ORIGINAL ARTICLE

Impacts of Access to and Use of Electricity on Households' Economic Status in Selected Informal Settlement Areas of *Woreda 12*, Yeka Sub City, Addis Ababa, Ethiopia

Nibretu Kebede[a] Degefa Tolossa[b] Tamirat Tefera[c]

Abstract

At present, although electricity is essential for all human beings, it is not equally accessible to all. This paper analyzed the impact of access to and use of electricity on the economic status of informal settlements in Addis Ababa based on 450 households drawn from three sites of Woreda 12, Yeka Sub-City. The respondents were selected using proportional random sampling method and data were analyzed using descriptive statistics and Endogenous Switching Regression (ESR) models. The study revealed that non-users of electricity shifted more family labor to domestic activities, baked Injera less frequently per week, owned small number of home-based businesses, and used less alternative fuels than electric-users. However, due to lack of reliable energy supply and food consumption behaviors (FCBs), households do not completely rely on a single energy source. These situations could draw the attention of the government to provide reliable electric supply to non-users of electricity living sporadically mixed with electric-users, close to electric facilities and change households' energy consumption behaviors using alternative energy sources with the concept of energy stacking.

Keywords: *Electric-Users, ESR, Fcbs, Energy Stacking, Home-Based Business, Informal Settlement*

1. Introduction

Access to adequate, reliable and affordable electricity is essential for fulfilling basic human needs, improving family income, creating wealth, saving energy expenditures, improving the quality of life, and speeding up households' energy transition in developing countries (WB, 2014; Torero, 2015; Stern, Burke, & Bruns, 2016; Beyene, 2018). It has the potential to simplify tasks, save family labor and time spent on food preparation,

a. *Center for Environment and Development, College of Development Studies, Addis Ababa University, E-mail: nibretud@gmail.com, (Corresponding author)*
b. *Center for Rural Development, College of Development Studies, Addis Ababa University, E-mail: degefatd@gmail.com*
c. *Center for Environment and Development, College of Development Studies, Addis Ababa University, E-mail: tamirat1995@yahoo.com.*

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create home-based businesses, increase household income, and reduce environmental damages (Bhattacharjee & Reichard, 2011; Pickering, et al., 2017; Li, et al., 2019). Most importantly, it saves households' fuel expenditures and helps to enjoy a wider range of energy services to domestic activities (Lloyd, 2017; Hanania, Stenhouse, & Donev, 2018).

Number of authors indicated that energy increases gross domestic product, raises per capita income, reduces energy imports, solves current account deficits, and attracts foreign direct investments (Li, et al., 2021; Zhe, Yüksel, Dinçer, Mukhtarov, & Azizov, 2021). It also changes the consumption behavior of human beings, reduces the workloads of family members, influences food prices, improves healthcare services, nutrition level, water supply, and education service (Fantu, Abebe, & Tadele, 2015; FAO, 2015; Lloyd, 2017; Ateba, Prinsloo, & Fourie, 2018; Rahuta, Alib, Mottaleba, & Aryal, 2019). As a result, providing affordable, reliable, sustainable and clean energy for all in 2030 has become an agenda of sustainable development goals (UNDP, 2015; World Bank & IEA, 2017).

With the growth of the economy, people tend to use higher quality, cleaner, more productive and flexible energy source (Stern, Burke, & Bruns, 2016; Gyamf, Bein, & Bekun, 2020). The demand for this kind of energy grows due to continuing economic expansion and rising income levels (Adebayo, et al., 2021). As a result, regulations that decrease the use of electricity have a negative impact on economic growth and obstruct economic growth at macro level.

The other issue initiated in this study is the reliability and affordability of energy consumed by households. Many people refer access to electricity only to availability. However, this concept incorporates adequacy, reliability, affordability, convenience to use, the length of time electricity is made available, amount of energy consumed per annum, legality and cleanness of energy sources (IEA, 2012; WB, 2015; Pueyo & Hanna, 2015; Padam, et al., 2018; UNESCAP, 2019). These concepts are crucial to properly analyze the impact of access to electricity on households' economic status in informal settlements.

Furthermore, residents found in different areas do not have equal access to electricity. The amount of energy consumed varies significantly among informal settlers. A study conducted by Njoroge, et al, (2020) identified the factors that influence households' fuel choices and the amount of energy consumed at the household level. These led households to increasingly rely on biomass and expend more effort in cooking food on regular basis (Medina, Cámara, & Monrobel, 2016; Rahuta, Alib, Mottaleba, & Aryal, 2019).

As Gaunt, et al.,(2012), OnYekachi (2014) and Njoroge (2020) indicated informal settlements exist due to population growth associated with migration, the inability of the economy to supply housing for the low-income groups, and expansion of informal businesses. They are located in an area between the urban center and the cultivated edge of rural areas; occupy small, unauthorized and unplanned land that is not zoned for residential purpose; live relatively far from the city center and in dispersed settlements making them economically unattractive to electric suppliers (Subbiah, Mansoor, Misra, Jaffer, & Tiwary, 2016; Butera, Caputo, Adhikaria, & Facchini, 2016).

Residents lack basic services, live in a very poor living condition, with dwellings that vary from simple shacks to more permanent structures found in different areas, and do not have equal access to electric power due to economic factors, population dynamics, the geographical location of residents, suppliers' limited capacity to provide electric power (Butera, Caputo, Adhikaria, & Facchini, 2016; Msimang, 2017; ESCAP, 2019). They are economically poor, earn irregular income, unable to pay connection charges, and even cannot use energy efficient technologies (Luhar, 2014; Dadzie, Runeson, Ding, & Bondinuba, 2018).

The provision of electricity to this area is constrained by capital investments and high costs of building infrastructures and transmission lines. Energy suppliers are not willing to make additional investments in informal settlements. This is mainly because of households' lower electric consumption associated with their socio-economic backgrounds, electric tariffs that are not cost-reflective, and strategies that encourage households conserve energy consumption and minimize peak-time electric use (Karatasou, Laskari, & Santamouris, 2014; Arlet, Ereshchenko, & Rocha, 2019; Chowdhury, et al., 2019; Bayera, Kennedy, Yang, & Urpelainen, 2020). Those who already had access to electricity have faced frequent power interruption, fluctuation, outages and sometimes over supply. These situations forced households in informal settlements to rely on traditional energy sources.

The government; on the other hand, overlooked the expansion of electric supply in informal settlements. It gave less attention to energy kiosks, decentralized electrical services, off-grid electric expansion, private sector involvement in energy supply, and electric access programs like Universal Electricity Access Program (UEAP) that ignored the city of Addis Ababa (Subbiah, Mansoor, Misra, Jaffer, & Tiwary, 2016; Beyene, 2018). Increasing demand for energy, insufficient finance, and the need to subsidize electricity and energy-efficient devices are the major challenges to energy suppliers (Karatasou, Laskari, & Santamouris, 2014; Grueneich, 2015; Barnes, Golumbeanu, & Diaw, 2016; Blair, Pons, & Krumdieck, 2019). Together with lack of integrated urban planning, these factors influenced the power supply and enhance income differences among informal settlements. The number of people that have access to electricity is 44.98%; only 27% has grid connection and 92% of the energy produced is consumed for domestic use (WB, 2020).

Impact evaluations made on energy sector in Ethiopia have focused on rural electrification, improved cook stoves and environmental impacts of solar Photovoltaic systems (Torero, 2015; Raitzer, Blönda, & Sibal, 2019; Bayera, Kennedy, Yang, & Urpelainen, 2020; Wassie & Adaramola, 2021). Currently, no study is found on the impacts of access to and use of electricity on the economic status of households in informal settlements. Failure to properly understand the economic impacts of electric use and households' energy consumption habits in informal settlements could lead to incorrect policy decisions.

The objective of this paper; therefore, was to analyze the impacts of access and use of electricity on the type of home-based business activities, income generated from these undertakings, number of times households bake per week, and the relationship between number of fuels utilized and monthly family income based on households' electric-use status. It assessed the impact of electric-use on informal settlers' family income, the share of each energy source on households' total energy expenditures and estimate the contribution of electric use on cost savings in informal settlements. Then, it indicated the need to conduct measures to change households' energy consumption behaviors and revise policies related to the provision of basic services to households living in the outreach areas.

