UNIVERSITY of RWANDA

College of Science and Technology

AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT

TITLE: SOCIOECONOMIC ANALYSIS OF ADOPTING MODERN COOKING FUELS

Thesis Number: 38

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Registration Number:217303165

A DISSERTATION SUBMITTED TO THE AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT

COLLEGE OF SCIENCE AND TECHNOLOGY

The University of Rwanda in partial fulfillment of the requirements of the degree of

MASTERS OF ENERGY ECONOMICS

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Month and Year of submission: OCTOBER 2020

Declaration

I declare that this thesis is a result of my work and has not been submitted for any other award at the University of Rwanda or any other institution

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Date of Submission: 23rd October 2020

This thesis has been submitted for examination with my approval as a university advisor.

Thesis Advisor: Johnson Bosco Rukundo

Signature

Dedication

The Almighty God

To my lovely Husband KAMWE RAYMOND,

To my lovely children ISHIMWE KAMWE Raylene and NTWALI KAMWE Jaden

Acknowledgment

The author would like to thank the Word Bank and the African Center of Excellence in Energy for Sustainable Development for their support of my studies. The center has provided me with knowledge, and skills that I'm able to apply while employed either, in the public or private sectors. Many thanks go to my supervisor, Dr. RUKUNDO Bosco Johnson for the good supervision work and guidance provided while writing this research Thesis.

I also express thanks to my husband, KAMWE Raymond who gave me possible support which was needed, I thank also Dr. KABIRI Charles who encouraged me and gave me good support during my study, I recognize also my family, and my friends for their emotional care and their help in all.

Abstract

The low adoption rate of modern cooking fuels has been a challenge in most countries with low development where biomass is used in high quantity cooking energy. Low adoption rates has been attributed to several factors, but little attention has been given to the household in terms of their economic status in the use of modern fuels for cooking. Further, results show that households headed by females living on their own within the urban region are likely to adopt modern cooking fuels. The research study concluded that although modern cooking fuels are appropriate for improved technology with multiple benefits including social and economic also environmental benefits, such benefits were not sufficient for the poor households to adopt the modern cooking fuels. Therefore, the study recommends the government and policymakers on increased awareness campaigns to emphasize the economic, social, and environmental values of modern fuels for cooking and to use more strategies for changing rural behavior.

Abbreviations

SSA:	Sahara south of Africa
GLSS6:	Ghana living standard survey
EICV:	Fifth Integrated Household Living Survey
MININFRA:	Ministry of infrastructure
NISR:	National Institute of statistic Rwanda
WHO:	World Health Organization
EAC:	East African Community
LPG:	Liquefied Petroleum Gas
REG:	Rwanda Energy Group
SACCO:	Saving and Crediting Cooperative
CO2:	Carbon Dioxide
CO:	Carbon monoxide
CH4:	Methane
NMHC:	Non-methane hydrocarbons
NO:	Nitric oxide
NH:	Ammonia

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CHAPTER ONE: GENERAL INTRODUCTION

1.1 The global use of Traditional fuels

Almost three billion people in the world lack access to energy infrastructure and use biomass solid fuels such as wood, charcoal, crop residues or dung for cooking, besides being highly inefficient, these traditional, open-fire cooking methods produce toxic particulates that cause household air pollution and contribute to around 4 million premature deaths per year especially among women and children.

In fact, because of social and cultural norms, in certain countries women spend most of their time in the home with children, so these two groups are more liable than men to breathe in the unhealthy smoke.

Severe impacts on health are not the only effects of the use of traditional cookstoves. For example, the emissions produced by the combustion of solid fuels also have a negative impact on the environment and contribute to global climate change, and intense use of firewood for cooking purposes substantially increases deforestation. This situation is not evenly distributed across the world. Rather, energy poverty, described by Bonan et al. (2017) (p. 492)

As the lack, scarcity or difficulty in accessing modern energy services by households in particular affects rural areas in developing countries in Africa, Asia, and South America

For its high social and environmental implications, clean cooking thus represents a central issue attracting increasing interest. Vania Vigolo et al. (November 2018)

High energy demand in world increases due to the increasing of population rate and their economic growth. An increase in that energy use cause the several problems in the world such as deforestation, environmental degradation, and climate change (. Asresu, 2017).

The research has shown that the emissions of those traditional fires, including carbon monoxide and particulate matter, result in indoor air pollution that cause both acute and chronic illnesses that lead to nearly three million premature deaths each year and is a leading cause of death of children under the age of 5years (Lindgren,2020)

Biomass fuels, which include wood, charcoal, crop residues and animal dung, are among some of the most widely used for cooking and heating, particularly in developing countries. Reliance on these materials can lead to numerous economic, environmental, social and health problems. Also, other problems that have already arisen may worsen. For example, increasing levels of biomass harvesting and combustion in response to the energy needs of growing populations can have important impacts on the global carbon cycle and consequently climate change.

This growing population also faces the problem of having to invest ever-increasing amounts of time and effort to gather these fuels as resources become scarcer, particularly when harvested non-renewably

From indoor to outdoor air pollution Air pollution is an international issue because of the transnational movement of pollutants across continents and oceans. Local sources usually only comprise part of the concentrations of particulate air pollutants in cities

However, an overlooked aspect of air pollution is indoor exposures. It has been estimated that 80% of the total global exposure to airborne particulate matter occurs indoors in developing nations. Indoor air pollution, when vented outside from biomass stoves, can also produce significant local outdoor pollution, particularly in dense urban neighbor hoods.

