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DETERMINANTS OF ELECTRIC BAKING STOVE ADOPTION IN URBAN TIGRAI, ETHIOPIA

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Abstract

The widespread use of biomass, as a source of energy, in urban centers, has serious environmental, health and economic implications. One important remedy is promoting transition to cleaner energy sources such as electricity. This study was, therefore, aimed at investigating the determinants of adoption of Enjera (a white leavened, Ethiopian bread, made from Teff flour) by baking in an electric stove (mitad), in Abi Adi District of Tigrai region, in northern Ethiopia. A total of 109 households (of which 47 were stove adopters), was surveyed for the study. Results, obtained from the probit model, revealed that age, education level, type of employment of household head, family size, household expenditure and prices of related goods, positively explained household's adoption of electric stove. Price of the electric stove negatively affected adoption. Policy intervention would facilitate the energy transition, from fuel wood and biomass to electricity and through widespread use of electric stoves, the pressure of urban centers on their rural hinterlands and the resulting deforestation, could be reduced.

Keywords: *Biomass Fuel, Electric Baking Stove, Adoption, Ethiopia.*

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1. Introduction

Ethiopia is one of the few countries in Africa, with an immense potential for producing energy power. According to the **World Bank (2010),** the total endowment or capacity of hydropower resource was estimated at 45,000 MW (Mega Watt) per annum. However, only about 2,100 MW of this capacity was being exploited, as of 2015. Similarly, the country has big potential in solar, wind and geothermal energy resources, with an estimated 4-5 Kilo Watt / meter square, 1,350 GW (Giga Watt), and 700 MW, respectively. Only 220 MW power of wind energy was utilized and 7.3 MW geothermal energy power was under construction, as of 2015. On the other hand, only 5MW solar energy power was exploited **(FDRE, 2015, Derbew 2013).** As a result, charcoal and fuel woods remained the principal sources of energy.

One of the fundamental realities of rural-urban interaction in Ethiopia is the energy dependence of urban centers on peri-urban and rural areas **(Barnes et al., 2005).** Fuel wood, which is the major product of rural areas, is important source of energy for urban activities **(Guta, 2012).** Ethiopia consumes over 100 million cubic meters of fuel wood each year**.** It was further estimated that during 2015-2030, fuel wood consumption could increases by forty million cubic meters per annum **(World Bank, 2010).** Much reliance on biomass energy, i.e. fuel wood, entails significant environmental, economic and other costs. Globally, about 1.3 million deaths, per year, were attributed to indoor pollution, from bio-mass energy utilization **(OECD/IEA, 2006). Arnold et al., (2006)** revealed that high level of deforestation in Ethiopia, had resulted in growing fuel scarcity and higher firewood prices in urban centers.

The main use of energy, in households, is for cooking, baking, followed by lighting and heating. Evidence suggests that about 81%, 12% and 7% of households, in Ethiopia, use firewood, leaves and dung and electricity, respectively, as source of energy for baking Enjera **(FDRE, 2012).** Majority of urban households generally use traditional energy sources (dung, agricultural residues and fuel-wood), for baking Enjera. Electricity is mainly used for lighting and small appliances, rather than baking. This has actually represented a small share of total household consumption in energy terms **(Gebreegziabher et al., 2012; Alem et al., 2013).** Transition from inefficient traditional biomass stoves to more energy efficient and clean stoves is one of the major sustainability challenges in Ethiopia **(Gashie, 2005; Alem et al., 2013).** Substantial resources have been devoted, to promote clean and energy efficient stoves, in developing countries **(Bruce et al., 2004; Mobarak et al., 2012).** However, the adoption and use of these electric stoves was low and poorly understood **(Kuto, 2010).**