2. Materials and Methods

2.1. Description of the Study Area

Like any other developing cities, the city of Addis Ababa faced with multiple development challenges; such as urban expansion in a sprawling manner resulting in an estimated 46% of unutilized or underutilized land, extremely high density (up to 30,000 people per square km) at the city center while the national average is 108 people per square km, and around 30% of the population live with poor living conditions (Young, Anderson, & Naughton, 2018; World Population Review, 2021).

Fig.1 shows the location of ten sub cities of Addis Ababa. Four of them are found in the downtown of the city while the rest border Oromia Region. Among these sub cities in the of Addis Ababa is *Yeka* sub city where most informal settlers live in ragged areas and in those close to the reserved forests. The sub city shares a long border with of Oromia region that extends from *Entoto Mariam* to *Legetafo*. These situations have drawn the attention of researchers to focus on this sub city.

Yeka sub city consists of thirteen *Woredas* [2], and five of them are found in the expansion areas. Among those Woredas found in the vicinity of Addis Ababa, Woreda 12, shares the largest territory with the cultivated edges of the rural areas, and informal settlers are found in its eight sites. The *Woreda* is located at about 9°3'2"N, 38°52'41"E, 2,450 meters above sea level and approximately 11 km from the city center. It is found around the holy church of Kotebe Gabriel and Kotebe Metropolitan University (Fig. 1).

Based on the data compiled from the respondents, in the study area, 78% of informal settlers have access to roads and transportation, 80% access to education and health centers, 20% live around river banks and low laying areas, 47% live close to forest resources, and 38% are located in a rugged topography/hilly areas.

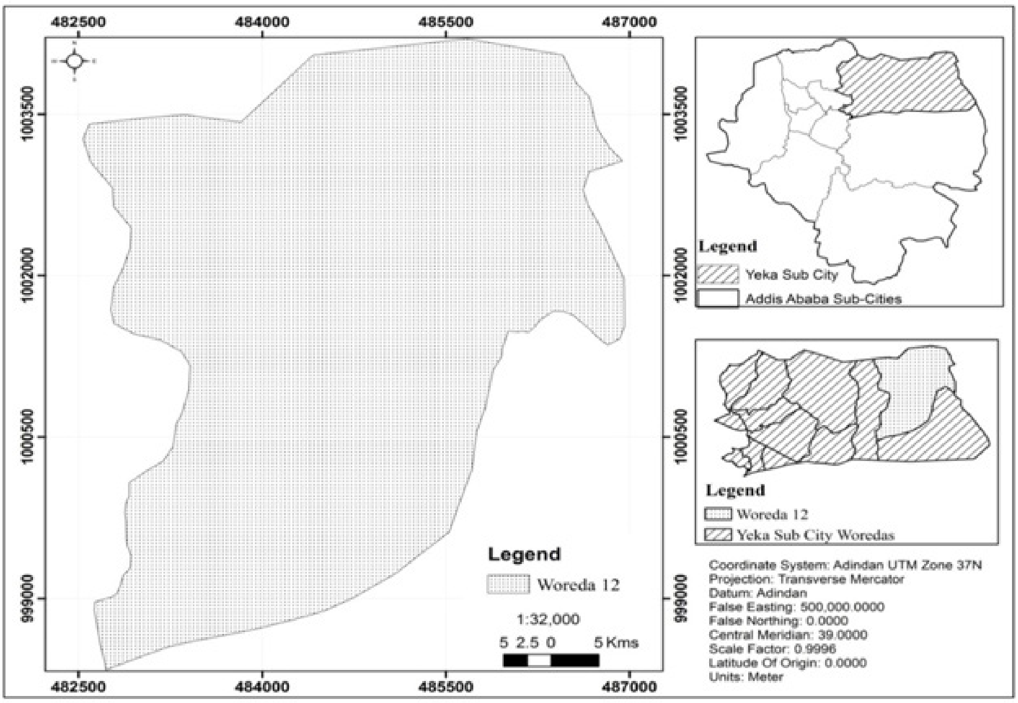

Fig.1: Location Map of the Study Area
Source: Modified from Ethio GIS shape file

2 Woreda is a local term used to describe the lowest administrative unit of Addis Ababa City Administration. It is equivalent to county in Western countries.

2.2. Sampling Method and Data Sources
2.2.1. Sampling Method

Considering the similarity of informal settlers and the difficulty to cover all sites in a given time and financial resources, the sample design was down-scaled to household level, and respondents were drawn in four stages.

1. *Woreda* 12 was purposively selected due to its location in the border areas and the relative longer territory it shares with the neighboring region than the other four *Woredas* in Yeka sub city..

2. Based on the documentary evidences obtained *Woreda* 12 Administration, informal settlers are specifically located in eight sites. From these, 1926 electric-users[3] are found in seven sites (Kotebe Gebriel, Hibret Amba, Rediet, Happy Village, Mesalemia, Sara Park, and Demamit), and 664 non-users[4] of electricity are located in three sites (Kotebe Gebriel, Kara and Demamit). These numbers are still very large and unbalanced to develop a sample frame.

3. As a result, two sites from electric-users (Kotebe Gebriel and Hibret Amba, with a total of 576 informal settlers) and two sites from non-users of electricity (Kotebe Gebriel and Demamit, with 516 informal settlers) were selected purposively. This helped to develop a balanced sample frame for electric-user and non-user informal settlers.

4. Once the population of interest (sample frame) is specified, the representative sample sizes for study considering relative heterogeneity among the sites and relative homogeneity among households within the same site is determined at 95% confidence interval using the formula as follows(Kothari, 2004):

$$n = \frac{Z^2 . N . p . q}{\sigma^2 (N-1) + (Z^2 . p . q)}$$

Where, N*i* & n*i* = Population and sample sizes respectively
p = Maximum possible proportion (p = 0.5 and q = 1-p)
σ = Precision level or margin of error at 0.05
Z = Researcher's margin of error at 95% confidence level

Based on this formula, 450 sampling units (229 are electric-users and 221 are non-users of electricity) were drawn randomly. The respondents were selected from Kotebe Gebriel, Hibret Amba and Demamit using aproportional sampling method, and these households served as a *unit of analysis* (Table 1). The method gave us equal chance of inclusion of each household from each site, fairly representing households from electric-users and non-users groups, and minimizing sampling errors. First, electric-users were selected randomly, and then, non-users of electricity were chosen using the *Nearest Neighborhood Method (NNM).*

3 Electric-users are households that use electricity for cooking and baking. They got this service from Ethiopian Electricity Utility or from their neighbor by sharing the cost.

4 Non-users of electricity refer to households who either do not use electric power at all or use it only for illumination purpose by buying from their neighbors at 50 Birr per lamp per month

Table 1: Sampled Households based on Site and User Status

Study Sites Selected	Electric-Users	Non-Users of Electricity	Total	
			Freq.	%
Kotebe Gebriel	184	104	288	64
Demamit/Demeka	-	117	117	26
Hibret Amba	45	-	45	10
Total	229	221	450	100

Source: Data organized through documentary reviews by author, April, 2021

2.2.2. Sources and Types of Data

Primary data were obtained using a multi-tire questionnaire survey administered on 450 randomly drawn households found in Kotebe Gebriel, Hibret Amba and Demamit and managed by the researcher, and the enumerators were well trained and closely monitored. The list of informal settlers' was obtained from the registry book and computerized data base of Woreda 12 Administration.

Field work during the pilot study and data gathering stages helped to observe the general housing condition, the landscapes, availability of infrastructures in the study area and the activities of data collectors were closely monitored. To minimize distortions and personal bias associated with respondents' opinions and attitudes, the validity and reliability of the data gathered was verified carefully using statistical software (SPSS and Stata).

2.3. Method of Data Analysis and Model Specification

This study utilized descriptive statistics and regression models to analyze the data gathered from sampled households. Descriptive methods were used to organize data on households' FCB and energy sources, the number of times households bake Injera[5] in a week, income generated from home-based businesses, and energy sources used for home-based businesses and domestic activities.

The study applied ESR model to estimate the treatment effect of electric-use. This helps to evaluate the impacts of access to electricity on informal settlers' economic situation and shows the relationship between the various explanatory variables and the dependent variable described by family income and households' monthly total energy expenditures. The guide to apply this method is to answer the question 'what would happen to households if they had access to electricity?'