The bulk of the global indoor air pollution exposures stems from two sources: environmental tobacco smoke and the combustion of solid biomass fuels for cooking and heating. However, the burning of biomass fuels is usually conducted under less-than-ideal conditions, which

leads to the incomplete combustion of this material and the subsequent release of a number of compounds, which can be detrimental to health and the environment. These include carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), non-methane hydrocarbons (NMHC), nitric oxide (NO), ammonia (NH_3), particu-lates and inorganics.

Another by-product of incomplete combustion is black carbon or soot. Soot, when released into the atmosphere, blocks and absorbs solar radiation, which can greatly

This research presents a literature review of the energy used overview and adoption of modern fuel for cooking in households. The purpose of this research was to analyze the different energy used for cooking and the social-economic effects of adopting modern cooking fuels in households. The modeling will help to analyze the data and discussion for well conclude making suggest some recommendations.

1.2 Background

In Rwanda, the modern energy used is still low. Biomass energy sources stay highly consumed with an average of 85 percent of total energy consumption for cooking. Another side derivative of gas occupies 11percent and electricity occupies 4 percent of total national energy consumption (Munyaneza, J., Wakeel, M., & Chen, B., 2016).
The poverty of modern energy used in Rwanda comes from socioeconomic and geographic factors. and the government use scenarios which can help to alleviate energy shortage (Munyaneza, J., Wakeel, M., & Chen, B., 2016).

In rural areas, around 93 percent of households chose to use firewood when they cook. The rate of biomass used for cooking still increased since 1991. (NISR 2014). About vision 2020, tried to increase electricity access to 35 percent and reduce wood consumption by 50 percent
(Mazimpaka, 2014). The expectation was to decrease use of firewood for cooking by introducing alternative fuels such as LPG and solar and thermal technologies.

(Munyaneza, J., Wakeel, M., & Chen, B., 2016) In Rwandan country, Biomass plays a role in total energy used where it contributes 85 percent, firewood contributes 57 percent, Charcoal contributes 23 percent, Crop residues, and peat contributes 5 percent. And other sources contribute 14 percent. Additionally, shifting consumption from biomass-based energies to clean energies like electricity and Gas reduces pressure on forest resources, protecting land arability, and mitigating climate change through sustainable environmental conservation (MININFRA, 2015). Global deforestation

In the urban areas, people used charcoal at the level of 65 percent by household, firewood 26 percentage of firewood While rural households still use traditional fuels in the last three years (EICV5, 2018).

Most city's people prefer to use charcoal, as a clean fuel than firewood, and petroleum products is comparatively much more expensive. Therefore, only households with high-income have been able to afford that petroleum products. According to the prices, LPG is the most expensive with USD0.20/MJ), followed by electricity with USD0.099/MJ (Jean de Dieu, K. H., & Kim, H. T., 2016).

Due to thigh contribution of biomass show that adaption of modern energy is low and cause more effects where smoke from polluting and inefficient cooking, lighting, and heating devices is a leading contributor to respiratory diseases and death in Rwanda (Mazimpaka, 2014).

1.3 Problem statement

In Rwanda, firewood is used for cooking in high quantity by the vast majority of the rural population, at the rate of 93 percent in 2017, and in the urban areas, charcoal is used by 65 percent of households, followed by firewood 26 percent (Mazimpaka, 2014). As a recent research showed that nearly 3 billion people use solid fuels to meet their daily cooking need, with resulting household air pollution contributing to about 4 million premature deaths each year (KL Dinckson et al,2019).Others showed that Cooking with unsustainably harvested biomass can affect climate because inefficient fuel combustion releases products of incomplete combustion with a higher global warming potential than carbon dioxide, such as methane and carbon monoxide (JJ Lewis,2012). The collection of firewood is a difficult task associated with time consuming and economic burdens preventing other participation in income generating activities for women, and leading to the incline in the numbers of children leaving schools (Lindgren,2020).

The over-dependency on the biomass and traditional cooking fuel is at a high rate with the 85 percent of households using the polluting and traditional cooking fuels, this research will be going to analysis the socio-economic driving factors inducing households' adoption of the modern fuels and the factors inducing the high dependency on traditional fuels and transitional movement from

traditional to the modern technology of cooking fuels for saving a life. At the end of this research, the recommendations will be presented for helping the policymakers in strategy formulation toward the adoption and dissemination of modern cooking fuels at household's level.

1.4 Objectives

The global objective of this research was to analyze socioeconomic factors of adoption of modern cooking fuels at households' level in Rwanda.

1.4.1 Specific objectives

1. To investigate the inducing factors influencing the adoption of modern cooking fuels in both urban and rural area
2. To determine the trend in use of traditional and modern fuels at households' level
3. To identify the available modern cooking fuels to be used at households' level in Rwanda

This study is organized as follow: Chapter 2 is the literature of background of energy for cooking Chapter 3 describes the data and the model which have been used. Chapter 4 presented and discussed the results, while chapter 5 concluded and presented some policy implications.

