

## The Impact of Improve Cookstoves on Environmental Sustainability

Dickens E. Dolor, Oghenekevwe A. OHWO, Ben-Collins O. Okonta, Nelly U. Ureigho, Felix E. Robert, Eduvie Okoromaraye And Kehinde Okunomo

Department of Forestry and Wildlife, Delta State University, Abraka, Nigeria

Received: 02 December 2025

Accepted: 15 December 2025

Published: 27 January 2026

**\*Corresponding Author:** Dickens E. Dolor, Department of Forestry and Wildlife, Delta State University, Abraka, Nigeria.

**Abstract** Most Nigerian households depend on fuelwood for cooking, which contributes significantly to environmental degradation. To mitigate this menace, adoption of improved cookstoves (ICSs) which reduce/prevent fuelwood usage for cooking in view of environmental sustainability is needed. The study assessed impact of ICSs on environmental sustainability. Multistage sampling was adopted to collect data from 428 households in Delta State through structured questionnaire. Likert scale analyzed household level of awareness and perception of ICSs. Logistic regression examined determinant of Willingness to Pay (WTP) for ICSs. Most respondents were within the age bracket of 21 - 40 years (57.6%) with secondary education (38.2%), had medium sized households (4 – 6 household members) (47.2%), and traders with income ranging within ₦185,000 – ₦284,999 (41.0%). About 62.7% utilize fuelwood for energy with  $X = 2.9 \pm 0.08$  being aware of the different types of ICSs from neighbors (74.4%). Respondents were aware of benefits of ICSs with means of various benefits above 2. Respondents' perception about ICSs was high with ICSs less bulky to traditional stove ( $3.7 \pm 0.04$ ). Respondents' level of adoption of ICSs was high for clay mould Garri fryer ( $3.9 \pm 0.48$ ), traditional cookstoves ( $3.7 \pm 0.09$ ) and clay mould cooking stoves ( $2.4 \pm 0.34$ ). Respondents do not have access to ICSs (92.2%) and credit (96.7%) with 61.1% and 81.0% WTP ₦6,000 (\$4.04) and ₦3,000 (\$2.02) respectively for purchase of ICSs. The significant determinants of WTP for improved cookstoves are educational qualification, household size, income level and type of ICSs. Synergy between intervention programme implementers and existing governmental agencies is needed to provide more targeted subsidies and credit options in order to address the barrier of availability and affordability of ICSs.

**Keywords:** Improved cookstove (ICS), Awareness, Perception, Willingness to Pay (WTP).

### 1. INTRODUCTION

Globally, over three billion people rely on burning biomass fuel, including firewood, charcoal, and agricultural residues for their daily cooking, in rudimentary or traditional stoves, on stones, over an open fire or metal platform (WHO, 2018; Stoner, et al. 2021; Jewitt et al. 2020). The use of firewood and charcoal for household cooking in Nigeria is estimated at 24,000,000 tons and 5,000,000 tons, respectively in 2021, the most consumed domestic fuel sources in Nigeria (Laska and Ige 2023). The unsustainable use of fuelwood, a major biomass fuel for cooking and heating in homes and small businesses globally is a major challenge especially in the global south (Ogeh, 2023; Dolor et al. 2023). According to the UNDP (2017), Nigeria's environment is highly vulnerable to the negative effects of the unsustainable environmental and natural resources management with over 70 percent of the more than 170 million inhabitants still relies on biomass fuel for cooking. This has resulted in cutting down of over half of the country's primary forest in the last 10 to 20 years.

The growing demand for biomass fuel (wood and charcoal) and the preference for the highly inefficient traditional cookstove or wood-fueled three stone stoves (WFTSS) by a vast majority of the inhabitants have further exacerbated the situation, leading to a systemic diminishing fuelwood supply, deforestation and de-vegetation on a regional and national scale (Orimoogunje and Asifat, 2015; Ohwo and Nzekwe-Ebonwu, 2021). In Africa, over 80% of the population especially in the rural areas relies on solid biomass for cooking (Abanikaanda and Dantani, 2021) and only 11% make use of improved cookstoves.

The age long practice of cooking with traditional cookstoves, indoors, in poorly ventilated spaces have been linked to numerous health problems like acute respiratory infections, asthma, tuberculosis, pneumonia, lung cancer, eye irritation, cataract, etc., especially in women and children, under the age of five (Wang and Bailis, 2015; USAID, 2018; IEA, 2018). Household air pollution from using inefficient cookstoves resulted in premature death of 3.2 million people annually (WHO, 2024). Women and children are at risk from air pollution as they are saddled with prevailing gender norms in Africa for firewood collection and preparation of meals for the family (Listo, 2018; Sovacool, 2012). Additionally, unsustainable biomass fueled cooking is linked to habitat degradation, carbon emission and global warming (Sovacool, 2012).