Propensity Score Matching (PSM) Method

The propensity score is the conditional probability of assignment to a particular treatment

5 Injera is traditional staple food (flatbread) made from fine iron-rich Teff (a cereal crop typically grown in Ethiopia) sometimes mixed with wheat, barley or sorghum flour.

given a vector of observed covariates (Rosenbaum & Rubin, 1983). The rationale for using the PSM model is that simple comparison of the outcomes before and after using electricity or between electric-users and non-users of electricity, and without establishing similar groundwork is considered as poor impact evaluation (Thoemmes, 2012; Torero, 2015). Rather, this can be better done by using Difference in Difference model (DID).

The PSM model helps to balance the distribution of electric-users and non-users with respect to measured baseline covariates for a more objective analysis excluding households who cannot be well matched. Bayera, et al., (2020) also explained failure to control confounding factors attributing to outcomes and nonrandom assignment of households to treatment groups brings differences across regimes and overestimates the impact of regressors. It helps to explain households' reasons for choosing electric power, and any differences in outcomes are exclusively attributed to treatment differences.

Variables that are observable, measurable, and that directly relate to the outcome and help to minimize imbalances between electric-users and non-users of electricity, and treatment outcomes that are assumed to have no effect on baseline variables in the reverse order are used to estimate the propensity scores. Based on these criteria, only five baseline covariates (sex, age, education, family size and number of years lived in the area) were considered. The probability of a household receiving treatment is calculated using the model as follows (Lane, et al., 2012):

$$Yi=(Ti\ /Xi\ \text{or}\ Ci/Xi) \quad [1]$$

Where, Yi = Propensity score, Ti = Treatment group, Ci = Control group,
Xi = A set of baseline variables

Then, non-users of electricity were matched with electric-users using the PS calculated. The system matches non-users of electricity more than once with one electric-user governed by Nearest Neighbor Matching (NNM) technique. This method helps to maintain large sample sizes, ensures both groups have equal chance of receiving treatment, and guarantees the two are matched equally on all baseline covariates considered except in energy use status (Thavaneswaran & Lix, 2008; Staffa & Zurakowski, 2018). This process narrows the gap between electric-users and non-users of electricity and households in the two groups are relatively homogenous after matching. It helps to evaluate the changes in outcome variables (in this case family income and total energy expenditures by a household) by comparing electric-users with non-users of electricity based on the relevant covariates.

Endogenous Switching Regression (ESR) Model

The PSM model does not account unobservable variables, and the outcome does not reveal precisely whether it is due to applying the preferred energy source or other unmeasured factors. When the outcomes of electric-users are different from non-users of electricity only on observable characteristics, the impact described by β is biased. Therefore, only the ESR model is applied to estimate the treatment effects by accounting both observable and non-observable variables such as the impact of the education of the household head and employment status on households electric use stats (Powers D. , 2007; Ifegbesana, Rampedia, & Annegarn, 2016). The dependent variables in the regression models are households' family income and total energy expenditures. It captures the latent benefit and the expected desirability of electric use by applying the model as follows (Pickering, et al., 2017; Wohlfarth, Eichhammer, Schlomann, & Worrell, 2018):

$Z_i^*=X\gamma+\varepsilon$ $\quad$ Z=1 if $Z_i^*>0$ $\quad$ and Z=0, Otherwise [2]

Where, Z_i^*= the latent effect of electric use; γ= Parameters to be estimated; ε=error term; Z= endogenous benefits of electric-use.

ESR model is used to estimate treatment effects by comparing electric-users with non-users of electricity. The model that accounts exogenous variables affecting both treatment selection and the expected outcomes is provided as follows (Antonakis, Bendahan, Jacquart., & Lalive, 2014; Ifegbesana, Rampedia, & Annegarn, 2016; Bayera, Kennedy, Yang, & Urpelainen, 2020):

$Y_1=\beta_1X_1+\mu_1$ (if Z=1) and $Y_0=\beta_0X_0+\mu_0$ (if Z=0) **[3]**

Based on this model, only one outcome is observed at a time. If a household uses electricity, Y_1 would be observed; if not, Y_0 would be observed. That is, when Y_1 is observed, Y_0 is missing and Z=1. When Y_0 is observed, Y_1 is missing and Z=0.

The model assumes that those households assigned to status 1 are identical to others assigned to status 0 and there is interchangeability across households' electric-use status. Thus, it is possible to ask what would be the outcome if a respondent in status 1 were assigned to status 0 and vice versa(Powers D. , 2007; Kanyamuka, 2017). To this end, four regimes describe households' energy user status.

Regime 1: $E(Y_1/X,Z=1)=\beta_1X_1+\varepsilon_1$ Households using electricity
Regime 2: $E(Y_0/X,Z=0)=\beta_0X_0+\varepsilon_0$ Households not using electricity
Regime 3: $E(Y_0/X,Z=1)=\beta_0X_1+\varepsilon_0$ Electric-users had they been non-users of electricity
Regime 4: $E(Y_1/X,Z=0)=\beta_1X_0+\varepsilon_1$ Non-users of electricity had they been electric users

[4]

Where, Regime 1 and Regime 2 are observed from survey data; Regime 3 and Regime 4 are hypothetical switching effects to be calculated; ε_i= error terms

Average Treatment Effect (ATE) on family income and households total energy expenditure is determined by taking the difference between the conditional expected outcomes of electric-users and non-users of electricity (Powers D. A., 1993; Antonakis, Bendahan, Jacquart., & Lalive, 2014; Dehejia & Wahba, 2002). That is, had electric-users not used electric power, the Average Treatment Effect on the Treated (ATET) is estimated by subtracting '*Regime 3 from Regime 1*'as follows:

$ATET=E(Y_1/X,Z=1)-E(Y_0/X,Z=0)$ **[5]**

Similarly, the average switching effect on non-users of electricity had they used electric-users, i.e., the Average Treatment Effect on the Untreated (ATEU) is estimated by subtracting 'Regime 2 from Regime 4'as provided under:

$ATEU=E(Y_1/X,Z=0)-E(Y_0/X,Z=0)$ **[6]**

3. Results and Discussion
3.1. Socio-Economic Profiles of Households

Energy is vital for all human beings. Nowadays, it is connected with everything. It is used for baking, cooking, lighting, heating, refrigeration, and other home applications that people use in their day to day life. It improves the health and education services, water supply, the environment, and family income (Torero, 2015; Beyene, 2018; Guta, 2020). Understanding the socio-economic and demographic characteristics of households; therefore, is critical to determine their energy choice and consumption levels (Agizew, 2017; Ateba, Prinsloo, & Fourie, 2018; Ayele & Demel, 2018).

Table 2 presents the socio-economic and demographic profiles of informal settlers and their electric use status. The data show that 63% are male headed households. From all households, 31% are male headed electric-users, and 20% are female headed electric-users. Age wise, 58% are below 45 years of age and from this group, about 48% are electric-users. From those above age 45 years (42% of all households), 55% are electric-users. This implies that male and aged household heads are more likely to use electricity than traditional fuels.

Among households in informal settlements involved in domestic activities (baking, cooking, and washing activities), 95.11% are women, 3.11% are children and the rest are men. About 98% of electric-users and 92% of non-users of electricity are women (including servants) involved in domestic activities. The number of households who shifted family labor to domestic activities also varies based on their electric-use status. That is, 24 households from electric-users and 62 from non-users of electricity shifted family labor to domestic activities. This indicates non-users of electricity are forced to use more than 2.5 times more family labor than electric-users for domestic activities.

In terms of education, 40% have first degree, and from this 76% are electric-users. About 56% of households are hired, and out of these 69% are electric-users. From those who are already hired, 91% are permanent employees, and 71% of them are electric-users. The number of years a household lived in the area, the condition and number of rooms owned as well as the size of land under his/her custody have close association with electric use status. For example, from households who lived more than 9 years (35% of all households), live in homes that are in a very good condition (6% of all households), owned more than 3 rooms (31 of all households), and held land above 240m2(12% of all households), 74%, 89%, 75% and 73% are electric-users respectively.