2. Review of Literature

Many studies on stove adoption, in developing countries, mainly focus on adoption of improved biomass cook stoves, in rural areas. **Amacher et al., (1992)** argued that rural households in Nepal compared gains with costs incurred, in adopting improved cooking stoves. The decision, to purchase the stove, depends on household attitudes regarding risk and expectation of gains from adoption. Educated households, households living in high fuel price regions, and those expecting greater fuel savings, are more willing to adopt improved cooking stoves. **Kanangire et al., (2016)** analyzed the determinants of improved biomass stove adoption of 350 rural households in Rwamagana Districts of Rwanda. It was found that social status, economic level, cultural beliefs and level of awareness of households, had significant and positive influence on adoption of improved biomass stoves. **Menon and Thandapani (2011)** conducted a study, to understand the adoption dynamics of improved biomass stoves, among people, living in rural India. The neighbors' influence, frequency of awareness campaigns, effect of perceived risks/benefits of improved cooking stoves vis- a-vis traditional stoves, income, education and stove design were found to be the enabling factors, for the adoption decision. **Levine et al., (2013)** identified factors, that impeded the adoption of improved biomass stoves, in rural Uganda. Customers' liquidity constraint, imperfect information, lack of confidence on new stove's fuel saving performance and skepticism about durability of the stove were important barriers of improved cook stoves adoption. Studies on Ethiopia remain scattered. In urban Ethiopia, few studies have been made on adoption of improved biomass and modern stoves **(Gebreegzabiher et al., 2012; Beyene and Koch, 2012). Damte and Kohlin (2012)** investigated the determinants of improved biomass stoves' adoption (Mirt stove). The effect of household head's level of education, income, availability of separate kitchen and household head's gender, were found to be significant and positive, in influencing the adoption of stoves. Substitutability of the stove and size of children in a household, were found to be insignificant. **Gebreegziabher et al., (2012)** also identified determinants of urban households' energy transition and the adoption of new electric cooking appliance and improved wood-burning stove technology, in Tigrai, northern Ethiopia. Household head's age, education, family size, and income/expenditure, were positive and significant factors, to determine the adoption while prices of fuel-wood, charcoal and kerosene were found to be insignificant, in influencing the adoption of stoves. **Beyene and Koch (2012)** revealed income and wealth as important contributors to adoption, and substitute technologies tended to hinder adoption.

3. Statement of the Problem

The adoption of electric stove, for Enjera baking, remains a major concern for urban households and policy makers in Ethiopia. Enjera baking accounts for over 50% of all energy consumption. According to **Getnet and Edilegnaw (2013),** 55% of total domestic urban customers, in large urban centers, used Enjera baking electric stove in 2012. The figure is below 10% in small and medium size towns. In short, adoption of Enjera baking electric stoves, remains very low. This shows that enormous numbers of urban households are still dependent on biomass energy. Despite this energy crisis, there exists scanty, systematic studies, on the determinants of adoption of Enjera baking electric stoves. Given the rapidly increasing electrification in Ethiopia and for mitigating the environmental, economic and health consequences of dependence on biomass energy, it would be important to understand the determinants of adoption of electric baking stoves and the variables, which have to be targeted, to promote its adoption for energy transition.

4. Need of the Study

By adopting different types of stoves, households can shift to clean energy. Besides, although stove adoption could be studied on a broader scale, which can include all urban areas of the Tigrai regional state, this research considered only Abi Adi Town, as the rural hinterlands of the town are greatly affected by deforestation and poor biomass management.

5. Objective of the Study

This study aims to investigate the energy consumption patterns and analyze the determinants of adoption of Enjera baking electric stove, at household level, in Abi Adi, Tigrai region, Ethiopia.

6. Hypotheses

The hypotheses were based on the research objectives.

NH-1: Household energy consumption, in Abi Adi District, is not mainly based on biomass.

NH-2: Household level adoption of Enjera baking electric stove is not determined by socio-economic factors of the household heads.

7. Research Methodology

7.1 Sample Selection

The study employed stratified sampling method, together with purposive sampling. Initially, the Abi Adi District was purposively selected as the area was highly affected by deforestation **(Arbonaut et al., 2015).** The households were grouped into two strata, based on adopter and non-adopter of improved Enjera baking stoves. The sample households were randomly drawn from each category. Abi Adi is a small town, which had most recently experienced rapid population growth. With the total number of household heads of the District estimated at 1,007, nearly 10% of the household heads were taken as the sample. The sample size of the study was 109. Among them, 47 were electric Enjera baking stove adopters and 62 were non-adopters. The sample size was large enough, compared to the previous studies, which were similar in nature and conducted in Ethiopia **(Gebreegzabiher et al., (2012); Beyene and Koch (2012)).**

7.2 Sources of Data

The data, for the study, were collected in 2016, from primary sources, through structured questionnaire, in order to get both qualitative and quantitative information. The data included household socio-economic characteristics as well as information on energy choices and consumption for improved cooking and baking stoves adopter and non-adopter households. In addition, secondary data were gathered from articles and related literature, to have a general idea on households' stove adoption and energy demand.

7.3 Period of the Study

The data were collected, for the study, during the year 2016.