In recognition of the facts that in decades to come fuelwood will remain the main source of fuel for cooking among the poor and vulnerable populations in developing countries, the United Nations Foundation, along with its funding partners established the Global Alliance for Clean Cookstoves, (now the Clean Cooking Alliance) in 2010 to foster the adoption of clean cookstoves, and fuels to improve livelihoods, save lives and empower women in 100 million households by 2020. Ürgen-Vorsatz *et al.* (2012) reported a significant global emission mitigation potential of 0.6 to 2.4 Gigatons of CO<sub>2</sub> annually with shift from traditional to improved cookstoves. Energy efficient stoves capable of cutting fuel use by 30 to 79% have been reported by Bantu *et al.* 2018; USAID, 2018). The use of improved cookstoves has been shown to be more efficient, reduce gas emission, improve health and reduce deforestation (Price, 2017). Furthermore, beyond the potential reduction in fuel consumption and toxic gas emission, energy efficient cookstoves use is time saving, improves safety, reduces cost among others (USAID, 2018).

However, improved cookstoves adoption among rural community dwellers in the third world countries is low and slow. The continuous dependence on fuelwood for household cooking by rural dwellers has contributed greatly to the depletion of the forest estate and the current climate change crisis. It is therefore important to state that fuelwood collection from the already degraded forests may not be minimized until there is sustained attempt to significantly improve the use of fuel efficient cookstoves. Many researchers have identified socio-economic, environmental, fuel availability and access, as factors influencing clean cookstoves adoption (Dresen *et al.* 2014; Malakor, 2018; Karanja and Gasparatos, 2020; Tambunan *et al.* 2022). Keese *et al.* (2017) reported a gradual adoption of clean cookstoves adoption in Cuzco region of Peru. This corroborates the findings of Ruiz-mercado *et al.* (2011), who reasoned that adoption is a 3 stage process, beginning with initial household acceptance level, progressing to a level of sustained use. They reported further that the users are expected to maintain sustainable or maximum level of adoption without reverting to the level of dis-adoption under close learning and monitoring over time.

This study evaluated the impact of improved traditional cookstoves adoption on environmental sustainability in Delta State. The outcome of this research is expected to create awareness and also highlight the potentials of improved traditional cookstove use to reduction of carbon emissions, deforestation and desertification. It is believed that the paper would serve as a guide to policymakers, researchers and organizations interested in the introduction and scaling up of improved cookstove adoption.

## 2. MATERIALS AND METHODS

### 2.1. The Study Area

The study was conducted in eighteen (18) selected communities from the three senatorial zones in Delta State. Delta State lies between longitude 5° and 6° 45' East and latitude 5° and 6° 30' North. It is within the rain forest zone with a yearly rainfall of 1,500mm-1,847.3mm. The area experiences double maxima of rainfall between June/July and September/October, a least and highest temperature of 26°C and 36°C and a mean temperature of 33°C. Sunshine is 8.1bars (Asaba Meteorological Station 2017)

### 2.2. Data Collection and Analysis

A multi-stage sampling procedure was employed for the study. The first stage involved a random selection of two LGAs each from the three senatorial zones of the state. The second stage involved the random selection of three communities from each of the selected LGAs, while in the third stage thirty respondents were purposively selected from each of the eighteen communities, translating to a total of