Mustefa & Lika (2016) has shown the nexus between energy and gender and (Danlami, Islam, & Applanaidu, 2015; Butera, Caputoa, Adhikaria, & Mele, 2019; Olugbire, et al., 2016)on the influence of energy price, home type, size, and condition on energy choice and consumption levels. This study showed that all households do not have equal access to electricity. As Table 2 indicates certain groups of households lack access to clean, reliable and affordable energy whilst providing affordable, reliable, sustainable and clean energy for all in 2030is an agenda of sustainable development goals (UNDP, 2015; World Bank & IEA, 2017).

Generally, he study conducted by Butera, Caputo, Adhikaria, & Facchini(2016) indicated that informal settlers were about 18.3% of the population of Addis Ababa. In this study, the proportion of electric- users was 51% of informal settlers while the rest were non-users of electricity. At present the number of informal settlers is continuously swelling at a fast rate, and this makes the provision of adequate, reliable and affordable electricity difficult. Such a study, therefore, helps to stabilize energy prices, increase the supply of alternative fuels, reduce the pressure on wood resources, and maintain appropriate energy mix (JICA, 2011; Nibretu, Degefa, & Tamirat, 2021).

Table 2: Households' Demographic and Socio-Economic Factors

Characteristics	EU	NEU	Total*
1.Sex:			
Male	138	146	284 (63)
Female	91	75	166(37)
2. Age			
Below 30	19	23	42(9)
30-45	106	113	219(49)
45-60	97	76	173(38)
Above 60	7	9	16(4)
3. Education level:			
Below grade 8	34	102	136(30)
Grade 9-Diploma	59	75	134(30)
Degree and above	136	43	179(40)
4. Employment status: Hired			
Self employed	171	81	252(56)
Retired/unemployed	50	120	170(38)
	8	20	28(6)
5. Employment type if hired:			
Hourly and daily	2	2	4(1)
Contract	6	13	19(8)
Permanent	163	66	229(91)
6. Family income:			
Up to 6,000 Birr	32	88	120(27)
Above 6,000 Birr	197	133	330(73)
7. Years lived in the area:			
Up to 3 years	9	64	73(16)
4-6 years	42	72	114(26)
7-9 years	62	41	103(23)
Above 9 years	114	41	155(35)
8. Home condition owned:			
Poor (wood & mud)	31	75	106(24)
Good (wood & cement)	170	143	313(70)
Very good (steel & blockets)	25	3	28(6)
9. Rooms owned:			
1-2 rooms	50	118	168(38)
3 rooms	71	68	139(31)
More than 3 rooms	104	34	138(31)
10. Land size held:			
Up to 120m^2	30	49	79(18)
120-240m^2	159	154	313(70)
Above 240m^2	38	14	52(12)

* Numbers in the parenthesis are percentages

Source: Survey data, April, 2021

Table 3 revealed households' most common food consumption behaviors (FCBs) that are linked to each energy source. Based on this data, households who want to add the taste and flavor of food staffs, roast and boil coffee, dry and fry cereals, and cook cultural dishes like *Doro Wot* and *Shiro Wot* use traditional energy sources. In other words, compared to electricity, biomass gives more taste and flavor to foods and households with lower family income are seen drying cereals and cooking foods using traditional energy sources. Contrary to this biomass has no substitute for cooking traditional foods, and its scarcity and terrifically raising price over time urges households to consume few hot meals and adopt meals that can be cooked fast (Getachew, 2016).

On the other hand, although a large number of households are forced to use biomass, they need to bake *Injera* using electricity. This is because electricity saves time, relatively cheaper, clean, and healthy source. Behaviors such as the need to get a variety of foods /more nutrition/ which are fresh and to frequently cook and take enough meals per day are often associated with using alternative energy sources with the concept of energy stacking.

Similar to these findings, prior studies revealed that all factors are not equally important in explaining households' fuel consumption behaviors. Danlami, Islam, & Applanaidu (2015) and Amoah (2019);for example, described that wealthy households headed by higher levels of education are less likely to use fire wood, kerosene and LPG. Instead, they consume more electricity and solar energy(Lay, Ondraczek, & Stoever, 2013; Baiyegunh & Hassan, 2014).

Table 3: Households' Food Consumption Behaviors Affecting Energy Choice

FCB	FWC	Electricity	Indifferent
• To get variety of foods /more nutrition/	46	12	389
• Frequently cook and get fresh foods	4	38	396
• Add flavor/taste to food staffs	267	5	174
• Help to get enough meals per day	29	26	392
• Roast and boil coffee	401	24	20
• Dry/fry cereals	421	20	3
• Cook cultural dishes	309	77	59
• Bake *Injera* and bread	115	271	59

FCB=Food Consumption Behavior, FWC=Firewood and charcoal;
Source: Data organized by the author, Oct., 2021

In an effort to study the factors affecting electric-use status of households, most electric-users and non-users of electricity agree that electricity helps them in generating more income, lowering indoor air pollution, keeping themselves clean and healthy, and reducing the workloads of family members (Table 4). However, due to lack of access to electricity, non-users of electricity (particularly low-income households) often consume biomass, and this exposes them to indoor air pollution and is associated health effects. According to Muller & Yanb(2018), this group of households heavily relies on plant and crop residues, animal dung, firewood and charcoal.

Table 4: Factors Influencing Households' Electric Use Status

Factors affecting energy choice	EU		NUE	
	FWC	Electricity	FWC	Electricity
• Helps to generate more income	16	210	27	184
• Consumed by low income groups	105	123	197	24
• Lowers air pollution and clean/healthy	1	223	-	210
• Exposes to indoor air pollution	215	4	170	23
• Reduces workloads of family members	1	218	4	201

EU=Electric-users, NUE=Non-users of electricity, FWC=Firewood and charcoal
Source: Data organized by the author, Oct., 2021

The number of days that households baked *Injera* per week also varies based on their electric-use status (Fig. 2). For instance, electric-users baking once and more than three times in a week are greater than the number of non-users of electricity. Those who bake only once are assumed to use electricity for personal consumption. The reason for larger number of households to choose electricity could be associated with its convenience, low air pollution effect, and cost saving and family labor saving nature. For business purposes, households bake more than three times per week using electricity. This in turn contributed to generate more income. Frequent power interruption and low power supply have also forced households to bake many times and use biomass for both business and domestic purpose.

As shown in Fig 2, 35% of non-users of electricity and 31% of electric-users baked twice in a week. Though the difference is small, due to their access to electricity, electric-users have relatively higher chance of cooking more than two times in a week than non-users. The cost of cooking food frequently using biomass is very high for non-users of electricity
.

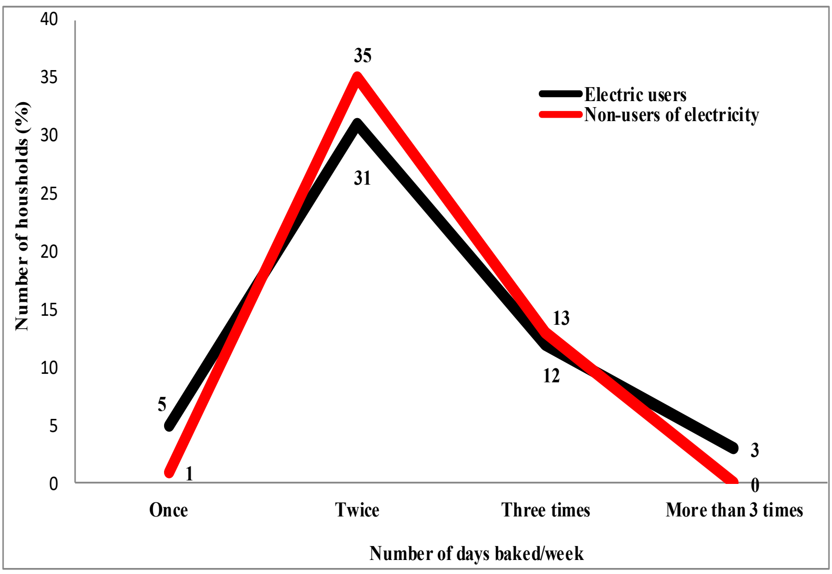

Figure 2: Number of Days Households Baked in a Week
(Source: Data organized by the author, Oct., 2021)

Table 5 presents the relationship between households' electric-use status and income generated from home-based business activities in informal settlements. The survey result indicated that from 450 households surveyed, 141 (31%) owned different kinds of home-based businesses and from these households, 63% were electric-users, and 37% were non-users of electricity.

