, Delta State, Nigeria.

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ABSTRACT:

The dearth of knowledge on the environmental hazard caused by the release of Palm oil mill effluent (POME) by smallholder oil palm farmers as a bane of health hazard emerged this study. This tends to know the willingness of these farmers to pay for modern POME treatment technologies for environmental sustainability with the objectives of examining their socioeconomic features and determining the factors responsible for their willingness to pay for the technologies. A random sample was employed for 133 respondents from a sample frame of 200 farmers to get valid sample size of 120 respondents from the list of contact farmers in the area at 95% confidence level used for the analysis. The results were analyzed with descriptive statistics and probit model. The result showed 66% of the farmers fell within ages of 45-65 years were in the middle age, 96% married, 17% post primary education, 92% of 1-6 household sizes and 97% farm size of 1-4 hectares. The probit result revealed that age, marital status, household size and distance at 1% each with transportation cost at10% had negative and significant effects while educational level and annual income at 1% with farm size, farming experience, extension services and extension visits at 5% each had positive and significant effects on the willingness to pay for the modern POME treatment technologies. The study recommends that there should be enhanced education / training through increasing farmer's income with a synergy to biotechnological and allied institutions to reduce the waste to enhance environmental sustainability.

Keywords: Environmental Sustainability, Modern Treatment Technologies, POME, Smallholder

INTRODUCTION: The increased demand for vegetable oils and biofuels alongside its environmental pollution due to population pressure has led to the accelerated area expansion of the global oil palm sector lately as the harvested area has expanded by 39% between 2004 and 2013 further till the present, (Sayer, Ghazoul, Nelson, and Klintuni, 2012; FAOSTAT, 2014). Oil palm is no doubt of a great economic benefit to man despite its negative effects due to its pollution and afforestation of other trees causing global warming. Its importance is numerous as it serves different beneficial purposes in proportion to its harmful effects. It serves in the employment generation and as a source of income generating revenue. It is a tree of wealth as from every part of the plant (Nairaland, 2016). There is nothing in palm tree that is wasteful starting from the fronds, the leaves used for brooms, the trunk and the fruits which are used for several purposes ranging from palm oil, palm kernel oil, palm wine, and palm kernel cake; everything is used for one thing or the other that brings benefit to man while the resultant effects is pollution in the course of its production. Outside used as food, the products serves as raw materials to industries in the production of margarine, non-diary creams and ice creams, polish, adhesives, gun powder, animal feeds, fertilizers, pharmaceutical industries in the production of medicines and vaccines, coal tar, among others. It also attracts both direct and foreign investments.

Cultivation of oil palm serves as a means of livelihood for many rural families and indeed the farming culture of millions of people in the country especially these smallholder farmers (Nigerian Institute for Oil palm Research, NIFOR, 2012) who do not take cognizance of the hazards in the production processes. It is the way of life of many Nigerians and their culture (World Rainforest Movement,WRM, 2010). The competition, usage and high demand in the products due to increasing population has mounted pressure on the sector leading to rapid expansion in the area thereby increasing the level of pollution of the area. The rapid expansion of oil palm sector has led to significant land-use changes, thereby affecting both the environment and human activities causing a lot of environmental externalities that may mar the existence of mankind and its functional performances, (Abood, Lee, Burivalova, Garcia-Ulloa, and Koh, 2015; Barnes, Jochum, Mumme, Haneda, Farajallah, Widarto, and Brose, 2014; Margono, Potapov, Turubanova, Stolle, and Hansen, 2014; Wilcove and Koh, 2010). This was as a result of the release of some environmentally unfriendly substances such as POME and other waste products in the cause of the processing activities to the environment by these farmers