**Table 1.** Socio-economic Characteristics of Respondents

Socio-economic characteristics	Frequency	Percentage (%)
<b>Age</b>		
0 – 20	5	1.2
21 – 40	248	57.9
41 – 60	152	35.6
61 above	23	5.3
<b>Total</b>	<b>428</b>	<b>100.0</b>
<b>Sex</b>		
Male	163	38.2
Female	265	61.8
<b>Total</b>	<b>428</b>	<b>100.0</b>
<b>Educational qualification</b>		
No formal Education	18	4.3
Primary school	154	35.9
Secondary school	164	38.2
NCE/ND	27	6.3
Degree/Equivalent	65	15.3
<b>Total</b>	<b>428</b>	<b>100.0</b>
<b>Household size</b>		
1 – 3	103	24.0
4 – 6	202	47.2
7 – 9	91	21.4
10 and above	32	7.4
<b>Total</b>	<b>428</b>	<b>100.0</b>
<b>Occupation</b>		
Farming	121	28.2
Trading	173	40.5
Fuelwood/Charcoal extraction	13	3
Hunting/NTFP collection	37	8.7
Civil Servant	26	6.1
Others	58	13.5
<b>Total</b>	<b>428</b>	<b>100.0</b>
<b>Income per annum</b>		
₦185,000 – ₦284,999	276	64.4
₦285,000 – ₦384,999	40	9.3
₦385,000 – ₦484,999	39	9.1
₦485,000 – ₦584,999	26	6.1
₦585,000 – ₦684,999	27	6.3
₦685,000 – ₦784,999	14	3.3
>₦784,999	6	1.5
<b>Total</b>	<b>428</b>	<b>100.0</b>

Source: Field survey, (2024)

### 3.2. Distribution of respondents according to their type of energy use

The distribution of respondents according to types of energy used for cooking (Table 2) indicated that firewood is the most used (62.7%) source of fuel for cooking, followed by kerosene (19.4), LPG (17.2), while Charcoal (0.6) and electricity (0.2) were the least. These ranking reflected findings of the Energy Commission of Nigeria, cited by David-Sarogoro et al., (2019) showing firewood were most used with 92.2%, followed by kerosene (7.3%), LPG (0.4% and charcoal (0.1%). The intense usage of fuelwood to other energy source is tied to the relatively no cost of purchase, availability and cheap prices where cost is involved. Firewood is obtained free of charge from the forest and this tends to show why there are fewer numbers of fuelwood sellers among the respondents.

This collaborates the findings of Lawal et al. (2023) that most rural communities in Niger state regards fuelwood as an endowment given by God, and is freely available. The petrol price hikes and unavailability of kerosene have further increased fuelwood dependence (National Bureau of Statistics 2023; Kanu and Osuji, 2024). However, households who use kerosene or LPG for cooking, still regularly use their traditional stoves (stove stacking). In stove stacking, the possession of a stove type

or category does not necessarily guarantee one’s interest in using it as many factors come into play. This is because one could prefer a stove type but, because of lack of finance, resorts to using a cheaper one. The results of the survey imply that most of the households seldom use the kerosene or LPG stoves due to the high cost of refilling. This was collaborated by Hooper *et al.*, (2018) findings that while 26% of households in Niakhar region of Senegal have LPG stoves, less than 1% uses LPG primarily for cooking.

**Table 2.** Distribution of respondent by energy used

Variable	Frequency	Percentage (%)
LPG	73	17.2
Kerosene	83	19.4
Firewood	268	62.7
Charcoal	3	0.6
Electricity	1	0.2
<b>Total</b>	<b>428</b>	<b>100.0</b>

Source: Field survey, (2024)

### 3.3. Level of household awareness of the benefits of improved cookstoves

Table 3 shows the Level of household awareness of the benefits of improved cookstoves. Generally, the respondents are aware of the potential benefits and availability of improved cookstove over the traditional ones. The mean ( $\bar{X}=2.1$ ) result shows that respondents are aware that improved cookstove can be used for cooking and heating,  $\bar{X}=2.9$  shows that the respondents are aware of the availability of the various type of improved cookstove,  $\bar{X}=2.7$  indicates that respondents are aware that improved cookstoves are readily available in their locality and  $\bar{X}=2.0$  shows that respondents are just sufficiently aware of improved cookstoves and its health benefits. These results are in disagreement with Rogers (2003) assertion that majority of respondents in rural areas are not aware of most improved cookstove technologies.

**Table 3.** Level of household awareness of the benefits of improved cookstoves

Awareness	Very aware	Aware	Not very aware	Not aware	Mean/Standard error
(i). Are you aware that clean cookstoves can be used for cooking and heating?	71(16.7)	43(10.0)	167(38.9)	147(34.4)	2.089±0.09
(ii). Are you aware of the various types of clean cookstoves?	128(30.0)	128(30.0)	143(33.3)	29(6.7)	2.900±0.08
(iii). Are you aware that clean cookstoves are readily available in your locality?	147(34.4)	62(14.4)	167(38.9)	52(12.2)	2.711±0.10
(iv). Are you aware of the benefits of using clean cookstoves?	14(3.3)	48(11.1)	309(72.2)	57(13.3)	2.044±0.06
(v). Are you aware that using clean cookstoves can save fuel wood/charcoal?	19(4.4)	76(17.8)	276(64.4)	57(13.3)	2.133±0.12
(vi). Are you aware that using clean cookstoves can reduce time spent on wood/charcoal collection?	19(4.4)	81(18.9)	276(64.4)	52(12.2)	2.156±0.09
(vii). Are you aware that using clean cookstoves can save time on meal preparation?	19(4.4)	57(13.3)	314(73.3)	38(8.9)	2.133±0.07
(viii). Are you aware that using clean cookstoves can reduce exposure to smoke and harmful gasses during cooking and heating?	14(3.3)	43(10.0)	314(73.3)	57(13.3)	2.033±0.06
(ix). Are you aware that using clean cookstoves can improve your health?	19(4.4)	47(11.1)	319(74.5)	43(10.0)	2.100±0.09