The types of home-based business activities carried out by households in informal settlements included baking *Injera* (57%); roasting and boiling coffee, preparing potato chips and drying cereals (14%); retailing and fruit selling (16%); and renting a house, selling firewood and charcoal and a mix of activities (13%). From the households baking *Injera*, 82% use electric power and from those roasting and boiling coffee, drying and frying potato chips and cereals, 68% use electricity. From home-based business activities that require little or no energy (such as retailing and fruit selling, renting a house and selling charcoal and firewood), 76% are non-users of electricity.

Households used different energy sources for their home-based businesses. These energy sources differ based on households' electric use status. The data in Table 5 below show that 56% used electricity, 36% biomass, and 8% low electric consuming activities or businesses that do not require energy at all. Among electric-users, 88% used electricity and the rest used biomass or business activities that do not require energy. On the other hand, 81% of non-users used biomass for their businesses and the rest used little energy or activities that do not require energy at all.

From households generating business income above 2,000 Birr per month, more than 63% are electric-users and from those earning more than 4,000 Birr per month, this group reaches to 92%. This shows electric-users generally earn greater family income per month and carried more business activities than non-users of electricity. This corroborates households' electric use status has a significant impact on the number of home-based businesses owned and amount of income generated that in turn influence access to electricity.

Table 5: Type of Home Business Activities, Energy Sources and Households' Income from these Activities based on Electric Use Status

Type of home-based business activities	EU	NUE	Total*
Baking Injera	66	15	81 (57)
Roasting and boiling coffee, potato chips and cereals	13	6	19 (14)
Retail trade and fruit selling	5	18	23 (16)
Renting a house, selling firewood and charcoal	2	4	6 (4)
A mix of activities	3	9	12 (9)
Total	89	52	141 (100)
Sources of energy			
Firewood and charcoal	9	42	51 (36)
Electricity	78	1	79 (56)
Not using energy at all	2	9	11 (8)
Total	89	52	141 (100)
Income from home-based business (Birr)			
< 2,000	49	29	78 (56)
2,001-4,000	29	22	51 (36)
Above 4,000	11	1	12 (8)
Total	89	52	141 (100)

Note: * Numbers in the parenthesis are percentages *EU=Electric-users, NUE=Non-users of electricity*
Source: Survey data, Oct., 2021

3.2. Households' Energy Consumption Levels in Informal Settlements

Based on Table 6, households' average monthly expenditure for firewood is 402 Birr. Non-users of electricity expend 542 Birr,and electric-users 252 Birr per month. For charcoal, households' average monthly expenditure is 248 Birr. Non-users of electricity spend 322 Birr,and electric-users spend 175 Birr per month. The data shows that households in informal settlements mainly use firewood and charcoal due to lack of adequate and reliable electricity supply, and compared to electric-users, non-users of electricity heavily rely on traditional energy sources. According to Getachew, Abera, Edwards, & Troncoso(2018), the gap between supply and demand for biomass is growing and the proportion of income spent on energy is increasing.

Electricity is the second most important energy source (following firewood)for households in the study area. On average,they expend 300 Birr. Non-users of electricity spend109 Birr, and electric-users 438 Birr per month. These indicate electric-users expend more for electricity, and this energy significantly affects their total energy consumption.

The overall average monthly energy expenditures of non-users of electricity (995 Birr) are greater than that of electric-users (882 Birr). This could be non-users' large amount of biomass consumption and inefficient use of resources, and this result shows the positive contribution of electric use in saving households' monthly energy expenditure.

Table 6:Households' Monthly Energy Expenditures (Birr)

Energy expenditures*	EU	NUE	Total
Firewood:			
Mean	252	542	402
Maximum	620	1200	1200
Minimum	100	60	60
Charcoal: Mean	175	322	248
Maximum	600	800	800
Minimum	50	50	50
Kerosene: Mean	110	160	132
Maximum	210	400	400
Minimum	50	20	20
Electricity: Mean	438	109	300
Maximum	1200	300	1200
Minimum	45	25	25
Total: Mean	882	995	938
Maximum	1580	2100	2100
Minimum	360	200	200

EU=Electric-users, NUE=Non-users of electricity
**The energy expenditures in a month cover for both domestic use and home-based business activities*
Source: Data organized by the author, Oct., 2021

A relationship between households' monthly income and the number of fuels consumed by households is established (Fig. 3). The survey data indicated that about 12% of households use two, 57% use three, and 31% use four kinds of energy sources. Income wise, 73% of households earn a family income more than 6,000 Birr and 27% below 6,000 Birr per month. Among households earning more than 6,000 Birr per month, 197 households (60%) are electric users. Further, from households earning more than 6,000 Birr per month,the proportion of electric-users consuming two or more energy sources are greater than that of non-users of electricity.

When we try to look the relationship between the number of fuels used by a household and family income from different perspective, as the number of fuels consumed by a household increases, the gap between households' earning an income below 6,000 Birr and above 6,000 Birr per month widens. This means as households' income increases, they tend to use two or more energy sources with the concept of energy staking, and no one relies on a single energy source. Similar to this finding, Alemu & Köhlin (2008), Fantu, Abebe, & Tadele (2015)and Agizew(2017)indicated that expenditures for energy and the number of fuels used increases with higher levels of income.

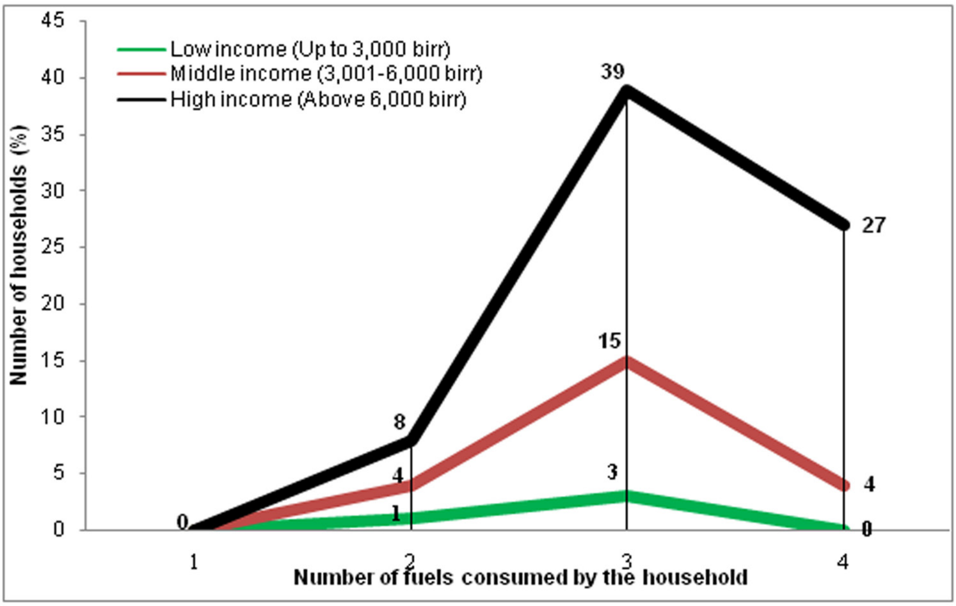

Figure 3: Households' Monthly Income and Number of Fuels Used
Source: Data organized by the author, Oct., 2021

3.3. Impact of Electric Use on Family Income: The ESR Model

For simplifying our discussion, the dependent variable (i.e., family income) is classified into two groups: those earning up to 6,000 Birr and those earning above 6,000 Birr. The first group constitutes 27% of the total sampled households (7% electric users and 20% non-users of electricity) while the second group includes 73% (44% electric users and 29% non-users of electricity).

The ESR model introduces exogenous variables affecting family income. It helps to avoid errors in estimating ATE simply by introducing instrumental variables as presented in Table 7 (Ifegbesana, Rampedia, & Annegarn, 2016; Pickering, et al., 2017; Wohlfarth, Eichhammer, Schlomann, & Worrell, 2018). The reverse effect of family income on the independent variables in turn induces changes in the explanatory variables and the final outcome of the model.