Palm oil mill effluent (POME) is the quantity of liquid waste or residue that comes from the sterilization and clarification process in milling oil palm containing about 90-95% water with residual oil, soil particles and suspended solids. POME is said to be the product of 5 - 7.5 tons of water from 1 ton of crude palm oil produced (Ahmad, Ismail, Bhatia, 2003). However, POME is not only the waste generated but the most expensive and difficult waste to manage by mill operators as its treatment is more of a burden rather than as part of the production process causing them to dispose it raw to the environment. POME is made from the abundant liquid waste from palm oil processing mill that creates a serious pollution problem due to its high amount of toxins, organic and inorganic materials to the environment as untreated POME is still being discharged into nearby rivers or land surface by these farmers as it is the easiest and cheapest method for disposal thereby polluting the environment more (Yahaya and Lau. 2013). POME is a strong pollutant due to the high concentration of 10,500 mg L^{-1} oil and grease against the maximum limit of 25 mg L^{-1} recommended in the Environmental Management Guideline for the Palm Oil Industry (Ebenezer, Mutiu, Oreoluwa, Olushola, (2021). POME could be treated to be useful or untreated to cause environmental pollution.

The untreated POME has extremely high content of degradable organic matter with highly polluting effects causing pollution of waterways due to oxygen depletion and suffocate aquatic life and other related effects (Ahmad, Ismail and Bhatia ., 2003; Okwute, and Isu, 2007).This occurs as POME uses the available oxygen in the river for degradation process thereby suffocating aquatic animals leading to death as opined by Razak, Bohari, Fishal, Mohamad, Azmi, Razali, and Ibrahim, (2022). Untreated discharged POME in the open or ponds leads to the emission of greenhouse gases depleting the ozone layers thereby causing global warming and bad odour emission to the environment that is hazardous to the inhabitants (Chavalparit, 2006). It causes the contraction of major minerals and trace elements that are harmful to living organism (Bankole and Ikhatua, 2009). It denatures the growth of soil micro-organisms such as the soil fauna and flora affecting the suitability of the soil for crop production which has direct and significant effects on smallholder farmers' activities at the long run. POME generates negative externalities, although not readily considered by these farmers as the private benefits dominate the private costs enough to sustain their livelihood. The overall outcome of it may affect the life of most of them within the dwellings of their operational activities where it is released due to the offensive odour from the waste sites causing a lot of health hazards, soil degradation, and unsustainable soil resulting to low productivity as most of them are constrained to the treatment of POME with some modern biotechnological processes and POME treatment technologies such as POMETHANE (Madaki and Seng, 2013).

POMETHANE is a modern biotechnological treatment system of an anaerobic thermophilic digestion process which maximizes the yield of biogas production, converting and or changing the status of POME from waste to useful resources that are environmentally sustainable. The anaerobic digestion of POME has been used to generate

Methane, a greenhouse gas, which is 25 times more potent than carbon dioxide in trapping heat (Yahaya and Lau, 2013). The Anaerobic degradation process has been proven in reducing the pollutant properties in POME up to 85% (Razak et al., 2022). In the same way, a high possibility for biological treatment could be in the ratio of 0.5 for biological oxygen demand to chemical oxygen demand (BOD/COD) according to Mad, Khairul, Moetaz, Syed, Ehssan, Yaacob, Amimul, Monzur and Arifuzzaman, (2020) ; Debbie and Siti, (2022). This is among the sole responsibilities of the newly established UNESCO International Centre for Biotechnology at University of Nigeria Nsukka with their sophisticated equipments for zero pollution tolerance while ensuring adequate food security and sustainability. The aim is to convert and recycle most of the environmental polluting substances in the course of agriculture and food production using biotechnological means for useful purposes in relation to environmental friendliness. POME could be useful when treated with biotechnological tools as a cheap organic fertilizer that is environmentally friendly over the artificial one (Wu, Mohammad, Jahim, and Anuar, 2009). The biologically treated POME is used in oil palm plantations for irrigation and as a liquid fertilizer that does not have negative effects to the environment (Wu et al., 2009).