7.4 Tools Used

The quantitative data analysis technique was applied, to analyze the data collected from primary and secondary sources. While analyzing the data, both descriptive statistics and econometric model were used, as described below. The Probit Model was used, to identify the factors affecting the adoption of Enjera baking electric stove, at the household level. This model was appropriate because the dependent variable was discrete (binary), which assumed the values 1 and 0 for households who adopted and not adopted stove, respectively. According to **Maddala (1983),** the Probit Model is specified as:

$$Yi = \beta_0 + \sum_{j=1}^{10} \beta j\ Xij + \varepsilon$$

where Y_i is the dummy variable, for the household's electric baking stove adoption, β is vector of parameters, X_{ij} is vector of exogenous variables, which are the socio-demographic characteristics, household economic conditions, dwelling context and [is the random error term.

8. Analysis of Data

Table-1 shows the average age of household heads, as 47, with 5.3 being household size. Relative to the non-adopters of Enejera baking electric stove, adopters recorded better level of educational attainment. 22 adopters and only 8 non-adopters reported education status, above 9th grade. About 78% adopters and 46% non-adopters lived in their own houses. Nearly 57% of respondents were self employed, followed by government employees.

Households used a combination of energy sources, for domestic consumption. 44% of respondents used charcoal and 89% used electricity as the source of energy. Besides, 81%, 17% and 14% used wood, dung and kerosene as sources of energy, respectively. The result indicated that households used a combination of energy sources, from the energy resources portfolio available in the Town. However, 37% relied on only fuel wood and electricity for baking Enjera and only 9% used dung. Households' expenditure, on these fuels, accounted for about 23% of the total budget and the share of wood was 11% of household budget (**Table-2**). The sample respondents relied on one of the energy sources: wood, dung, kerosene, and electricity for cooking, baking Enjera and other uses. In the case of the use of wood and dung, or any combination for baking Enjera, the traditional clay enclosed stove, the open hearth with three stones stove, *Mirte* stove, *Tehesh*, and electric mitad (stove) were used. During the interview, it was observed that the open hearth stove with three stones, and the *Tehesh* and *Mirte* stoves, were less preferred stove types, compared to the traditional clay enclosed and the electric mitad stoves.

Fire wood and dung were the major sources of energy, for cooking and baking Enjera while electricity had become a source of energy, for lighting and baking Enjera, since the Town was grid connected. Traditional clay enclosed baking stove was a direct replacement for all electric stove users when there was power blackout or severe fluctuation. Majority of sample respondents relied on traditional clay enclosed stove and the open hearth with three stones stove, for baking Enjera, which implied that households depended on inefficient biomass stoves **(Table-3).** Hence **NH-1** is rejected.

A bivariate Probit Model was applied, to identify the determinants of Enjera baking electric stove adoption **(Table-4).** Household income (expenditure), price of related goods, family size, age, and education of the household head, were considered as explanatory variables. To find out whether access to electricity was a determinant of baking electric stove (*Mitad)* adoption or not, access to electricity was analyzed. It was found that all sampled non-adopters had access to electricity, except only 13% of the sampled households who did not have connection to private meter. Then, to control any bias in terms of access to own electric meter, as determinant of adoption, a separate regression was run by including a dummy variable (for access to private meter) and excluding households who did not have access to own meter. The electric stove price was significant in determining the adoption. The household employment type, house ownership status, and electricity price also determined the adoption. The results suggested that a year increase in the age of household head and a unit change in family size, resulted in increase in the probability of adoption of the stove, by 0.061 and 0.037, respectively and one year extra schooling of the household head also increased the probability of adoption of the stove, by 0.033 **(Table-4).** The computed value of chi-square was also greater than the critical value, at better than 1% level of significance. This reinforced adoption of clean stoves was affected by socio-economic factors of the household head **(Table-4).** Hence **NH-2** is rejected.

9. Conclusion

Majority of sample respondents relied on traditional clay enclosed stove and the open hearth, with three stones stove, for baking Enjera, which indicated that households depended on inefficient biomass stoves. The fact that socio-economic characteristics of the household head were determinants of adoption, indicated the trickle-down effects of factors such as education and income, on clean energy adoption. Therefore, raising the level of education and income of household heads would enhance electric stove adoption. Besides, reducing the price of stove and improving access to financial or in kind (stove itself) credit, would result in the adoption of such stoves and transition to cleaner energy sources. Findings of the study present useful insights into the literature on factors of adoption and non adoption of improved stoves. Furthermore, higher the household expenditure increase, higher the likelihood of adopting Enjera baking electric stove. Lastly, a unit increase in the stove price would lead to decrease in the probability of adoption of the stove.