The p-value and the strength of the model are statistically significant indicating the strong correlation between households' family income and various independent variables. High R2values for both electric users and non-users of electricity indicate the explanatory power of the model and the variables considered in estimating the impact of electric-use on family income. The equivalency of the endogenous variable (employment status) and the instrumental variable (education level) portrays the model as just and defined correctly.

After a long iterative process, the regression results indicated that employment status of the household head, energy that add the taste and flavor of food staffs, and sources that are appropriate to dry and fry cereals, but expose households to indoor air pollution, have negative impact on family income of electric-users whilst the type of home-based business owned, energy source appropriate to prepare a variety of food staffs, and land size held have significant positive effect on the family income of electric-users. However, demographic factors (such as sex, age and family size), shelter type, land holding status, availability, reliability and price of energy sources have no significant impact on family income in informal settlements.

The survey data indicated that among households holding a relatively large plot of land (above 180m2), 63.57% are electric-users. The appropriate source for carrying out home-based business activities and for cooking a variety of food staffs is electricity or a mix of alternative energy sources. To this end,as electric-users' land size increases, the number of households' earning a family income increases.

Similarly, the amount of income generated from home-based business activities, energy sources that add the taste and flavor of food staffs, and those that are used to bake *Injera*, have significant positive influence on family income of non-users' of electricity. On the contrary, biomass (firewood and charcoal) that are mainly used to cook cultural dishes (like Doro Wot and *Shiro Wot*) have negative influence on the family income of non-users of electricity. This might be because of the health effects, inefficient use of biomass and the shifting of family labor from other income generating activities.

Table 7: Factors Affecting Family Income: The ESR Model

Family income	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z
Electric users				**Non users of electricity**		
Employment status	-0.4410	0.2650***	-1.66	-0.6011	0.4747	-1.27
Income from home businesses	0.0382	0.0454	0.84	0.3792	0.1209*	3.14
Type of home business owned	0.0621	0.0347***	1.79	-0.0431	0.0595	-0.72
Sex	0.0818	0.0900	0.91	-0.0127	0.2792	-0.05
Age	0.0731	0.0880	0.83	-0.0134	0.1310	0.10
Family size	0.0558	0.0727	0.77	-0.1608	0.1279	-1.26
Energy to take food variety	0.2910	0.0728*	4.12	-0.1538	0.0983	-1.56
Energy that adds food flavor/taste	-0.0355	0.0408	0.87	0.1747	0.0652*	2.68
Energy used to dry and fry cereals	-0.1610	0.0905***	-1.78	-0.1375	0.0991	-1.39
Energy to cook cultural dishes	-0.0382	0.0406	-0.94	-0.2603	0.0698*	-3.73
Energy for baking Injera	0.0432	0.0637	0.68	0.1901	0.0753*	2.53
Shelter type	0.0586	0.1072	0.55	0.3389	0.2736	1.24
Land size	0.0684	0.0344**	1.99	-0.1181	0.0944	-1.25
Land holding status	-0.0115	0.0407	-0.28	-0.0545	0.1553	-0.35
Air pollution effect Θ	-0.2803	0.1461**	-1.92	-0.0431	0.2080	-0.21
Available and reliable energy	-0.0342	0.0573	-0.60	-0.2569	0.1718	-1.50
Affordability of energy source	0.0277	0.0797	0.35	-0.1179	0.1298	-0.91
_cons	-0.1219	0.4104	-0.30	2.1274	0.9001	2.36

, ** and * statistically significant at p<1%, p<5% and P<10% respectively.*
Θ Pollution effect is measured based on the energy source that has more indoor air pollution effect /cause headache and burning of eyes/.
EU=Electric-users, NUE=Non-users of electricity

Source: Data developed by the author, Oct., 2021

The regression result presented in Table 8 shows the impact of expenditures made for each source on electric-users' total energy expenditure. The result revealed that the use of electric power and firewood positively affect monthly total energy expenditures of households. On the other hand, expenditures made for kerosene and charcoal have no significant impact on total energy expenditures of electric-users. That is, keeping all other variables in the model constant, as expenditure for electricity increases by one unit, the total energy expense of the household increases by 0.4254 whilst per unit increase in firewood expenditure increases the total energy expenditure of the same household by 0.2548. This implies that electric use has more significant impact on increasing households' total energy expenditure than firewood use. Hence, any measure taken to save electric power could contribute to the total energy saving efforts of households.

The family income is also influenced by households' electric use status. For example, under citreous paribus assumption, as the income of electric users increases by one unit, their family income increases by 0.6184 while other sources of energy have no significan- impact on households' family income.

Table 8: The Impact of Energy Sources on Electric-users' Energy Expenditure and Family Income: The ESR Model

	Coef.	Std. Err.	z	p>/z/
Total expenditure	0.4254***	0.2550	1.67	0.09
Electricity	0.2548**	0.1133	2.25	0.02
Firewood	0.0597	0.0920	0.65	0.52
Charcoal	0.0923	0.0657	1.41	0.16
Kerosene	0.4015	0.5661	0.71	0.48
_cons				
Family income	0.6184*	0.2477	0.2477	0.01
Electricity	0.0777	0.1101	0.1101	0.48
Firewood	0.0571	0.0894	0.0894	0.52
Charcoal	-0.0545	0.0638	0.0638	0.39
Kerosene	-0.3488	0.5501	0.5501	0.53
_cons				

*** and *** statistically significant at p<5% and p<10% respectively.*
Source: Data developed by the author, Oct., 2021

Finally, estimating the average effect of electric-use is crucially important, and Table 9 portrays the treatment impact of the variables identified in Table 7 above. The estimates of the average treatment effect on the treated (ATET) and average treatment effect on the untreated (ATEU) showed households' family income differences due to their electric use status. That is, ATET and ATEU are both positive, and the mean values of the independent variables are significantly higher for electric-users than had they been non-users of electricity. The mean treatment effects are statistically significant indicating the considerable impact of electric use on family income. This is clearly seen when electric-users had been non-users of electricity,and non-users of electricityhad turned to be electric-users. That is, as a result of electric use, ATET has increased from 0.7609 to 0.7703, representing 2.02% increase in family income, ATEU has increased from 0.5163 to 0.5803, representing a 12.40% increase in family income, and ATE has increased by 25.85%.

The test for heterogeneity effect (HE) indicates 1) the difference between the impact of electric use on family income of electric-users and non-users of electricity had they been electric-users and 2) the difference between the impact of electric use on family income of electric-users had they been non-users of electricity and non-users of electricity on family income. In both cases, the HE test showed that electric use has high potential impact on family income, and its impact on non-users of electricity is higher than that of electric-users. These could be associated with non-users' limited and less frequent use of biomass and electric-users' high electric consumption experience relative to their family income.

Table 9: Impact of Electric Use on Family Income: The ESR Model

Electric use status	EU	NUE	TE
Electric-users (n=229)	0.7763	0.7609	0.0154*(ATET)
Non-users of electricity(n=221)	0.5803	0.5163	0.0640*(ATEU)
Heterogeneity effect (HE)	0.1960	0.2446	-
All households (n=450)	-	-	0.2585*(ATE)

** Statistically significant at p<1%*
EU=Electric-users, NUE=Non-users of electricity, TE= Treatment effect
Source: Data developed by the author, Oct., 2021

4. Conclusions and Recommendations

Conclusions

Transition to modern energy sources facilitates the socio-economic growth in informal settlements. However, complete dependence on a single energy source (i.e, electricity) does not ensure improvements in the quality of life of households and may not help to meet their FCBs. The study revealed that about 31% of households in informal settlements owned different kinds of home-based businesses, and from these households 63% are electric-users. The number of family labor shifted to domestic activities, frequency of baking per week, type of home-based business activities carried, the amount of income generated from these businesses and energy expenditures made by electric-users indicate the significance of access to electricity and its positive effect on improving households' economic status in informal settlements. The results of the treatment effects of electric use also indicated the positive impact of electric-use on family income.

However, lack of access to electricity does not totally prohibit non-users of electricity from carrying out home-based business activities, and one has to pay attention that households will continue to use biomass due to lack of access to reliable and affordable electric supply and in relation to their FCBs. Besides, these informal settlers have low paying capacity to electric service, and living for longer periods in the area does not ensure legal entitlement to own land get formal access to electricity.