Irrespective of the advantages of the treatment technologies and its environmental sustainability, smallholder oil palm farmers still dispose the untreated POME as waste to the environment. This result to depleting the environment more due to dearth of information, constrained with a lot of challenges and lacks the capacity to POME modern treatment technologies despite the economic benefits and environmental sustainability in accordance with of the growing policy measures and concern on the environmental issues. The inabilities of the farmers to modern biotechnological treatments technologies prompted the study hence the likelihood of the farmers to pay for the treatment technologies will The Sample Size formular is giving as:

reduce the negative effects of POME for environmental sustainability and balance the ecosystem. However, environmental sustainability is responsible for the interaction of the activities of POME (by regenerating it to some useful resources) with the environment to avoid depletion or degradation of natural resources and allow for long-term environmental quality. This study tends to know the willingness of these farmers to pay for the POME modern treatment technologies by examining the socioeconomic features of the farmers and to determine the likelihood of them to pay for the technologies.

METHODOLOGY: This research was done in Agbo, the headquarters of Ika South Local Government Area of Delta State, Nigeria. It is located on latitude 6.2541^0N and longitude 6.2057^0 E on the elevation of 130 meters (427 feet) with a population of 45,800 people (Wikipedia Open Data). The high concentration of oil palm production activities with regular discharge of these wastes as pollutants by smallholder oil palm farmers was the interest for the study. Information was sourced using both primary means from a well-structured questionnaire and secondary means from bulletins, magazines, publication and internet. Primary data obtained was used for the analysis. A random sample of 133 respondents were chosen from a sample frame of 200 farmers to get valid sample size of 120 respondents from the list of contact farmers in the area at 95% confidence level used for the analysis. This was because of unequal number of farmers across the area as equal number is imperative. The data were analyzed with descriptive statistics such as the frequencies and percentages for the socioeconomic characteristics like; age, sex, marital status, household size, farming experience, farm size, annual income etc while the probit model was to determine the willingness to pay for POME modern treatment technologies by smallholder oil palm farmers.

$$S = \frac{N}{1+N(e^2)} \quad \text{.....(1)}$$

Where;

S = sample size

N = Total population of contact smallholder oil palm farmers in the Area

e = Critical level (100 -95)% = 5%

Information obtained from the farmers were illicited using the Contingent Valuation Method (CVM) to establish if smallholder farmers will / will not pay for the technologies at a particular price. Data collected from the information and ranked using Likert Scale Model rating on a four point rating scale of; "Strongly Agreed, Fairly Agreed, Agreed and Disagreed" to get the values that were used for the analysis. Results were analyzed with descriptive Statistics such as frequencies and percentages for the socioeconomic characteristics and Econometric Tool such as the Probit Model because of its dichotomous nature to explain the yes / no decision by set of variables relating to smallholder characteristics willingness or not willing to pay. The socioeconomic features tested were; age, sex, marital status, educational level, household size, experience, farm size, annual income etc. The values of the explanatory variables were fitted into the Probit model for the analysis to determine the likelihood of the willingness to pay for the POME modern treatment technologies by smallholder oil palm farmers. Probit model was chosen because of its binary nature and has been used by some authors to determine the likelihood to pay for particular goods and services (Aklilu, 2002: Akinyemi, Ekpa, and Adetunji, 2014).

The Probit model form is:

$Y = \alpha + \beta_1 X_1 + \beta_n X_n + \varepsilon$…….(2)

α = intercept/constant
$\beta_1 - \beta_n$ = Coefficients of the Variables
ε = Error Term
X_1= Age (years)
X_2 = Sex (Male = 1 or female= 0)
X_3 = Marital Status (dummy= 1 or 0)
X_4 = Educational Level (No)
X_5 = Farming Experience (years)
X_6 = Farm Size (Ha)
X_7 = Household Size (No)
X_8 = Annual Income (Naira)
X_9 = Extension Services (No)
X_{10} = Visits / contacts (No)
X_{11} = Transportation cost (Naira)
X_{12}= Distance (kg)

Where Y is the yes/no response for the willingness to pay or not, α is the intercept, X_1-X_n is a vector of independent variables (socioeconomic characteristics; age, sex, educational level, sex, experience, farm size etc, income, distance, transportation cost, extension services, visits etc), β_1- β_n is the coefficients and ε is an error term.