Source: Field survey, (2024)

### 3.4. Source of Information on Improved Cookstove

Entries in Table 4 show that friends and neighbors ranked highest (74.4%) as the source of information on improved cookstove by households in the area of study. Adverts by Non-

Governmental Organisations (NGOs) and Cooperative Societies was ranked second most used sources (15.2%) while newspapers (6.7%), internet (2.2%), television (1.1%) and Agric/Forest Extension Agents (0.4%) were the other sources of information.

These findings are in line with the researcher expectation because friends and neighbor often interact among themselves and pass information during such interactions which is also similar to the findings of Sanni et al., (2009). The poor rating of information from television, and internet is not surprising as electricity supply to most rural communities in Nigeria is abysmal. Similarly, lack of services of Agric/Forest Extension Agents as sources of vital information in rural areas in Nigeria is obviously evident from the result.

**Table 4.** *Source of Information on Improved Cookstove*

Variable	Frequency	Percentage	Rank
Television	5	1.1	5
Friends/ Neighbors	318	74.4	1
Newspaper	29	6.7	3
Internet	9	2.2	4
Avert by NGOs, Cooperative Societies	65	15.2	2
Agric/Forest Extension Agents	2	0.4	6
<b>Total</b>	<b>428</b>	<b>100</b>	

Source: Field survey, (2024)

### 3.5. Perception on the use of Improved Cookstoves

The result of perception on the use of clean cookstoves is presented in Table 5. The overall result indicates a high perception of the use of improved cookstoves. The mean result (3.2) shows that the respondents would prefer clean cookstoves to traditional stove. The mean result (2.5) indicates that the respondents disagreed with perception that clean cookstoves is not a better alternative to traditional stove. However, the mean (3.2) result shows that the respondents agreed with the idea that clean cookstoves are useful only with small family size. Clean cookstove is not readily available to buy compared to traditional stove (3.5), clean cookstove is less bulky than traditional stoves (3.0), clean cookstove is more economical than traditional stove (3.5) and clean cookstove is not more environmentally friendly than traditional stove (3.6). The mean of means indicates that the respondents agreed with the perception on the use of clean stove. This result agrees with Johnson (2013) who recorded high level of agreement of technologies adoption.

**Table 5.** *Perception on the use of improve cookstove*

Perception	Strongly Disagree (%)	Disagree (%)	Not Sure (%)	Agree (%)	Strongly Agree (%)	Mean
I will prefer clean cookstove to traditional stove	24(5.6)	138(32.2)	86(20.0)	100(23.3)	81(18.9)	3.178±0.11
Clean cookstove is not a better alternative to traditional stove	124(28.9)	28(6.7)	205(47.8)	67(15.6)	4(1.0)	2.533±0.08
Clean cookstove is useful only with small family size	34(7.8)	52(12.2)	185(43.3)	90(21.1)	67(15.6)	3.244±0.10
Clean cookstove is not readily available to buy compared to traditional stove	48(8.9)	18(3.3)	216(40.0)	138(25.6)	120(22.2)	3.489±0.09
Clean cookstove is less bulky than traditional stoves	0(0)	45(10.6)	45(10.6)	318(74.3)	19(4.5)	3.727±0.04
Clean cookstove cannot cook large amount of food	62(14.4)	76(17.8)	204(47.8)	67(15.6)	19(4.4)	2.778±0.07
Clean cookstove is more economical than traditional stove	19(4.4)	219(51.1)	167(38.9)	19(4.4)	4(1.1)	3.467±0.09
Clean cookstoves is not more environmentally friendly than traditional stove	19(4.4)	24(5.6)	152(35.6)	133(31.1)	100(23.3)	3.633±0.08

Source: Field survey, (2024)

The level of adoption of improved cookstoves as presented in Table 6 shows that clay mould garri fryer, clay mould cooking stoves and traditional cookstoves have high level of adoption with mean values of 3.92, 2.39 and 3.74 respectively. The high level of usage of these cookstoves is tied to the ease of access and low cost of production. Also, the heat retention effect of clay pots and low quantity of fuelwood consumption further heightens its usage which makes it environmental friendly curbing deforestation due to fuel wood harvesting. The low usage of other improved cookstoves technology may be due to the high cost of purchase and availability as further buttressed by the result in Table 7 where 92.2% and 96.7% of the respondents do not have access to improved cookstoves and loans respectively.