Recommendations

Policy prescriptions shall focus on improving electric supply to households with power shortages, frequent interruption and fluctuation. Subsidizing electricity or making it affordable to low income groups for primary functions like illumination and charging of batteries, encouraging households using electricity during slack periods and power saving devices, and changing their FCBs are very critical policy measures. The government shall also consider the possibilities of "formalizing the informal settlers" based on the number of years they lived in the area and the suitability of their living area to the urban plan as short-term strategy. Furthermore, special attention should be given to non-users of electricity living sporadically mixed with electric-users and close to electric lines in the provision of electricity.

Ethical Considerations

This research paper is part of my original dissertation. It is not published anywhere and the authors declare that there is no conflict of interest (financial or personal relationships) that influenced the findings of this study.

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References

Adebayo, T. S., Agboola, M. O., Rjoub, H., Adeshola, I., Agyekum, E. B., & Kumar, N. M. (2021). Linking Economic Growth, Urbanization, and Environmental Degradation in China: What Is the Role of Hydroelectricity Consumption? *Int. J. Environ. Res. and Public Health*, 18(6975), 2-14.

Agizew, A. W. (2017). *Determinants of Household Energy Consumption in Urban Areas of Ethiopia. Cape Town, South Africa*: IUSSP International Population Conference.

Alemu, M., & Köhlin, G. (2008). *Environment for Development: Determinants of Household Fuel Choice in Major Cities in Ethiopia,* Working Papers in Economics No 399. Sweden: University of Gothenburg.

Amoah, l. T. (2019). Determinants of Household's Choice of Cooking Energy in a Global South City. *Energy and Buildings,* 196, 103-111.

Antonakis, J., Bendahan, S., Jacquart., P., & Lalive, R. (2014). C*ausality and endogeneity: Problems and solutions*. In D. Day (Ed.), The Oxford Handbook of Leadership and Organizations (pp. 93-117). New York: Oxford University Press.

Arlet, J., Ereshchenko, V., & Rocha, S. L. (2019). *Barriers to Urban Electrification in Sub-Saharan Africa from the Perspective of End-Users.* World Bank Group.

Ateba, B. B., Prinsloo, J. J., & Fourie, E. (2018). The Impact of Energy Fuel Choice Determinants On Sustainable Energy Consumption of Selected South African Households. *Journal of Energy in South Africa*, 29(3), 51-65.

Ayele, S. T., & Demel, T. (2018). Supply and Consumption of Household Energy in Central Ethiopia: The Case of Debre Berhan Town. *Journal of Fundamentals of Renewable Energy and Applications,* 8(5), 1-11.

Baiyegunh, L., & Hassan, M. (2014). Rural Household Fuel Energy Transition: Evidence from Giwa LGA Kaduna State, Nigeria. *Energy Sustain. Dev.*, 20, 30-35.

Barnes, D. F., Golumbeanu, R., & Diaw, I. (2016). *Beyond Electricity Access: Output-Based Aid and Rural Electrification in Ethiopia.* Washington, DC: World Bank.

Bayera, P., Kennedy, R., Yang, J., & Urpelainen, J. (2020). The Need for Impact Evaluation in Electricity Access Research. *Energy Policy*, 137.

Beyene, G. (2018). *The Challenges and Prospects of Electricity Access in Ethiopia, masters thesis.* Addis Ababa, Ethiopia.

Bhattacharjee, S., & Reichard, G. (2011). *Socio-Economic Factors Affecting Individual Household Energy Consumption: A Systematic Review,* Proceedings of the ASME 2011 5th International Conference on Energy Sustainability. Washington: https://www.researchgate.net/publication/267646836.

Blair, N., Pons, D., & Krumdieck, S. (2019). Electrification in Remote Communities: Assessing the Value of Electricity Using a Community Action Research Approach in Kabakaburi, Guyana. *Sustainability,* 1-31.

Butera, F. M., Caputo, P., Adhikaria, R. S., & Facchini, A. (2016). *Analysis of Energy Consumption and Energy Efficiency in Informal Settlements of Developing Countries, The Challenge of Energy in Informal Settlements. A Review of the Literature for Latin America and Africa*. Procedia Engineering, 161, 2093–2099.

Butera, F. M., Caputoa, P., Adhikaria, R. S., & Mele, R. (2019). Energy Access in Informal Settlements. Results of a Wide on Site Durvey in Rio De Janeiro. *Energy Policy,* 134(110943).

Chowdhury, P. K., Weaver, J. E., Weber, E. M., Lunga, D., LeDoux, S. T., Rose, A. N., & Bhaduri, B. L. (2019). Electricity Consumption Patterns within Cities: Application of a Data-Driven Settlement Characterization Method. *International Journal of Digital Earth*, 119-135.

Dadzie, J., Runeson, G., Ding, G., & Bondinuba, F. K. (2018). Barriers to Adoption of Sustainable Technologies for Energy-Efficient Building Upgrade Semi-Structured Interviews. *Buildings,* Vol. 8(57), 1-15.

Danlami, A. H., Islam, R., & Applanaidu, S. D. (2015). An Analysis of the Determinants of Households' Energy Choice: A Search for Conceptual Framework. *International Journal of Energy Economics and Policy,* 5(1), 197-205.

Dehejia, R. H., & Wahba, S. (2002). Propensity Score-Matching Methods for Nonexperimental Causal Studies. *The Review of Economics and Statistics*, 84(1), 151–161.

ESCAP. (2019). *Electricity Access for Social Change. Bankok, Asia Pacific: Economic and Social Commission for Ascia and Pacific* (ESCAP), UN.

Fantu, G., Abebe, D., & Tadele, F. (2015). *The Residential Demand for Electricity in Ethiopia. Addis Ababa: Ethiopian Development Research Institute* (EDRI/AAU).

FAO. (2015). *FAO and the 17 Sustainable Development Goals.* Food and Agricultural Organization of the United Nations.

Gaunt, T., Salida, M., Macfarlane, R., Maboda, S., Reddy, Y., & Borchers, M. (2012). *Informal Electrification in South Africa: Experience, Opportunities and Challenges. Sustainable Energy Africa*.

Getachew, B., Abera, K., Edwards, R., & Troncoso, K. (2018). *Opportunities for Transition to Clean Household Energy in Ethiopia: Application of the WHO Household Energy Assessment Rapid Tool (HEART).* Geneva: WHO.

Getachew, M. M. (2016). Biogas Technology Adoption and Its Contributions to Rural Livelihood and Environment in Northern Ethiopia, the Case of Ofla and Mecha Woredas. Addis Ababa.

Grueneich, D. M. (2015). The Next Level of Energy Efficiency: The Five Challenges Ahead. *The Electricity Journal,* 28(7), 44-56.

Guta, D. D. (2020). Determinants of household Use of Energy-Efficient and Renewable Energy Technologies in Rural Ethiopia. *Technology in Society*, 61, 1-8.

Gyamf, B. A., Bein, M. A., & Bekun, F. V. (2020). Investigating the Nexus between Hydro-electricity Energy, Renewable Energy, Nonrenewable Energy Consumption on) utput: Evidence from E7 Countries . *Environmental Science and Pollution Research,* 27, 25327–25339.

Hanania, J., Stenhouse, K.,& Donev, J. (2018). *Access to Electricity.* https://energyeducation.ca/wiki/index.php?

IEA. (2012). *World Energy Outlook 2012.* Paris, France: OECD/International Energy Agency.

Ifegbesana, A. P., Rampedia, I. T., & Annegarn, H. J. (2016). Nigerian Households' Cooking Energy Use, Determinants of Choice, and Some Implications for Human Health and Environmental Sustainability. *Habitat International,* https://doi.org/10.1016/j.habitatint.2016.02.001, 55, 17-24.

JICA. (2011). *Energy Policy of Ethiopia. Tokyo International Center:* Japan International Coperation Agency.

Kanyamuka, J. S. (2017). A*doption of Integrated Soil Fertility Management Technologies and Its Effect on Maize Productivity: A Case of the Legume Bets Bets Project in Mkanakhoti Extension Planning Area of Kasungu District in Central Malawi,* Thesis in Agri. & applied economics. Lilongwe University of Agriculture and Natural Resources.