10. Suggestions

Improving access to education and credit and increasing the price of biomass would help facilitate the transition from biomass to electricity. This study offers useful inputs for policy makers and stakeholders, such as NGOs, that aim to promote the adoption of clean stoves and reduction of the pressure on forest resources of peri-urban areas, in developing countries.

11. Limitation of the Study

This research was limited to the investigation of adoption of Enjera baking electric stove. It was very difficult to access secondary information on town-wide energy consumption patterns and market prices, for alternative stoves. In addition, demand for owning consumer durables, such as the electric Enjera baking stove under investigation, arises from the flow of services in terms of efficiency, capacity, versatility, and corresponding prices. In such a case, a consumer would ultimately utilize the stove, at an intensity level, that provides the necessary services. Hence investigating the adoption of such consumer durables, may require use of a sophisticated utility theory, which goes beyond the Probit Model.

12. Scope for Further Research

Further research is warranted for evolving a more advanced utility theory, to analyze determinants of adoption of other improved stoves. Besides, it is essential to investigate whether the adoption of such stoves necessarily results in the reduction of biomass fuel use or deforestation and improve the household welfare in the process.

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Table-1: Summary Statistics of Socio-Economic Characteristics of the Respondents

Variable	Mean	Std. Dev.	Min.	Max.
Age of household head	47	12	19	72
Average family size	5.3	2.3	1	12
Education level of head (%)	**Adopters**	**Non-Adopters**	**Total**	
Illiterate	3	19	22	
1- 3	6	16	22	
4- 6	7	13	20	
6 - 8	9	6	15	
9 - 11	11	5	16	
12 and above	11	3	14	
Total	47	62	109	
Live in own house	37	29	66	
Household head employment type	**Percent**			
Government employed	18			
Employed in private sector	13			
Self employed	53			
Unemployed	16			

Source: Computation by using Primary Data (2016).

Table-2: Summary Statistics of Energy Use Variables Used in the Analysis

Use of Fuel (Domestic)	**Percent**			
Wood	81			
Dung	17			
Charcoal	44			
Kerosene	14			
Electricity	89			
Use of fuel (for Enjera baking)	**Frequency**	**Percent**		
Only wood	49	0.371		
Only dung	13	0.098		
Wood and dung	28	0.212		
Only electricity	14	0.106		
Wood and electricity	17	0.128		
Dung and electricity	11	0.083		
Total	132	1		
Per Unit Price of Energy	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Wood price (ETB/Kg)	0.521	0.43	0.911	2.502
Dung price (ETB/Cake)	0.413	0.31	0.045	0.623
Kerosene price (ETB/Lit)	4.306	0.79	0.684	1.335
Electricity price (ETB/KWh)	0.451	0.42	0.083	5.601
Total energy expenditure (ETB)	4,241	5,267	1,470	9,651
Budget Share in %	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Budget share of wood	0.110	0.019	0.001	0.572
Budget share of dung	0.024	0.017	0	0.162
Budget share of charcoal	0.030	0.026	0.002	0.991
Budget share of kerosene	0.011	0.011	0.001	0.141
Budget share of Electricity	0.055	0.058	0.001	0.250
Budget share of Energy (Total)	0.230	0.099	0.011	0.478
Budget share of food (Total)	0.710	0.120	0.081	0.790
Budget share of other goods and services (Total)	0.070	0.111	0.001	0.742

Source: Computation by using Primary Data (2016).

Table-3: Enjera Baking Stove Types Used by Sample Households

Stove type	Frequency	Percent
Electric stove (*Mitad*)	42	0.302
Tihesh	13	0.093
Mirte	17	0.122
Traditional clay enclosed stove	58	0.417
Open hearth three stone stove	9	0.064
Total	139	1

Source: Computation by using Primary Data (2016).

Table-4: Bivariate Probit Estimates of Determinants of Enjera Baking Electric Stove Adoption

Variable	Coefficient	Std. error	Marginal Effect	Std. error
Age of household head	0.421**	0.015	0.061**	0.004
Family size	0.310*	0.072	0.037*	0.045
Education level of head	0.220***	0.041	0.033***	0.022
Household head employment type	0.037**	0.045	0.019**	0.020
Household expenditure	0.072*	0.019	0.011*	0.001
Wood price	0.550	0.407	0.220	0.152
Live in own house	0.113	0.056	0.012	0.021
Dung price	0.121	0.049	0.172	0.243
Electricity price	0.067	0.101	0.0452	0.056
Stove price	-0.154**	0.601	-0.071**	0.291
Constant	-4.221	2.548		
Pseudo R-squared	0.58			
Rho	0.98			
Log likelihood	-72.01			

Source: Computation by using Primary Data (2016).