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The link between improved cook-stove use and farm labour input in farming communities in Benue and Kaduna States, Nigeria

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Abstract: The study analysed the link between improved cook-stove (Save80 and Greenwatch cook-stoves) use and farm labour input in farming communities in Benue and Kaduna States, Nigeria. The study adopted purposive and random sampling techniques in the selection of 440 farming households (ICS users and non-users). Questionnaire was the main instrument for data collection. Data collected were analysed using ordinary least-square regression analysis. Two main ICS namely Save80 cook-stove in Kaduna State and Greenwatch cook-stove in Benue State were identified. The result revealed that use of Save80 cook-stove increased the time allocated to agricultural activities by 2.127 h per day while the use of Greenwatch cook-stove increased the time allocated to agricultural activities by 0.998 h per day. The study concludes that there is need to introduce improved cook-stoves in all farming communities in Nigeria.

Subjects: Environment & Agriculture; Environmental Studies & Management; Food Science & Technology; Development Studies, Environment, Social Work, Urban Studies; Social Sciences; Development Studies

Keywords: effects; improved cook-stove; Save80 cook-stove; Greenwatch cook-stove; farming communities; farm labour; Benue State; Kaduna State; Nigeria

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PUBLIC INTEREST STATEMENT

Proper analysis of the relationship between improved cook-stove (ICS) use and farm labour input is crucial in understanding the impact of ICS projects on the productivity of farming households in Nigeria where about 72.7% of the households rely on fuel-wood as their primary cooking fuel. The current pattern of use of fuel-wood causes significant negative impacts of several types, including reduction in agricultural production and productivity. Furthermore, inefficient open-fire method of cooking often requires farmers in the study area to travel far from home to gather fuel-wood. Anecdotal evidence recently suggests that they are being exposed to violence and other threats to their security like attacks by insurgents and herdsmen. Therefore, intensive use of fuel-wood as a result of cooking with inefficient systems is very much associated with several agricultural, economic and security-related problems. Introduction of ICS, therefore, is believed to enhance agricultural productivity, and save time for farmers which they invest in other income-generating activities.

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1. Introduction

Globally, more than 2 billion people depend on wood energy for cooking, heating and food preservation (United Nations Development Programme (UNDP), 2000). In Nigeria, about 72% of the population depends on fuel-wood for cooking (National Bureau of Statistics [NBS], 2010). In the Guinea Savanna region of Nigeria, deforestation rates are severe and the highest in the country. Deforestation is largely due to household fuel-wood use (Eleri, Ugwu, & Onuvae, 2012). States like Benue and Kaduna have 93.2 (the highest in the country) and 83.2% of households depending on fuel-wood for cooking, respectively, (NBS/CBN/NCC, 2010 cited in Eleri et al., 2012).

The current pattern of fuel-wood use causes significant negative impacts, including human morbidity and mortality, indoor air pollution, climate change, biodiversity loss (Smith, Mehta, & Maeusezahl-Feuz, 2004) and reduction in agricultural production and productivity. Traditional open-fire methods of cooking, which require large quantities of fuel-wood, often means that farmers in the Savanna region of Nigeria have to travel far from home to gather their fuel-wood. Recent anecdotal evidence suggests that farmers, usually women, are exposed to violence and threats to their security from attacks by insurgents and herdsmen. Therefore, the gathering and use of fuel-wood is associated with several agricultural, economic, security and environmental problems. Reducing fuel-wood consumption is an important strategy to reduce these negative impacts.

The introduction of improved cook-stoves (ICS) has been shown to enhance agricultural productivity and reduce the labour inputs for farmers, especially women, which they can then invest in other activities. ICS technology uses combustion of solid biomass fuel to produce heat for use in domestic cooking (Umogbai & Orkuma, 2011). Improved cook-stove programmes focusing on energy efficiency began in the 1970s following oil price increases (Gifford, 2010). Since then, 700 improved cook-stove programmes have been launched worldwide, ranging from non-governmental organization (NGO) projects to nationwide government initiatives in countries such as in Nigeria, Nepal, China and Mexico (Accenture, 2011; Jessica, Jaspal, Domitila, Expedita, & Smith, 2009; Kammen, 2005; Masera Díaz, & Berrueta, 2005; Masera et al., 2007; Nigerian Environmental Study Action Team (NEST) & Woodley, 2011; Salawu & Ali, 2011).