**Table 6.** Level of adoption of improved cookstoves

Technology	Always	Occasionally	Seldom	Not at all	Mean/Standard error
I use Garri fryer (Clay mould)	404(94.3)	13(3.1)	9(2.0)	3(0.6)	3.916±0.48
I use clay mould cooking stove	42(9.9)	129(30.1)	207(48.3)	50(11.7)	2.386±0.34
I use firewood Improved cookstove	31(7.2)	44(10.3)	10(2.4)	343(80.1)	1.446±0.44
I use charcoal Improved cookstove	0(0)	17(3.9)	23(5.3)	389(90.8)	1.133±0.15
I use sawdust stove	0(0)	1(0.2)	4(1.0)	423(98.8)	1.014±0.58
I use traditional Garri fryer	5(1.1)	27(6.2)	70(16.4)	314(73.3)	1.297±1.00
I use traditional cookstove	350(81.8)	49(11.5)	24(5.6)	5(1.1)	3.738±0.09
I use traditional charcoal cookstove	0(0)	73(17.1)	89(20.7)	266(62.2)	1.549±0.12

Source: Field survey, (2024)

**Table 7.** Access to improve cookstoves and credit

Variable	Yes/%	No/%
Do you have access to improved cookstove	33(7.8)	395(92.2)
Do You Have Access To Loan	14(3.3)	414(96.7)
Have you borrowed in last three months	0(0)	428(100)

Source: Field survey, (2024)

**3.6. Willingness to pay for clean cookstoves**

About 61.1 and 81.0 percent of the respondents were willing to pay the sum of ₦6,000 (\$4.04) and ₦3,000 (\$2.02) respectively for the purchase of clean cookstoves while majority of the respondents declined to pay values above this amount for improved stoves (Table 8). Cost and benefits of new technology is often considered in its adoption. Although the respondents are well aware of the benefits and have good perception of improved cookstoves, the cost of purchase hinders their adoption. The cost of the improved clean stoves to the respondents outweighs its benefit in regards to its adoption and agrees with Asiabaka and Owen (2002) and Rogers (2003). Foster and Rosenzweig (2010) observed that cost of adoption is a barrier to diffusion of technologies in low income countries. This further unveils the level of environmental cautiousness of respondents as perceived from the result that they are unlikely willing to sacrifice for environmental sustainability with regards to energy consumption, however, according to Ohwo et al., (2024) respondents were willing to pay for urban tree retention for recreational purposes.

**Table 8.** Willingness to pay for clean cookstove

Variable	Frequency	Percentages (%)
Willingness to pay ₦18,000 (\$12.13) for ICS as it is healthier and environmentally friendly than traditional stove		
Yes	100	23.3
No	328	76.7
Total	428	100
Willingness to pay ₦15,000 (\$10.11) for ICS as it is more convenient than traditional stove		

## The Impact of Improve Cookstoves on Environmental Sustainability

Yes	86	20.0
No	342	80.0
Total	428	100
Willingness to pay ₦12,000 (\$8.09) for ICS as it more economical than traditional stove		
Yes	133	31.1
No	295	68.9
Total	428	100
Willingness to pay ₦9,000 (\$6.07) for ICS as it is a better alternative than traditional stove		
Yes	158	37.0
No	266	62.2
Total	428	100
Willingness to pay ₦6,000 (\$4.04) for ICS as it is readily available		
Yes	262	61.1
No	166	38.9
Total	428	100
Willingness to pay ₦3000 (\$2.02) for ICS as it is less bulkier than the traditional stove		
Yes	347	81.1
No	81	18.9
Total	428	100

Dollar to Naira (\$1 to 1484)

Source: Field survey, (2024)

### 3.7. Factors influencing willingness to pay for clean cookstove

The logistic regression result had a pseudo  $R^2$  of 0.5068, that is, 51% of the variation in farmers' WTP for clean cookstove was explained by the explanatory variables (Table 9). Furthermore, the regression analysis shows non-significant and negative effect of age on willingness to pay for clean cookstove. An inverse relationship is evident between WTP for improved cook stoves and age. The younger the respondents, the less likely they are WTP and vice versa. This explains that younger adults also known as Generation Z (Gen Z's) do not subscribe to usage of fuelwood as they are much more sophisticated and prefers the use of cooking gadgets like air fryers, microwaves, ovens, gas and electric cooking devices. They are known for a stress free lifestyle. However, older adults are conservative and traditional, hence are WTP for improved cookstoves.