Karatasou, S., Laskari, M., & Santamouris, M. (2014). Models of Behavior Change and Residential Energy Use: A Review of Research Directions and Findings for Behavior-Based Energy Efficiency. *Advances in Building Energy Research*, 8(2), 137–147.

Kothari, C. (2004). *Research Methodology: Methods and Techniques* (Second revised edition ed.). New Delhi, India: New Age International (p) Ltd., Publishers.

Lane, F. C., To, Y. M., Shelley, K., & Henson, R. K. (2012). A*n Illustrative Example of Propensity Score Matching with Education Research.* Career and Technical Education Research, 37(3), 187-212.

Lay, J., Ondraczek, J., & Stoever, J. (2013). Renewables in the Energy Transition: Evidence on Solar Home Systems and Lighting Fuel Choice in Kenya. *Energy Econ.* , 40, 350–359.

Li, C., Wang, N., Zhang, H., Liu, Q., Chai, Y., Shen, X., . . . Yang, Y. (2019). Environmental Impact Evaluation of Distributed Renewable Energy System Based on Life Cycle Assessment and Fuzzy Rough Sets. Energies, Switzerland, 12(21).

Li, K., Zu, J., Musah, M., Mensah, I. A., Kong, Y., Owusu-Akomeah, M., . . . Agyemang, J. K. (2021). *The Link Between Urbanization, Energy Consumption, Foreign Direct Investments and CO2 Emanations: An Empirical Evidence from the Emerging* Seven (E7) Countries. Energy Exploration & Exploitatio, 0(0), 1-24.

Lloyd, P. (2017). The Role of Energy in Development. *Journal of Energy in Southern Africa,* 28(1).

Luhar, H. (2014). Causes for the creation and expansion of slum Sai Om. *Journal of Commerce & Management,* 1(10), 56-58.

Medina, A., Cámara, Á., & Monrobel, J.-R. (2016). Measuring the Socioeconomic and Environmental Effects of Energy Efficiency Investments for a More Sustainable Spanish Economy. *Sustainability,* 8(1039), 1-21.

Msimang, Z. (2017). *A study of The Negative Impacts of Informal Settlement on the Environment:A Case Study of Jika Joe*, Pietermaritzburg. https://researchspace.ukzn.ac.za/handle/10413/16293.

Muller, C., & Yanb, H. (2018). Household Fuel Use in Developing Countries: Review of Theory and Evidence. *Energy Economics,* 70, 429–439.

Mustefa, A., & Lika, T. (2016). The Energy-Gender Nexus: A Case Study among Urban and Peri-urban Female Headed Households in Arba-Minch Town, Southern Ethiopia. *EJOSSAH*, Vol. XII (1), 1-38.

Nibretu, K., Degefa, T., & Tamirat, T. (2021). Determinants of Energy Choice for Domestic Use in Informal Settlements of Addis Ababa. J*ournal of Science & Sustainable Development,* ISSN: 2070-1748 Vol. 8; https://dx.doi.org/10.4314/jssd.v8i1.3, 33 - 44.

Njoroge, P., Ambole, A., Githira, D., & Outa, G. (2020). Steering Energy Transitions through Landscape Governance: Case of Mathare Informal Settlement, *Nairobi, Kenya. Land*, 9(206), 1-19.

Olugbire, O., F.J., A., O.H., O., C.A., O., O.O, O., & A., A. (2016). *Determinants of Household Cooking Energy Choice In Oyo State, Nigeri*a. DOI http://dx.doi.org/10.18551/rjoas.2016-04.04, 4(52), 28-36.

Onyekachi, A. F. (2014). Prospects and Challenges of Informal Settlements and Urban Upgrading in Abuja. *International Journal of Innovation and Scientific Research,* 11(2), 420-426.

Padam, G., Rysankova, D., Portale, E., Koo, B. B., Keller, S., & Fleurantin, G. (2018). *Ethiopia Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework.* Washington DC: World Bank Group.

Pickering, E. M., Hossain, M. A., Mousseau, J. P., Swanson, R. A., French, R. H., & Abramson, A. R. (2017). *A Cross-Sectional Study Of The Temporal Evolution of Electricity Consumption of Six Commercial Buildings.*12(10, https://doi.org/10.1371/journal.pone.0187129).

Powers, D. (2007). *Censored Regression, Sample Selection, Endogenous Switching, and Treatment-Effect Regression Models.* Soc385K.

Powers, D. A. (1993). Endogenous Switching Regression Models with Limited Dependent Variables. *Sociological Methods & Research, Sage Publications, Inc.*, 22(2), 248-273.

Pueyo, A., & Hanna, R. (2015). *What Level of Electricity Access is Required to Enable and Sustain Poverty Reduction.* UK.

Rahuta, D. B., Alib, A., Mottaleba, K. A., & Aryal, J. P. (2019). *Wealth, Education and Cooking-Fuel Choices Among rural Households in Pakistan. Energy Strategy Reviews,* https://doi.org/10.1016/j.esr.2019.03.005, 24, 236-243.

Raitzer, D. A., Blönda, N., & Sibal, J. (2019). *Impact Evaluation of Energy Interventions: A review of the evidence.* Manila, Philippines: Asian Development Bank.

Rosenbaum, P. R., & Rubin, D. B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. Biometrika, 70(1), 41-55.

Staffa, S. J., & Zurakowski, D. (2018). F*ive Steps to Successfully Implement and Evaluate Propensity Score Matching in Clinical Research Studies. Anesthesia & Analgesia* (Special Article), www.anesthesia-analgesia.org, XXX(XXX).

Stern, D. I., Burke, P. J., & Bruns, S. B. (2016). *The Impact of Electricity on Economic Development: A Macroeconomic Perspective. Energy and Economic Growth: Applied Research Programme*, 1-44.

Subbiah, A., Mansoor, S., Misra, R., Jaffer, H., & Tiwary, R. (2016). Addressing Developmental Needs Through Energy Access in Informal Settlements, Decentralized Electrification and Development. *Open Edition Journal*s(15), 80-91.

Thavaneswaran, A., & Lix, L. (2008). *Propensity Score Matching in Observational Studies.* University of Mqnitoba: Manitoba Centre for Health Policy.

Thoemmes, F. (2012). *Propensity Score Matching in SPSS.* Cornell University, NY.

Torero, M. (2015). The Impact of Rural Electrification: Challenges and Ways Forward. *Revue d'économie du développement,* 23, 49-75.

UNDP. (2015). *Sustainable Development Goals (SDGs). The United Nations Development Programme (UNDP).*

UNESCAP. (2019). *Electricity Access for Social Change, Open Meeting. Bangkok, Asia Pascific: UN Economic and Social Commision for Asia and Pascific.*

Wassie, Y. T., & Adaramola, M. S. (2021). Socio-economic and Environmental Impacts of Rural Electrification with Solar Photovoltaic Systems: Evidence from Southern Ethiopia. *Energy for Sustainable Development,* 60, 52–66.

WB. (2014). *Access to Electricity (% of Population)*, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS. World Bank.

WB. (2015). *Beyond Connections: Energy Access Redefined.* Washington D.C: World Bank.

WB. (2020). Energy Situation, Ethiopia Group. Addis Ababa: energypedia.info.

Wohlfarth, K., Eichhammer, W., Schlomann, B., & Worrell, E. (2018). Tailoring Cross-Sectional Energy-Efficiency Measures to Target Groups in Industry. *Journal of Energy Efficiency,* 11(5), 1265–1279.

World Bank & IEA. (2017). *Global Tracking Framework—Progress Towards Sustainable Energy.* Washington DC, USA: International Bank for Reconstruction and Development.

World Population Review. (2021, May. 11). https://worldpopulationreview.com, Ethiopian Population 2021. Retrieved May 11, 2021

Young, J. D., Anderson, N. M., & Naughton, H. T. (2018). Influence of Policy, Air Quality, and Local Attitudes toward Renewable Energy on the Adoption of Woody Biomass Heating Systems. *Energies, Switzerland,* 11(2873), 1-24.

Zhe, L., Yüksel, S., Dinçer, H., Mukhtarov, S., & Azizov, M. (2021). The Positive Influences of Renewable Energy Consumption on Financial Development and Economic Growth. *SAGE open,* 1-10.