CHAPTER TWO: REVIEW OF LITERATURE

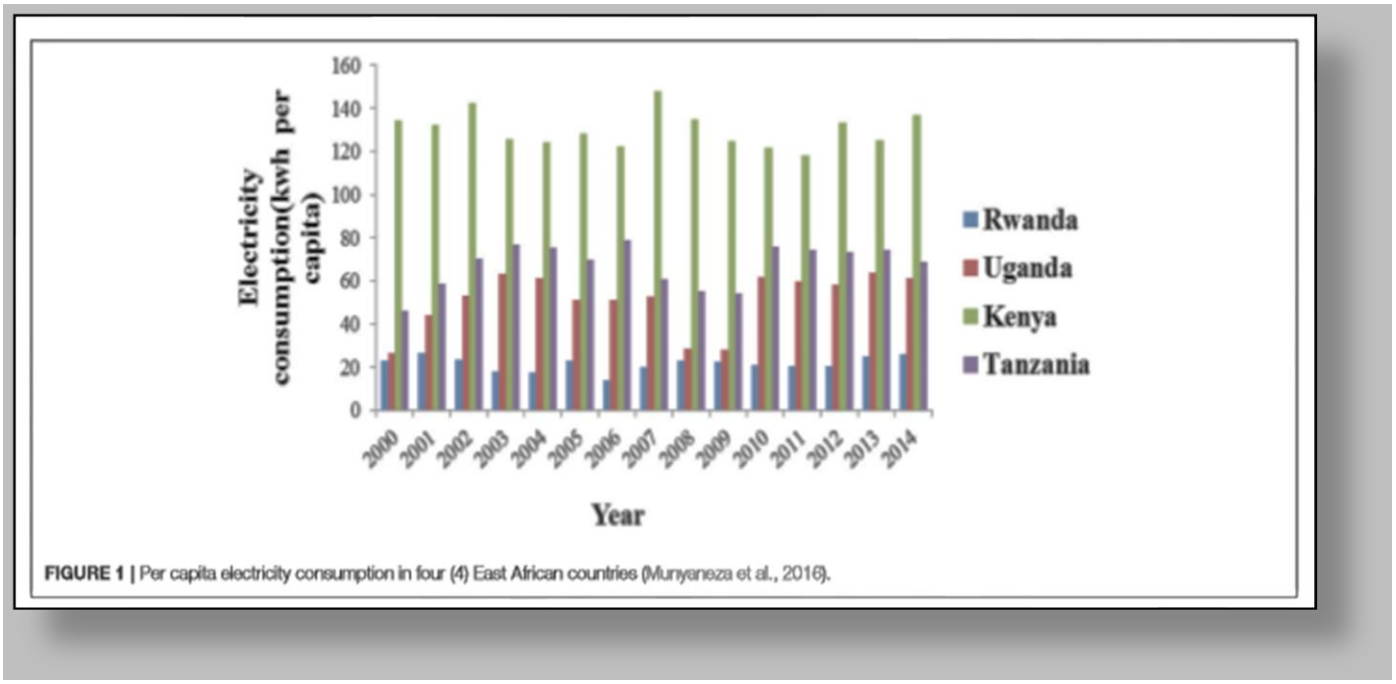
2.1 Theoretical Background

The current national energy balance statistics fuels shown that biomass fuels (mostly wood fuel) have 83 percent of the total energy consumption, petroleum at 9.7percent, electricity at 1.3 percent, and others at about less than 0,5 percent. Rural people, prefer to use biomass as energy for cooking at level of 90 percent (Mwampamba, T. H., Owen, M., & Pigaht, M., 2013).

MININFRA (2009a) has estimated rural energy consumption at 4 million tons of biomass. This is likely to continue even in the future, except household with high income levels substantially increase to enable to afford modern sources of energy (Dinkelman, 2011).

Rwanda per capita electricity consumption (30kWh) is the lowest in the East African Community (EAC), when compared to Kenya (140 kWh), Tanzania (85kWh), and Uganda (66kWh); where about 25 percent of the imported petroleum products is used for electricity generation at the thermal power plants (Bimenyimana, S., Asemota, G. N., & Li, L., 2018).

Figure 1:Electricity consumption (Kwh per capita)



Source: Ministry of Infrastructure,2016

2.2 Studies related to Drivers of fuel adoption in modern Cooking

2.2.1 Biomass

Biomass contributes between 10 and 12% of the overall energy in the world, although this varies with very low percentages in industrialized countries and values of 50% or more in developing

countries. A study in India using several stove and fuel combinations found that the energy and efficiency of fuels vary widely. Depending on the type of stove used, conversion efficiencies of biomass fuels typically range between 8 and 18%. Energy losses, particularly with traditional stoves like those used in Nouna, are largely in the form of heat and the PICs, including CO, NO, and particulates. Additionally, the moisture content of solid.

Availability In terms of the exploitable quantity of ligneous fuel, Burkina Faso is estimated to have approximately 4.5 tonnes/capita/year. Wood fuel production estimates for Burkina Faso were 9,150,000 m 3 in 1994.

However, this is probably not evenly distributed, which may lead to shortages and surpluses in different parts of the country. Wood, and particularly charcoal, can be economically transported from rural areas to urban areas, which may offset some of these disparities. Nonetheless, biomass fuel is poorly characterized because it is not traded in markets and is generally used or gathered locally (non-commercially) and is therefore not part of national statistics

Wood can also be gathered for free from nearby sources. However, gathering wood is a time-consuming activity. For example, women in a rural area of Sri Lanka were forced to walk an average of 5.8 km to collect firewood when an irrigation project brought about widespread environmental damage and tree destruction. The time expended on this chore alone was 4.7 hours per week. Thus, in an effort to reduce the time demands for fuel collection, women began to carry average loads of 24 kg. The consequences of increased gathering time for fuels can be the substitution of inferior fuels, reductions in the amount of wood used and the cooking of fewer meals, which in turn can lead to less income, rest, space, and water heating as well as hygiene. Fewer special foods

may also be prepared for the ill, pregnant or children, and the elderly. Nonetheless, biomass fuels are usually available and inexpensive, making them attractive alternatives, especially for the rural poor. Both wood and LPG can pose additional hazards to health that also need to be considered. For example, gathering wood fuel can be linked to increased risk.