. RESULTS AND DISCUSSION:

Table 1: Socioeconomic Features of the Respondents

Variables	Frequency	Percentage	Variables	Frequency	Percentage
Age			**Extension contact**		
25 – 45	20	17	1-5	110	92
45 – 65	80	66	6-10	8	6.6
≥ 65	20	17	≥ 10	2	1.6

Total	**120**	**100**	**Total**	**120**	**100**
Sex			Farm Size (ha)		
Male	115	96	1-2	100	83.3
Female	5	4	3-4	17	14.2
Total	**120**	**100**	≥ 5	3	2.5
Marital Status			**Total**	**120**	**100**
Single	5	4.2	HHSize		
Married	115	95.8	1-3	50	41.7
Total	**120**	**100**	4-6	60	50
Educational Level:			≥ 6	10	8.3
Non formal	40	33.3	**Total**	**120**	**100**
Primary	60	50	Annual income		
Secondary	15	12.5	<₦100000	30	25
Tertiary	5	4.2	₦100000-₦200000	60	50
Total	**120**	**100**	≥ ₦2000000	30	25
Farming Experience (yrs)			**Total**	**120**	**100**
< 10	20	17	Distance		
10 – 20	40	33.3	1-5	10	8
20 – 30	40	33.3	6-10	20	17
≥ 30	20	17	≥10	90	75
Total	**120**	**100**	**Total**	**120**	**100**

Source: Field Survey 2022

The result showed that 66% of the farmers fell within ages of 45-65 years are in the middle/old age with lesser strength and less concerned with the adoption / payment of the modern treatment technologies for environmental sustainability as they freely disposed their wastes for years making them less willing to pay for modern technologies (Awunyo-Vitor, Ishak and Jasaw, 2013). The result from sex indicated that 96% of them were males in the business as oil palm investment is known as a male enterprise that may likely adhered to their old practice than to consent for the payment of the modern treatment technologies for a friendly environment. The result further showed that 96% were married. The high level of married farmers indicated that oil palm farmers in the area are responsible and may likely have large size of family labour for increase in production, generates more waste and likely to pay to avoid disease infestation of the family (D a g n e w, Al e mu, a n d Ze n e b e, 2012). It could be seen that only 17% of them had post primary education. However, this level of education may not equip and expose the oil palm farmers with enough managerial skills for agri-business, health management strategies, adoption and concise reason for the payment of the new technologies as education enlightens them by getting information and the information creates awareness and convinces them about the benefits obtained from improved treatment technologies (Tesfahun , 2014). It showed that 66% of them had 10-30 years of experience and are used to their old system hence might be unwilling to pay extra cost for the treatment. Farm size indicated that 97% of them plants between 1-4 hectares which is within the range of smallholder farmers but less likely to pay for the modern treatment technologies due to the limited farm size with respect to the outputs. The result showed that 92% of them had a household size of 1-6 persons on average as not much. This is in contrast with the findings of Abdarbo, (1996) who opined that as the number of households increases, the tendency to clean their environment to avert harm by disease outbreak as to enhance environmental sustainability

The annual income indicated that 75% of them earned less than ₦200000 per annum while 25% earn more than ₦200000 per annum as compared to the estimated average annual output (income) of integrated smallholder oil palm farmers from 2.7 – 7.4 tons per hectare in Nigeria (Solidaridad, 2020) which were not a motivating factor for the alternative modern treatment technologies. The result further showed that 75% of them had a distance of ≥10 kilometers to access the technologies coupled with the high transportation cost which is a discouragement on their willingness to pay.