ICS programmes are considered useful for both a climate change mitigation and adaptation as they reduce dependence on forest resources, thereby reducing CO_2 emissions (mitigation) and leaving forest resources for other sustainable livelihood activities (adaptation) (Arnold, Kohlin, & Shepherd, 2003; Barnes, Openshaw, & Smith, 1993; Barnes, Openshaw, Smith, & van der Plas, 1994; García-Frapolli et al., 2010; NEST & Woodley, 2011). ICS programmes not only reduce pressure on the biomass resource base but also minimize household expenditures on fuel-wood, shorten the time required for cooking, and reduce concentration of smoke and indoor pollution (Barnes et al., 1994; Habermehl, 2008; Jessica et al., 2009; Kanagawa & Nakata, 2007). The use of ICS also reduces the labour load, usually for women, by reducing time spent on fuel-wood collection, and may increase the amount of time allocated to agricultural activities and farm production as a result of time saved from fuel-wood collection and cooking. As well, there is a growing interest in the potential for trading carbon offsets from ICS programmes in voluntary reduction carbon markets, or as part of the compliance reductions of the Clean Development Mechanism (CDM) of the Kyoto Protocol (Blodgett, 2011; Developmental Association for Renewable Energies (DARE), 2011; Johnson et al., 2009; Mann, 2007; Nwajiuba, 2011; Simon, Bumpus, & Mann, 2010).

Reducing per unit consumption of fuel-wood to combat deforestation, enhance agricultural productivity and production, improve safety and security of farmers, reduce indoor air pollution, and respond to climate change by developing improved cook-stoves (Amacher, Hyde, & Kanel, 1996; NEST & Woodley, 2011) have become important issues within the broader topic of rural economic development, energy economics, health economics, agriculture, resource and environmental economics, and rural sociology.

To date, ICS technology has focused on the development of stove design, the improvement of large-scale manufacturing processes, marketing strategies and financial incentives for stove dissemination (Komolafe & Awogbemi, 2010; Ojolo, Orisaleye, Ismail, & Odutayo, 2012; Ruiz-Mercado, Masera, Zamora, & Smith, 2011). Studies evaluating ICS interventions have almost exclusively focused on the related household pollution and health impacts (Diaz et al., 2007; Hanna, Duflo, & Greenstone, 2012; Masera et al., 2007; Smith-Sivertsen et al., 2009; Yu, 2011). Economists have studied the agricultural, productivity and economic benefits of using improved stoves (Dasgupta, Huq, Khaliquzzaman, Pandey, & Wheeler, 2006; Duflo, Greenstone, & Hanna, 2008; Gajate-Garrido, 2010; Levine & beltramo, 2011; Mobarak, Dwivedi, Bailis, Hildemann, & Miller, 2012; Okuthe & Akotsi, 2014; Yu, 2011). However, no studies have examined the effect of ICS use on farm labour input in farming communities in the Savanna region of Nigeria where the bulk of the country's food production takes place and the dependence on fuel-wood for cooking is very high. The purpose of the research is therefore to examine the effect of ICS use on farm labour input in Benue and Kaduna States of Nigeria.

2. Methodology

This study was conducted in Benue and Kaduna States, Nigeria. These states have benefitted from NGO-supported ICS programmes. The Developmental Association for Renewable Energies is promoting the Save80 cook-stove in Kaduna State while the Greenwatch Initiative is promoting the Greenwatch ICS in Benue State (DARE, 2011; Salawu & Ali, 2011; NEST & Woodley, 2011). The population of Benue State in 2006 was 4,219,244 and Kaduna State was 6,066,562 (NBS, 2006). These populations rely heavily on forest resources for firewood for cooking. In Benue State, 93.2 per cent (the highest in Nigeria) and in Kaduna, 83.2 per cent of households depend on fuel-wood for cooking (NBS/CBN/NCC, 2011 cited in Eleri et al., 2012). This dependence on forest resources has contributed to the highest rates of forest degradation in the country.

The study adopted purposive and random sampling techniques in the selection of respondents for this study. The choice of Kaduna and Benue states was based on three important reasons: the first is the high dependence on fuel-wood as the main source of household energy in the area; the second reason is the involvement of the states in ICS programmes conducted by NGOs. The third reason is that these two states are vital to food production in Nigeria.

The NGOs promoting ICS work in selected communities in Kaduna and Benue States. DARE is promoting Save80 cook-stoves in nine communities (Tawakiri, Gazare, Pambogua, Yarkanuwa, Saminaka, Kafanchan, Kagoro, Kachia, and Zaria) in Kaduna State. Greenwatch Initiative promoting the Greenwatch cook-stove in five communities (Daudu, Jato, Ahumbe, Igbor, and Mase) in Benue State. For this study, seven communities were randomly selected in Kaduna State and four communities were randomly selected in Benue State.