2.2.2 Biomass pollutants

The health effects associated with exposure to biomass pollutants are well known (19, 49, 53). These pollutants stem from the incomplete combustion of wood, charcoal and LPG, which releases several by-products in addition to heat. These include CO2, CO, CH4, particulates like black carbon and other organic compounds.

Extremely high levels of pollutants can occur with the burning of biomass fuels for cooking. The mean concentration of PM 10 measured in the kitchens during the day of148 households in Nouna was 4.06 mg/m concentrations greatly exceeded the maximum 24hour limit of B50 mg/m3 recommended by WHO. Levels recorded in Nouna kitchens also exceeded those reported in studies in rural India and South Africa, Mexico and Mozambique. CO levels were also very high in the kitchens and sleeping rooms of households in Nouna. The mean area concentration of CO in 121 kitchens and sleeping areas combined was 17.02 ppm. These CO concentrations were within the ranges reported by others.

A study by Naeher et al. (in Guatemala found that the concentration of CO released from gas stoves, improved stoves, and open fires were 1.5, 2.4, and 6.7 ppm, respectively. Similarly, Smith et al. also observed decreasing levels of CO emitted with the ascension of the energy ladder. Per meal, combusted wood residues typically release 19 g/MJ-d CO per meal.

Some of the researchers conclude that income is a key driver of demand and adoption of modern energy as much as income increases and demand increases (Karimu, A., Asiedu, E., & Abor, J., 2018) research used by (Karimu, A., Mensah, J. T., and Adu, G., 2016)
The country of Ghana has a general picture of SSA regarding dependence on biomass fuel. The latest Ghana living standard survey (GLSS6) indicates that close to 76.3 percent of Ghanaian households depend on biomass fuel for cooking, but only 0.3 percent rely on electricity for cooking, which is an indication of the high use of biomass in Ghana, especially for their cooking needs (Karimu, A., Asiedu, E., & Abor, J., 2018).

Similarly, data from qualitative interviews in Tanzania analyzed by Winther, showing that the men like the taste of food which have been cooked by using firewood for cooking while the women focused on time savings related to using the electrical stove (Dinkelman, 2011).

The women expressed the advantages of cooking with electricity. Furthermore, the author suggests that the men, who paid for the electricity in other service, did not want to pay for electricity for cooking (Wamukonya, Njeri, & Davis, Mark, 2001).

More than 95% of the population in Burkina Faso uses some form of solid biomass fuel. When these fuels are burned in traditional, inefficient stoves, pollutant levels within and outside the home can be very high. This can have important consequences for both health and climate change. Thus, the push to switch to cleaner burning fuels is advantageous. However, there are several considerations that need to be taken into account when considering the use and promotion of different fuel types. In the setting of the semi-urban area of Nouna, Burkina Faso, we examine the

common fuel types used (wood, charcoal and liquid petroleum gas (LPG)) in terms of consumption, energy, availability, air pollution and climate change.

Although biomass solid fuel does offer some advantages over LPG, the disadvantages make this option much less desirable. Lower energy efficiencies, higher pollutant emission levels, the associated health consequences and climate change effects favour the choice of LPG over solid biomass fuel use. Further studies specific to Burkina Faso, which are lacking in this region, should also be undertaken in this area to better inform policy decisions

Also, the research which ended in Nicaragua, found that households with electricity in the rural communities are only 22 percent (Grogan, Louise, & Sadanand, Asha, 2013), means that there is the limited for electricity used for cooking fuels (Dinkelman, 2011).

According to many discussions about the use of fuels for cooking, this research will identify different type of energy use for cooking in Rwanda and analyzing socioeconomic factors of Rwandan household as barriers of adopting modern fuels for cooking like gas and petroleum as alternative energy.

Some of the researchers accomplish that income is a key driver of demand and adoption for modern energy as much as income increase and demand increase (Karimu, A et al,2018)

(Karimu et al. (2016)), the research findings that apart of income more household fuel adopting is strongly influenced by traditional cooking techniques, taste, and preferences to the extent that demand for fuelwood is price inflexible in some cases.

The Government of Ghana, in its resolve to reduce the overdependence on biomass, adopted a programme to encourage use of liquefied petroleum (LP) gas by homes and small scale enterprises (Seth A,et al,2018)

The literature identifies several factors that influence the adoption of modern cooking fuels. A study by (Pine, K., Edwards, R., Masera, O., Schilmann, A., Marrón-Mares, A. and Riojas-Rodríguez, H., 2011) in Mexico identified factors like household size as influential in the adoption of modern cooking fuels. Furthermore, women's age and remoteness of the village have a positive impact on the adoption of modern fuels for cooking, whereas decreased cooking frequencies and the time spent on the wood collection are the inspiration behind the adoption of modern cooking fuels in Ethiopia (Gebreegziabher, Z. and Van Kooten, G. C., 2011).