There was positive and insignificant relationship between sex, occupation and access to credit with household WTP for clean cookstove. Access to credit has been shown to be a major factor in adoption of new technology in developing countries. However, education had a positive and significant effect on respondent's willingness to pay for clean cookstove. This agrees with Gebreyohanes *et al.*, (2024) who found that education has a positive significant influence on early adoption of Improve cooking stove. This shows also that literate women are more adopters of ICS as compared to the illiterate women, as they are more aware of its benefits compared with uneducated ones. Thus, education is a major driver of environmental sustainability.

Likewise, type of energy shows an evidence of positive and significant relationship with willingness to pay for clean cookstove. The result also showed a positive and significant relationship between household size and willingness to pay for clean cookstove. This was in accordance with Gebreyohanes *et al.*, (2024) who equally found that higher family size has a positive significant influence on early adoption of Improve cooking stove.

Lastly, the result indicates that there was a positive and significant relationship between income level and willingness to pay for clean cookstove. This also supports Lewis and Pattanayak (2012) finding that households with greater income are more likely to use more expensive, healthier and environmentally friendly stoves such as ICS. Poverty is a major driver of environmental degradation in developing country. With aids and incentives to household, the adoption of environmental friendly cookstoves will go a long way to curb environmental destruction.

**Table 9.** Determinants of Willingness to pay for improved cookstoves

Willingness to pay	Coefficient	Standard error	Z	p>/z /
Age	-0.6983582	0.5010436	-1.39	0.163
Sex	0.9656104	0.7210168	1.34	0.180
Education	0.8700559	0.5119617	1.70*	0.089
Household Size	1.930881	0.9923539	1.95*	0.052
Occupation	0.0214356	0.357539	0.06	0.952
Income	0.9270133	0.314136	2.95*	0.003
Type of cookstove	1.319519	0.5293351	2.49*	0.013
Access to Credit	0.5140202	0.4872508	1.05	0.291
Constant	-5.567812	3.042212	-1.83	0.067

Number of observations = 428; Log likelihood = -25.740988; LR Chi<sup>2</sup> = 52.90; Pseudo R<sup>2</sup> = 0.5068;

Source: field survey (2024)

#### 4. CONCLUSION

Impact of improved cookstoves on environmental sustainability was examined. Respondents are aware of the environmental benefits of improved cookstoves from friends and neighbors. The good perception of improve cookstoves by respondents stems from experience in its usage. However, the adoption of improved cookstoves depends on ease of access, cost of production and access to credits. With credit being a constraint to adoption of new technology, most respondents were only willing to pay a meager sum for the purchase of these stoves which was simulated by education, household size, income and type of cookstoves. The goal of environmental sustainability via energy utilization can be achieved through education/awareness, availability and access to credit/loans through grants/incentives to support the shift from deforestation stemming from poverty to adoption of environmental friendly cooking stoves.

#### DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### ACKNOWLEDGEMENTS

This work was solely supported by the Government of Nigeria’s Tertiary Education Trust [TETFUND/]