In each community, a list was drawn to capture users and non-users of improved cook-stoves. The list of ICS users was compiled with the assistance of NGOs that introduced the stoves in the communities. The list of non-users was compiled with the help of community heads. From the compiled lists, 20 households were randomly selected in each community (10 users and 10 non-users). A total of 440 households in the 11 communities were sampled. The NGOs promoting ICS were also selected for detailed study.

The main instrument for data collection was questionnaires. Three different questionnaires were used—one for users of ICS, one for non-users and one for NGO staff involved in ICS programmes in the communities.

In order to explain the possible association between use of ICS and household labour input in farming, a farm labour input equation was used:

$$L = f(Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, e)$$

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where L = On-farm person time per day for household (hours), Z_1 = Use of improved cook-stove (Dummy variable: user = 1, non-user = 0), Z_2 = Daily time spent in cooking (hours), Z_3 = Daily time spent in collecting firewood (hours), Z_4 = Farm size (ha), Z_5 = Gender (Dummy variable: female = 1, male = 0), Z_6 = Age (years), Z_7 = Household size (number of persons), e = error term, presumed to have no correlation with the respective explanatory variables and to have the usual properties for ordinary least-squares (OLS) estimation.

The selection of these variables is based on the fact that rural households rely largely on their own labour to meet daily farm labour requirements for planting, weeding and harvesting. Households dependent on fuel-wood for cooking tend to take time away from agricultural activities and reallocate the time for fuel-wood collection. In addition, households using ICS would likely save time from cooking and fuel-wood collection which will improve their time allocated to farming and increase their output. This combination of effects seems likely, a priori, to influence allocation of time for farming for different households using different devices for cooking. The dependent variable is household's time allocation to farming measured in hours per day. This is expected to be a function of: (i) household cropping characteristics such as proportion of land under crops (in hectares); (ii) use of ICS; (iii) time allocated to cooking, and time allocated to fuel-wood collection and (iv) household composition (number of people, gender, age).

In this equation, other variables of interest are: (i) use of ICS; (ii) the degree of deforestation measured by the time taken to collect a unit of fuel-wood; and (iii) time allocated to cooking.

The use of improved cook-stoves (Z_1): *A priori,* the use of ICS should improve the time allocated to farming as households would be expected to cook with less fuel-wood and thus spend less time in search of fuel-wood. The assumption is that they will allocate this extra time to farming because their main means of livelihood is agriculture. Therefore the variable Z_1 is expected to be positively correlated with farm labour input.

Time allocated to cooking (Z_2): It is assumed that the time taken up by cooking reduces the time spent on the farm. Therefore this variable is hypothesized to be negatively correlated with farm labour input.

Time allocated to fuel-wood collection (Z_3): Up to some point, time allocated to the collection of fuel-wood should reduce labour time on the farm. Therefore, this variable is hypothesized to be negatively correlated with farm labour input.

Farm size (Z_4): It is assumed that farm size increases farm labour input since farmers with more land to cultivate will spend more time on their farms. Therefore, farm size is expected to be positively correlated with farm labour input.

Gender (Z_5): Gender is expected to have a positive coefficient with farm labour input in the Savanna area of Nigeria. This is because the bulk of agricultural activities in this area are carried out by women.

Age (Z_6): Age is hypothesized to negatively correlate with farm labour input. This is because younger persons tend to be more productive and work longer than older persons.

Household size (Z_7): Household size is expected to positively correlate with farm labour input of the household, since more people in the household that are capable of work will be able to contribute to agricultural activities.

3. Description of the improved cook-stoves studied

The Save80 cook stove has a stainless steel combustion chamber where the fire is contained and the fuel is burned in a single combustion stage. The Save80 comes with a pot, suspended above the combustion chamber on the metal edge of the stove. Greenwatch cook-stove is promoted by the Greenwatch Initiative (GI) and fabricated locally. It is made of clay, stones/mould blocks and water. On one side of the stove is an opening for placing fuel-wood into the burn chamber.

4. Results and discussion

4.1. The effect of Save80 cook-stove use on farm labour input in Kaduna State

Multiple regression analysis was done to determine the effect that Save80 cook-stove use has on farm labour input in Kaduna State. The regression was subjected to four functional forms (linear, semi log, double log and exponential forms). The result of the regression is presented in Table 1. The linear form was chosen because it has the highest value of the coefficient of multiple determination of 0.832 (83.2%), and highest F-ratio value (192.1). The F-ratio was significant at 1% level of probability indicating the overall significance of the model. The value of the coefficient of multiple determination was 0.832, indicating that the explanatory variables jointly explained 83.2% of the variation in farm labour input. This shows a very good fit for the model. Age was the only statistically insignificant variable; the other six variables were statistically significant.