Table 2: Probit Model Estimates of WTP for Modern POME Treatment Technologies

Variables	Coefficients	Std. Eror	Z-Value	P-Value
CONSTANT	-4.343**	-3.1010	-2.66	0.0020
AGE	-0.0316***	-0.0102	-3.10	0.0050
Sex	0.005	0.002	1.404	0.044
Marital Status	-0.841***	-0.4010	-3.58	0.0780
Educational Level	0.016***	0.018	3.44	0.066
Farming Experience	2.011**	-0.6210	2.62	0.0110
Farm Size	0.222**	-0.0641	2.71	0.0010
Household Size	-0.003***	0.002	-3.822	0.002
Annual Income	0.004***	-0.0010	6.562	0.1960
Extension Services	2.474**	0.005	2.85	0.26
Visits	0.335**	-0.0100	2.74	0.344
Transportation cost	-0.653*	-0.5120	-1.98	0.0980
Distance	-0.0548***	-0.0230	-3.78	0.0030
Observation	120			
Psuedo R^2	0.687			

Source: Field Survey Data, 2022

Significant at 1%= ***, 5% = ** and 10% = * respectively

The result of the probit model analysis revealed that age, marital status, household size. transportation cost and distance had negative and significant effects on the willingness to pay for the modern POME treatment technologies. It further showed that educational level, farm size, farming experience, income, extension services and extension visits had positive and significant effects on the willingness to pay for the modern POME treatment technologies. The findings showed that age had a negative significant effect at 1% level implying that any addition in age leads to a 3.10% decrease in the willingness to pay for the modern POME treatment technologies. This indicates that the older the farmer the lesser the likelihood to pay for the technologies (Gebrelibanos, 2012). The result showed that any addition in marital status leads to a 3.58% decrease in their likelihood to pay for the modern POME treatment technologies as opined by (Akinyemi, Ekpa and Adetunji, 2014). Also, increase in the population of household size leads to a proportionate 3.822% decrease in the tendency to pay for the technologies in contrast to the finding of Abdarbo, (1996). This could be as a result of large household size to carter for and the use of family labour (Akinyemi, Ekpa and Adetunji, 2014). The result revealed that any addition to transportation cost and distance to cover by either the farmers to access modern treatments technologies from biotechnology centres and its affiliates leads to proportionate decrease of 1.98% and 3.78% of the farmers willingness to pay for the technologies as most of them are unwilling and lacks the capacity to bear the responsibilities sticking to their old disposal means thereby affecting the environmental sustainability of the area. The result further revealed that educational level, farming experience, extension services and visits showed that knowledge is the key and a great motivator for the willingness to pay for the modern POME treatment technologies for environmental sustainability. It equally showed that Farmer's income was an incentive in the likelihood to pay for the technologies. This implies that as the income of the farmers increase the probability of them to pay

for the technologies for sustainable environment (Rahji & Oloruntoba, 2009). This is line with economic theory that income is proportional to the demand of general goods such as environmental demand (goods) as a normal good since its demand increases with income as opined by Niringiye & Omortor (2010). The coefficient of variation of 0.687 or 68.70% willingness to pay for the modern POME treatment technologies was accounted for by the included explanatory variables in the model.

CONCLUSION: It could be observed that the willingness to pay for the modern POME treatment technologies by smallholder oil palm farmers for environmental sustainability in Agbo, Delta State was associated with some factors. These were age, marital status, household size. transportation cost and distance that were militating against the likelihood to pay for modern POME treatment technologies for sustainable environment while educational level, farm size, farming experience, income, extension services and extension visits were the likelihood to pay for the modern POME treatment technologies. The study recommends that there should be enhanced education / training of the farmers to increase income, exposing them to the benefits of the modern POME treatment technologies with a synergy from biotechnological and allied institutions to reduce and recreate wastes for environmental sustainability.

Therefore, in a bid to enhance the likelihood to pay for the modern POME treatment technologies for sustainable environment, there should be enhanced education / training to increase income and by exposing them to the benefits while exploring their farming and life activities. There should be a synergy between the farmers and these biotechnological and allied institutions as to create, maintain and recycle these products through enlightenment via training and workshops.

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