#### REFERENCES

- [1] Abanikanda, J.O. and Dantani, A. (2021). Fuel Wood Exploitation and Sustainable Forest Management, *Journal of Applied Science and Environmental Management*, 25(6), 987-993
- [2] Asaba Meteorological Station. Monthly record of meteorological observations; 2017
- [3] Asiabaka, C. C. and Owens, M. (2002). Determinants of adoptive behaviors of rural farmers in Nigeria. In *AIAEE Proceedings of the 18th Annual Conference. Durban, South Africa*, Pp. 123-136.
- [4] Bantu, A.A., Nuwagaba, G., Kizza, S., and Turinayo, Y.K. (2018). Design of an improved cooking stove using high density heated rocks and heat retaining techniques, *J. Renew. Energy*, 9, 9620103, <https://doi.org/10.1155/2018/9620103>.
- [5] David-Sarogoro, N., Timitimi, E. and Emerhi, E.A. (2019). Fuel wood utilization and Sustainable Management of Forestry Resources: Panacea for Poverty Alleviation. Proc of 41<sup>st</sup> FAN conf, Abuja, 7th to 11th October, 2019. Pp. 49-55
- [6] Dolor, D.E., Ohwo, O.A., Ogeh, K.T. and Okonji, L.O. (2023). The impact of socio-economic activities of rural dwellers on forest resources in Aniocha North Local Government Area of Delta State, Nigeria, *International Journal of Biosciences Vol. 22 (5)*: 137-148
- [7] Dresen E., DeVries B., Herold M., Verchot L., and Müller R., (2014). Fuelwood savings and carbon emission reductions by the use of improved cooking stoves in an afro-montane forest, Ethiopia, *Land 3*: 1137–1157, <https://doi.org/10.3390/land3031137>.
- [8] Foster, D.A. and Rosenzweig, M.R. (2010). Microeconomics of technology adoption, *Annual Review of Economics* 2:395-424
- [9] Gebreyohannes, A., Shimelis, H., Mashilo, J., Odeny, D. A., Tadesse, T., and Ojiewo, C. O. (2024). Finger millet (*Eleusine coracana*) improvement: Challenges and prospects—A review. *Plant Breeding*, 143(3): 350-374.

- [10] Hooper, L.G., Dieye, Y., Ndiaye, A., Diallo, A., Sack, C.S., Fan, V.S., et al. (2018) Traditional cooking practices and preferences for stove features among women in rural Senegal: Informing improved cookstove design and interventions. *PLoS ONE* 13 (11): e0206822. <https://doi.org/10.1371/journal.pone.0206822>.
- [11] IEA (International Energy Agency), (2018). Tracking SDG7. The Energy Progress Report 2018. International Renewable Energy Agency, United Nations Statistics Division, World Bank Group, World Health Organisation, International Bank of Reconstruction and Development, Washington, DC, 2018
- [12] Jewitt, S., Atagher, P. and Clifford, M. (2020). “We cannot stop cooking”: Stove stacking, seasonality and the risky practices of household cookstove transitions in Nigeria. *Energy Research & Social Science*, 61: 101340.
- [13] Johnson, E. N. (2013). Adoption of improved technology and farm level technical efficiency of small-scale oil palm producers in the Western Region of Ghana (Doctoral dissertation, University of Ghana).
- [14] Kanu, S. I., and Osuji, J. I. (2024). Ascertaining the Relationship between Subsidy Removal on Petroleum Products and Inflationary Trends in Nigeria. *Journal of the Management Sciences*, 61(6): 1-15.
- [15] Karanja, A. and Gasparatos, A. (2020). Adoption of improved biomass stoves in Kenya: a transect-based approach in Kiambu and Muranga Counties, *Environ. Res. Lett.* 15, 024020, 1-16 <https://doi.org/10.1088/1748-9326/ab63e2>.
- [16] Keese, J., Camacho, A., and Chavez, A. (2017). Follow-up study of improved cookstoves in the Cuzco region of Peru, *Dev. Pract.*, 27: 26–36 <https://doi.org/10.1080/09614524.2017.1257565>.
- [17] Laska, G. and Ige, A.R. (2023). A review: Assessment of domestic solid fuel sources in Nigeria. *Energies*, 16. 10.3390/en16124722
- [18] Lawal, M.O., Olawale Olufemi Akinrinde, O.O. and Sulyman, A. (2023). The praxis of fuelwood consumption and the challenge of sustainable biodiversity in Nigeria. *Arts and Social Science Research*, 13 (2): 47-72
- [19] Lewis, J.J. and Pattanayak, S.K. (2012) Who Adopts Improved Fuels and Cookstoves? A Systematic Review. *Environmental Health Perspectives*, 120, 637-645.
- [20] Listo, R. (2018) Gender myths in energy poverty literature: a critical discourse analysis, *Energy Res. Soc. Sci.* 38: 9–18, <https://doi.org/10.1016/j.erss.2018.01.010>.
- [21] Malakar, Y. (2018). Studying household decision-making context and cooking fuel transition in rural India, *Energy Sustain. Develop.* 43 68–74, <https://doi.org/10.1016/j.esd.2017.12.006>.
- [22] NBS (2014). Household Budget Survey Poverty Key Findings Report 2011/2012. Dares Salaam: National Bureau of Statistics.
- [23] Ogeh, K.T. (2023) Fuel wood consumption in selected communities in Oshimili North Local Government Area, Delta State, Nigeria. , *Asian Journal of Research in Agriculture and Forestry*, 9: 149-153
- [24] Ohwo, O. A. and Nzekwe-Ebonwu N. F. 2021. Impacts of rural community on the forest estate in Ugbolu, Oshimili North Local Government Area, Delta State, Nigeria. *Journal of Forest* Vol. 8 (1): 45-60
- [25] Ohwo, O.A., Oyibo, O. and Itoje, B.A. (2024). Assessment of perception on the environmental benefit of urban trees in Asaba, Delta State. *Taraba Journal of Agricultural Research*, 12(1): 1-10
- [26] Orimoogunje, O. O. and Asifat, J. (2015). Fuel wood consumption and species degradation in south-western Nigeria: the ecological relevance. *J. Landsc. Ecol*, 8, 56-68.
- [27] Price, R. (2017) “Clean” Cooking Energy in Uganda—Technologies, Impacts, and Key Barriers and Enablers to Market Acceleration. Institute of Development Studies, Brighton
- [28] Rogers, EM, (2003). Diffussion of innovations, New York, Free Press.
- [29] Ruiz-mercado, I., Masera, O., Zamora, H., and Smith, K.R. (2011). Adoption and sustained use of improved cookstoves, *Energy Policy*, 39: 7557–7566, <https://doi.org/10.1016/j.enpol.2011.03.028>.
- [30] Sanni, L. O., Onadipe, O. O., Ilona, P., Mussagy, M. D., Abass, A., and Dixon, A. G. O. (2009). Successes and challenges of cassava enterprises in West Africa: a case study of Nigeria, Benin and Sierra Leone. IITA.
- [31] Sovacool, B.K. (2012). The political economy of energy poverty: a review of key challenges, *Energy Sustain. Develop.* 16 (3): 272–282, <https://doi.org/10.1016/j.esd>.
- [32] Stoner, O., Lewis, J., Martínez, I.L., Gumy, S., Economou, T. and Adair-Rohani, H. (2021). Household cooking fuel estimates at global and country level for 1990 to 2030, *Nat. Commun.* 12 <https://doi.org/10.1038/s41467-021-26036-x>.
- [33] Tambunan, B.H., Simanjuntak, J.P. and Koto, I. (2022). The use of thermo electric generator to utilize the waste heat from the biomass stove into electricity, *J. Phys. Conf. Ser.* 2193, <https://doi.org/10.1088/1742-6596/2193/1/012045>.
- [34] United Nations, (2017). The sustainable development goals report 2022. <https://unstats.un.org/sdgs/report/2022/> (accessed Oct 05, 2025).