Use of the Save80 cook-stove had a positive correlation with farm labour input. This impact was also significant at 1% level of probability. This implies that households using the Save80 cook-stove had more time and thus labour input for their farms than those using traditional cooking methods. The use of the Save80 cook-stove increased the time available for farming by 2.127 h, which implies that use of Save80 cook-stove can increase the farm output.

Time allocated to cooking has a negative and significant impact on farm labour input. This result was expected and was significant at 1% level of probability. Time allocated to cooking food

Table 1. Multiple regression estimates of the effect of use of Save80 cook-stove on farm labour input

Variables	Linear	Exponential	Double-log	Semi-log
(Constant)	1.663 (30.117)***	5.038 (18.399)***	1.487 (14.773)***	4.446 (9.072)***
Use of ICS	2.127 (10.081)***	1.227 (8.118)***	0.304 (10.854)***	1.587 (11.649)***
Time spent in cooking	−0.029 (−2.599)***	−0.107 (−1.912)*	−0.017 (−0.918)	−0.049 (−0.544)
Time spent in fuel-wood collection	−0.068 (−5.351)***	−0.269 (−4.286)***	−0.064 (−2.892)***	−0.268 (−2.481)**
Farm size	5.372 (3.281)***	−0.001 (−0.069)	−0.010 (−0.983)	−0.035 (−0.738)
Gender	0.048 (3.735)***	0.286 (4.497)***	0.040 (2.976)***	0.253 (3.893)***
Age	0.001 (−0.252)	−0.002 (−0.475)	−0.010 (−0.353)	−0.080 (−0.559)
Household size	2.001 (1.823)*	0.004 (0.442)	0.010 (0.736)	0.057 (0.834)
R^2	0.832	0.830	0.816	0.820
F-ratio	192.1***	189.3***	172.3***	177.1***

Note: values in parenthesis are *t*-values.

Source: Field Survey, 2014 and Computer printout of SPSS result.

*Significant at 10% respectively.

**Significant at 5% respectively.

***Significant at 1% respectively.

competes with the time allocated to other productive activities like farming. Rural areas of Kaduna State are predominantly agricultural. Women do the bulk of the farming activities as well as cooking, which underscores the need for adoption of time-efficient cooking devices that can reduce the labour load for women and enable them to increase time on the farm if needed.

Time allocated to fuel-wood collection had a negative and significant impact on farm labour input. This result is expected and was significant at 1% level of probability. Time spent on fuel-wood collection competes with the time for other productive activities such as farming. Again, this underscores the need for the adoption of fuel-efficient cooking devices that reduce demand for fuel-wood, save cooking time and fuel-wood collection. It may be preferable for farming households to have more time for agricultural activities.

Farm size is of course a determinant of farm labour input. A unit increase in the number of hectares cultivated by farmers led to a corresponding increase of farm labour input of 5.372 h, implying that farm size increases farm labour input, and vice versa. Therefore, in communities where the Save80 cook-stoves were used in Kaduna State, it again provides the option for more time to be dedicated to farming activities. The relationship was significant at the 1% level of probability. This is in line with the a priori expectation.

The gender of the household head was positively associated with increased farm labour input. The relationship was significant at the 1% level of probability. This result is expected. Female-headed households are associated with increased labour input to farm work as they do the bulk of the tasks in the farm. Also, women play a central role in fuel-wood collection, and therefore it is expected that their allocation of time to fuel-wood collection and farming is more critical than that of men. Another reason could be that most women have the sole responsibility of cooking, child care and other domestic chores. These tasks significantly impact the time allocated to farming by this group.

Household size had a significant and positive influence on farm labour input. This is in line with the a priori expectation. This effect was significant at the 10% level of probability. More people in the household implies that labour for farming is more abundant, which increases the farm labour input. Agriculture in Kaduna state is non-mechanized and labour intensive, therefore household members are required to work in their farms.