In Sudan, adoption of the modern cooking fuels was associated with relative advantages to housewife in her work and education level as well as the average educational level of the female household's members were found that it has a significant effect on the adoption of modern cooking fuels (Muneer, S. E. T., & Mohamed, E. W.M., 2003).
An alternative study in Pakistan discovered that the working members in the household, income level and biomass collection were found to have some effects on the adoption of modern cooking fuels (Jan, I., Khan, H. and Hayat, S., 2012).

Studies that give emphasis to income as a socio-economic indicator that controls the adoption of modern cooking fuels are based on the theory of moving up the energy ladder. The theory of energy ladder associate's household's income with a shift to cleaner cooking energy technologies and fuels (Masera, O.R., Díaz, R., Berrueta, V., 2005). The postulate is that the household switches to more modern energy and appliances as the household income increases. Likewise, it assumes that an increase in the household income leads to reaching a higher socioeconomic status and thus expanding the household choices on goods and services. However, this concept raises the basic

question as to whether the increased income in the household pledges that it is spent on purchasing modern fuels or appliances rather than on other goods and services.

2.2.3 Social policy in adoption of modern cooking fuel: ubudehe category

Ubudehe is a term used to refer to the culture of collective work by community members aimed at either addressing general challenges or to assist individual households who are short of labour to address their own challenges. Ubudehe in the area of agriculture, for instance, would see some members of community coming together to assist vulnerable households such as the handicapped, aged and widows to cultivate their land at no cost. The idea is that any member of the community could be in need of community efforts and that the community should be available to assist. By way of community work, members of the community can come together to repair roads damaged

by use or other natural phenomena or construct new roads or build town halls, or other necessary projects that need a collective effort. (Ezeanya-Esiobu, Chika 2017)

The new categorization is as below:

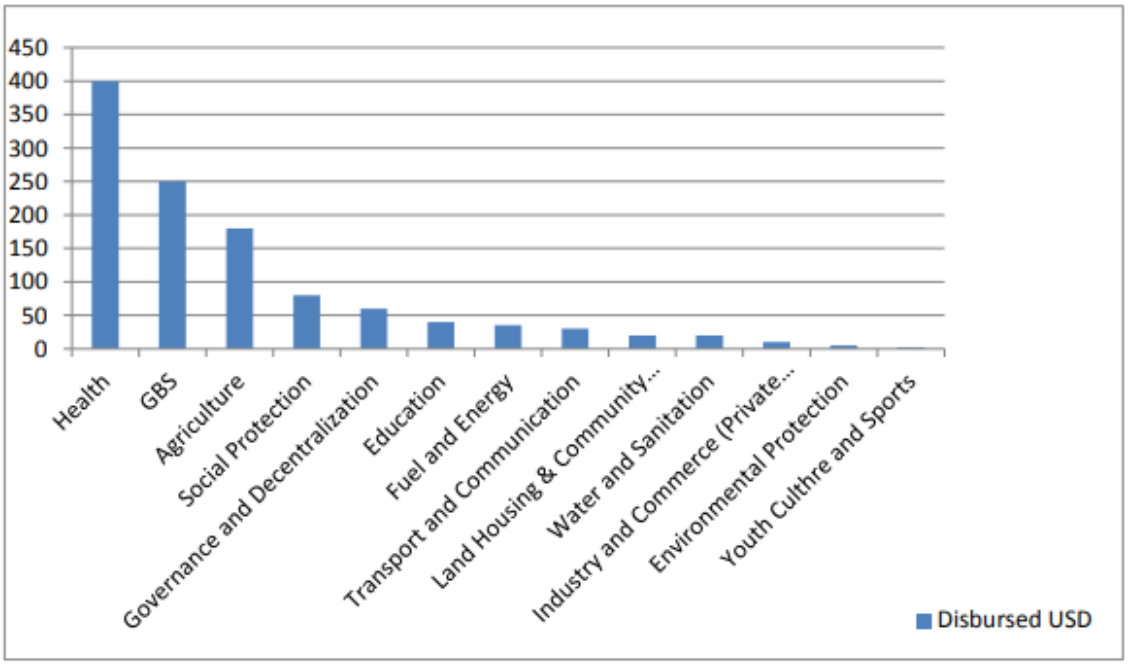
Category 1: Very poor and vulnerable citizens who are homeless and unable to feed themselves without assistance. Category 2: Citizens who are able to afford some form of rented or low-class owned accommodation, but who are not gainfully employed and can only afford to eat once or twice a day.

Category 3: Citizens who are gainfully employed or are even employers of labor. Within this category are small farmers who have moved beyond subsistence farming, or owners of small and medium scale enterprises.

Category 4: Citizens classified under this category are chief executive officers of big businesses, employees who have full-time employment with organizations, industries, or companies, government employees, owners of lockdown shops or markets, and owners of commercial transport or trucks (Government of Rwanda 2015; MINALOC 2015).

The chart below shows available statistics on the allocation of aid to social protection when compared to other sectors of the Rwandan economy.