- [35] Ürge-Vorsatz, D., Eyre, N., Graham, P., Harvey, D., Hertwich, E., Jiang, Y., Kornevall, C., Majumdar, M., McMahon, J.E., Mirasgedis, S., Murakami, S., Novikova, A., Janda, K., Masera, O., McNeil, M., Petrichenko, K., Herrero, S.T., and Jochem, E. (2012). Energy end-use: buildings, *Glob. Energy Assess. (GEA)* 649–760, <https://doi.org/10.1017/cbo9780511793677.016>, 2012.
- [36] USAID, (2018) “The Bureau for Development, Democracy and Innovation (DDI),” September 7, 2018, [https://www.usaid.gov/sites/default/files/documents/1868/Fact\\_Sheet\\_The\\_Bureau\\_for\\_Development\\_Democracy\\_and\\_Innovation\\_DDI.pdf](https://www.usaid.gov/sites/default/files/documents/1868/Fact_Sheet_The_Bureau_for_Development_Democracy_and_Innovation_DDI.pdf) (accessed August 19, 2021).
- [37] Wang, Y and Bailis, R, 2015. The revolution from the kitchen: Social processes of the removal of traditional
- [38] World Health Organization (WHO), (2024). Household air pollution, 2024. <https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health> (accessed Oct 05, 2025).
- [39] World Health Organization (WHO, 2018). Burden of Disease from Household Air Pollution for 2016.

**Citation:** Dickens E. Dolor et al. *The Impact of Improve Cookstoves on Environmental Sustainability. International Journal of Forestry and Horticulture (IJFH)*. 2026; 12(1):1-11. DOI: <https://doi.org/10.20431/2454-9487.1201001>

**Copyright:** © 2026 Authors. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.