4.2. The effect of Greenwatch cook-stove use on farm labour input in Benue State

In order to analyse the effect of Greenwatch ICS use on farm labour input in Benue State, a multiple regression was done and subjected to four functional forms (linear, semi log, double log and exponential forms). The result of the regression is presented in Table 2. The linear form was chosen as the lead function because it has the highest R^2 value of 0.874 and the highest *f*-value of 151.1. The *f*-ratio was significant at 1% level of probability indicating the overall significance of the model. The empirical result is consistent with the theoretical postulations of the model. The coefficient of multiple determination of 0.874 indicates that about 87.4% of the variation in farm labour input has been captured by the explanatory variables in the model. Age and gender were the statistically insignificant variables; the other five variables were statistically significant.

Use of Greenwatch cook-stove recorded a positive coefficient with farm labour input. This impact was also significant at 1% level of probability. This implies that households using the Greenwatch cook-stove had more time available to spend on their farms than those using the traditional open-fire method of cooking. The use of the Greenwatch cook-stove in each household increased the extra time available by 0.998 h. Therefore, the use of Greenwatch cook-stove significantly increased the time available for farming, which can also increase the farm output.

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Table 2. Multiple regression estimates of the effect of use of Greenwatch cook-stove on farm labour input

Variables	Linear	Exponential	Double-log	Semi-log
(Constant)	4.239 (7.783)***	1.437 (20.895)***	1.415 (12.972)***	4.188 (12.190)***
Use of ICS	0.998 (8.119)***	0.432 (11.122)***	0.433 (14.110)***	0.222 (11.437)***
Time spent in cooking	−0.202 (−1.916)*	0.019 (1.269)	0.030 (1.419)	0.139 (1.875)*
Time spent in fuelwood collection	−0.199 (−1.663)*	−0. (−1.429)	−0.033 (−1.380)	−0.121 (−1.568)
Farm size	5.268 (5.348)***	−0.005 (−1.183)	−0.022 (−1.825)*	−0.025 (−1.287)
Gender	−0.125 (−1.529)	−0.040 (−2.425)**	−0.038 (−2.316)**	−0.139 (−1.685)*
Age	0.006 (0.039)	0.001 (0.449)	0.007 (0.238)	0.001 (0.197)
Household size	2.207 (1.920)*	0.001 (−0.152)	0.004 (0.270)	−0.004 (−0.373)
R^2	0.874	0.869	0.871	0.873
f-ratio	151.1***	144.6***	146.5***	149.0***

Note: values in parenthesis are *t*-values.
Source: Field Survey, 2014.
*Significant at 10% respectively.
**Significant at 5% respectively.
***Significant at 1 respectively.

Time allocated to cooking has a negative and significant impact on farm labour input. This result was expected and was significant at 10% level of probability. This means that time allocated to cooking food reduces the time allocated to other productive activities such as farming. Similar to Kaduna state, women are mainly involved in farming as well as cooking. This underscores the need for adoption of time-efficient cooking devices to reduce the labour load for women so that can reallocate extra time to agricultural activities if they so choose.

Time allocated to collection of fuel-wood had a negative and significant impact on farm labour input. This result is expected and was significant at 10% level of probability. Time allocated to fuel-wood collection competes with the time allocated to other productive activities such as farming. Time allocated to fuel-wood collection takes time away from other activities, thus highlighting again the need for adoption of fuel-efficient cooking devices that reduce demand for fuel-wood, save time from cooking and fuel-wood collection, and reallocate such time to productive activities such as agriculture.

Farm size had a positive and significant influence on farm labour input in the sampled communities in Benue State. The relationship was significant at the 1% level of probability. This is in line with the a priori expectation of the study, in that farmers with larger area cultivated spent more time on their farms. A unit increase in the area cultivated by the farmers led to a corresponding increase of farm labour input of 5.268 h. This means that farm size increases farm labour input, and vice versa.

Household size had a significant and positive influence on farm labour input. This is in line with the a priori expectation. This effect was significant at the 10% level of probability. More people in the household implies that labour for farming is more abundant, which increases the farm labour input. Again, as in Kaduna State, the areas surveyed in Benue State are farming communities where agriculture is non-mechanized and labour intensive. Household members therefore tended to work in their farms.

5. Conclusion and recommendations

The study showed that improved cook-stoves reduce the time allocated to cooking and fuel-wood collection and therefore increase time spent on other activities, which include agricultural activities. Government agencies and NGOs should work in collaboration with agricultural communities to develop pro-poor energy policy frameworks that include wide-scale dissemination of improved cooking technologies in rural areas. This may help to improve the chronic situation of low labour inputs in agriculture in the Savanna region of Nigeria. It is suggested that the establishment of a household energy centre in the Savanna region of Nigeria may act as an effective focal point for dissemination of energy-efficient technologies to farming households.

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