Figure 2: Statistics of Aid Allocation to Social Protection in Comparison to other Sectors of the Rwandan Economy



Source: Modified from Republic of Rwanda Ministry of Finance and Economic Planning (2013)

From the research carried out there are limited investigations about the socio-economic driving factors influencing the household adoption of the modern cooking fuels focusing on the poverty category namely UBUDEHE CATEGORY and the limited investigation took into consideration the influencing factor which is a type of habitant currently being Implemented in the different

country regions due to poor settlements in the rural regions in our country Rwanda and this research will be used as the driving tool for the policymakers towards the energy sector modern cooking fuel dissemination and adoption at household level in Rwanda

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Data sources

The research study uses household level, cross-section data from the Fifth Integrated Household Living Conditions Survey (EICV5) collected by the government of Rwanda, National Institute of Statistics for Rwanda (NISR). EICV has become an important survey for Rwanda, as it captures various variables at the household level, that are important for the planning process aimed at accelerating the growth and development of the country. The survey was carried out collecting a comprehensive set of data on the different aspects of household welfare such as demography, consumption, income, housing, labor market, education, health, and other socio-economic factors in the year 2017. In this study, we extract data from EICV 5 for particular variables on interest, that would respond to understanding the socio-economic analysis of adopting modern energy fuels.

3.2 Data analysis

In this research study, a multinomial logistic regression model is used to analyze the data. Multiple logistic regression is used when the dependent variable has two or more outcome categories. It uses one of the categories as a referenced category (any one of them) and compares other categories with the reference category. It compares the remaining categories with the reference category by taking log odds. In general, logistic model log-odds are the log of probability ratio of a particular category versus a reference category.

The dependent variable of this study is the choices of fuel for cooking in both urban and rural households. Rather than the amount of energy consumed by the household, it explains the types of

fuel, firewood, charcoals, Liquefied Petroleum Gas (LPG), and electricity used by the household for cooking.

The Independent variables used in this study are: the family size of the household includes all the family members living together under the same roof and using the same kitchen, basic education attained, total household income, marital status of household head (categorized into ever married, married, divorced, separated, widow/widower) and never married, the gender of household head, type of habitant, ubudehe category (there are four family categories), the geographical location of house categorized, and rent part dwelling used to explain whether a family lives in a rented house or not.

The multinomial regression model used in this research study is shown in equation 1.

$$\log odds = log\left(\frac{P(Y=j|x)}{P(Y=J|x)}\right) = \beta_0 + \sum \beta_i \vec{X} + \sum \gamma_i \vec{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where X is a set of Social independent variables, Y is the set of economic independent variables is an intercept, and is a vector of the regression coefficient is associated with independent variables.

For this model, there are two log odds and compare each of them with the reference (base) category. It is assumed that log odd is a linear function of the predictor. The log odds ratio shows how many times more likely a particular variable is to be adopted relative to the reference category.

The dependent variables of this study are the adaptation of fuel for cooking: Firewood=1, charcoal=2, LPG=3, electricity=4. For multinomial regression, we have 4-1 = 3 equations. Each equation model has the odds of adaptation relative to baseline. We considered firewood as a baseline variable. One is the odds of adapting charcoal relative to firewood:

$$\log odds = log\left(\frac{P(Y=2|x)}{P(Y=1|x)}\right) = \beta_0 + \sum \beta_i \vec{X} + \sum \gamma_i \vec{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\log odds = log\left(\frac{P(Y=3|x)}{P(Y=1|x)}\right) = \beta_0 + \sum \beta_i \vec{X} + \sum \gamma_i \vec{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\log odds = log\left(\frac{P(Y=4|x)}{P(Y=1|x)}\right) = \beta_0 + \sum \beta_i \vec{X} + \sum \gamma_i \vec{Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Equation (2), (3), and (4) show how the independent variables, X, affect the relative odds of charcoal among Firewood, LPG among Firewood, and electricity among firewood respectively. The above equation is an intercept and is a vector of the regression coefficient. The set of coefficient shows us how the independent variable affects relative odds of other modern cooking fuels versus Firewood

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presented the findings results and their discussion of data analysis. The overall discussion, builds on the prior discussions, utilizing the interaction between them. The format for the presentation of results and its discussion for each table have been highlighted in their respective sections

4.1 Descriptive results

In the descriptive results, there are two tables that present the using and non-using of modern fuels piloted by urban and rural areas. Table 1 shows the comparative analysis of adopting modern fuels like gas and electricity both in urban and rural areas.

In terms of Gas adoption, the research found that only 0.15 percent of households use Gas as modern fuel for cooking in an urban area, and 99.85percent of households are non-using Gas as modern energy for cooking. Further, results indicate that 5.74 percent of households adopted Gas in the rural area and 94.26 percent of households are not adopting Gas as Modern cooking fuel

With regard to the use of electricity, 0.02 percent of households adopt electricity in an urban area as modern fuels for cooking and 99.98 percent of households are not using electricity in an urban area and 0.24 percent of households adopt electricity in a rural area and 99.76 percent are not using electricity for cooking in a rural area. The Results of this research confirm that adopting modern fuels for cooking is not dependent on location. It may probably depend on other factors like the accessibility of the cheap fuels, the mindset, and others as indicated by the results, that in both urban and rural areas, over 90 percent of households are not adopting modern fuels

Table 1:Modern cooking fuel used by households in urban and rural areas

Gas						**Electricity**					
Urban			**Rural**			**Urban**			**rural**		
	Freq	Perc		Freq	Perc		Freq	Perc		Freq	perc
Using	18	0.15	Using	145	5.74	Using	2	0.02	Using	6	0.24
Non-using	12036	99.85	Non-using	2381	94.26	Non-using	12052	99.98	Non-using	2520	99.76
Total	**12054**	**100**	**Total**	**2526**	**100**	**Total**	**12054**	**100**	**Total**	**2526**	**100**

Source: author's computations

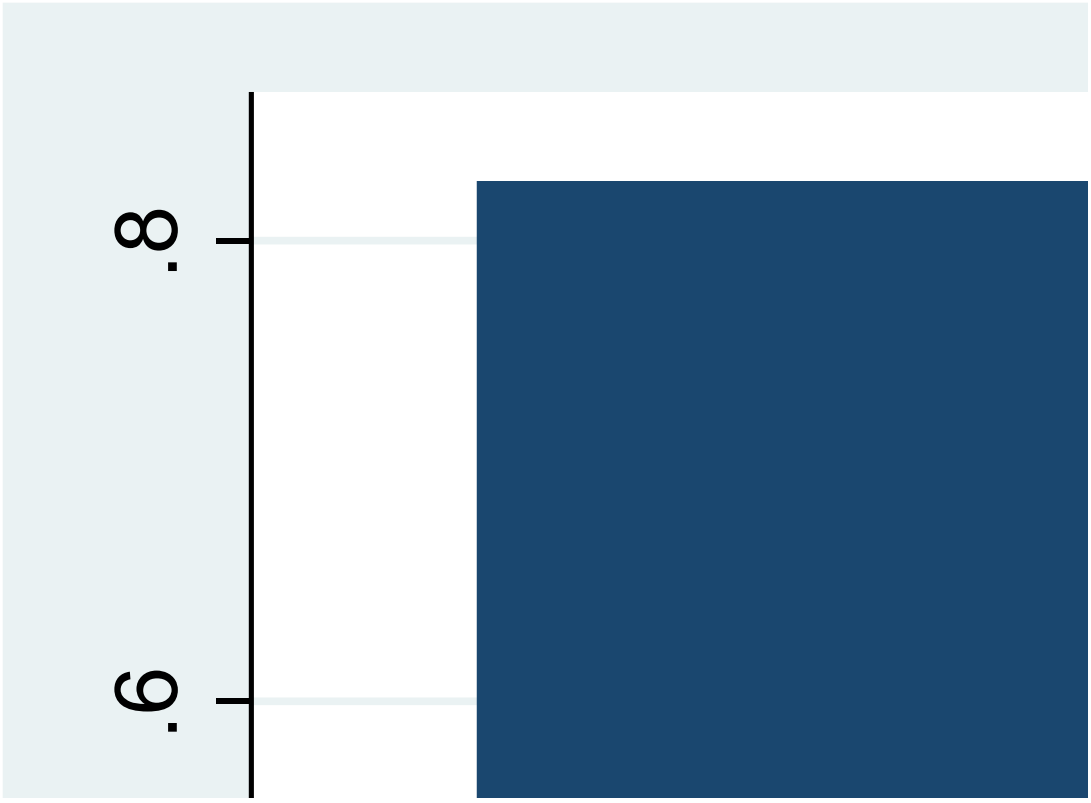
In terms of charcoal choice, the research found that 4.99 percent of households do not use charcoal as a source of traditional fuel for cooking and 95.01 percent of households are using charcoal for cooking in an urban area and 61.4 percent of households do not use charcoal where 38.6 percent of the household do use charcoal in a rural area. The research study results further indicate that 93.72 percent of the households do not use firewood as a source of energy for cooking in the urban areas whereas 29.45 percent of the households do not use firewood as a source of fuel in rural areas. The results from this research confirm that there is a high usage of charcoal in urban areas compared to rural areas. Firewood is predominantly used in rural areas.

Table 2: Usage of traditional energy fuels of households in urban and rural areas

Charcoal						**Firewood**					
Urban			**Rural**			**Urban**			**Rural**		
	Freq	Perc		Freq	Perc		Freq	Perc		Freq	Perc
Non-using	602	4.99	Non-using	1551	61.4	Non-using	11297	93.72	Non-using	744	29.45
using	11452	95.01	Using	975	38.6	Using	757	6.28	Using	1782	70.55
Total	**12054**	**100**	**Total**	**2526**	**100**	**Total**	**12054**	**100**	**Total**	**2526**	**100**

Source: author's computations

Figure 3: Trend in Cooking fuels usage at household level



The above graph reports that there is a high dependency on the firewood at households level for cooking purposes where over 80 percent of the households still rely on firewood and traditional fuels for the households cooking fuels and the households depending on charcoal are at the more than 15 percent and this high reliance on the charcoal biomass will lead to indoor air pollution resulting to severe death of people from pollution and there is the limited transition to modern cooking fuels where the households using the gas as clean and modern cooking fuels are less than 1 percent and not surprisingly the households that are currently shifting to using electricity for cooking purposes are limited due to limited electrification rate in the country and the usage of electricity for cooking purposes are still very low;

4.2 Estimation results

The research found that there are some independent variables that are factors of adopting and non-adopting statistical modern cooking fuels. Results showed that one-year addition of household head age is associated with less likelihood to adopt gas fuel by changing factor of 0.00394. And one-year addition of household head is associated with less likelihood to adopt electricity by changing factor of 0.00254. This finding illustrates that an increase in age decreases the probability of adopting modern energy fuels. This may be largely due to fact that the households have been using the traditional energy sources and are adamant to change. When the household head is female, it associates with less likelihood to adopt gas at a level of 0.143, and about electricity, the result showed that if the household head is female leads to associate with less likelihood by changing factor of 0.0293. This explains the effect of less adoption of modern fuels, showing that more of the traditional fuels are still heavily dependent on households, especially female-headed households. Results present that an increase of some knowledge in the household is associated with less likelihood by changing factor of 1.791 to adopt gas fuel means in household there are other factors which can push or not education to be associated with gas fuel adoption like the size of household, an increase of the size of the household can associate with less likelihood to use gas fuel even household head are educated or not.

Results further indicate that when a family receives an additional sibling in the household, there is a probability that the use of modern fuels reduces by 0.0854 gas and by 1.167 electricity. This shows that as household size increases, there is a probability that less of the modern energy fuels will be used, whereas usage of traditional energy fuels especially firewood, will increase.

Owning a home by the households reduces the probability of using modern fuels like gas and increases the usage of firewood Engagement in non-farm activities by the household increases the probability of using gas and charcoal in Rwanda. This clearly illustrates that more non-farm incomes are important to reduce the use of traditional energy fuels. The research results reveal that an increase in household incomes increases the probability of adopting modern energy fuels and reducing the probability of using firewood. In addition, results show that if a household is

more isolated, it will associate with a more likely to adopt gas fuel by changing the factor of 2.240 and also by changing the factor of 2.499 likelihood of adopting the use of charcoal. A change in the poverty level (Ubudehe), increases the likelihood of adopting the use of gas and charcoal and reducing the likelihood of using firewood. The result showed that when household live modern village is more likely to adopt gas fuel by changing the factor of 0.242 and more likely by changing the factor of 0.552 to adopt electricity fuel

After all, this research results summarized how many households adopt modern fuels for cooking due to many factors that we have seen in the below table which are positive signs to adopt modern fuels, On the other side there are many households that still use traditional fuels for cooking due to some factors. When some household chooses to buy LPG for the first time, will be a barrier because the initial cost of LPG in both bottles and slender is high, becoming a limit to adopting modern cooking fuels. And also, about Ubudehe category is another key factor that encourages households to move from traditional fuels to modern fuels means that shift from low category to high category, showing that household income increases and can adopt modern fuels at changing factor of 0.140 using modern fuel

Table 3: Model estimation results

Variables	Charcoal	firewood	Gas	Electricity
Age of Household	-0.0256***	0.0270***	-0.00394	-0.00254
	-0.00273	-0.00273	-0.0081	-0.0293
Gender of Household head	-0.104	0.131	0.143	-1.222
	-0.0844	-0.0868	-0.212	-1.118
Education	0.278***	-0.242***	-1.791***	-0.916
	-0.0729	-0.0753	-0.368	-1.078
Household size	-0.017	0.174***	-0.0854*	-1.167***
	-0.0167	-0.0183	-0.0469	-0.452
Homeowner	-1.020***	1.176***	-0.550**	-1.104
	-0.0738	-0.075	-0.234	-1.386
Non-farm activity	0.461***	-0.321***	0.935***	-0.483
	-7.04E-02	-7.18E-02	-2.69E-01	-0.797
Household Income	1.61e-08***	-3.31e-07***	2.60e-08***	2.78e-08*
	-5.15E-09	-1.83E-08	-4.99E-09	-1.66E-08
Location	2.499***	-2.572***	2.240***	0.287
	-0.0715	-0.0744	-0.307	-1.064
Ubudehe	0.0500***	-0.0677***	0.140***	-0.247
	-1.70E-02	-1.73E-02	-3.53E-02	-0.215
Type of Habitant	0.230***	-0.272***	0.242***	0.552*
	-0.0163	-0.0173	-0.0519	-0.304
Constant	-1.929***	1.263***	-6.843***	-4.875**
	-0.148	-0.151	-0.497	-2.167
Observations	14,572	14,572	14,572	14,572

*** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses

below the table, the results showed that one-year addition of household head age is associated with less likelihood to adopt gas fuel by changing factor of 0.00306 and 0.00959 both urban and rural area also one-year addition of household head is associated with less likelihood to adopt electricity by changing factor of 0.00119 and 0.0966 both in urban and rural area respectively. When the household head is female, lead an associate with less likelihood to adopt gas at the level of 0.21 and 0.656 in both urban and rural areas also when the household head is female is associated with less likelihood to adopt electricity at the level of 0.939 in an urban area. An increase of one sibling in the household will decrease the use of modern fuels like gas by changing the factor of 0.0626 in an urban area but the addition of one sibling will be more likely to adopt gas by changing the the factor of 0.448 in a rural area. Results indicate that the addition of one unit of non-farm associated with more likely to adopt gas fuels by changing factor of 0.565 in an urban area because

in the urban area more people work in a non-farm business where they need to save time for working. The result showed that an increase of one unit of income will lead to an associate with more likely to adopt gas by changing the factor of 2.6 and the addition of one unit of income will increase the adoption of electricity by changing the factor of 2.78. If a household is more isolated will associate of more likely to adopt gas fuel by changing the factor of 2.240 and also by changing the factor of 0.237 to be more likelihood of adopting electricity

Changing one category of ubudehe from low category to high category associate of more likely to adopt gas fuels by changing factors of 0.144 and 0.0796 both in an urban and rural area. The result showed that when households live in a modern village is more likely to adopt gas fuel by changing the factor of 0.244 and 0.269 in both urban and rural area.

Table 4: Logistic model estimation for each dependent variable by location

Variables	Charcoal		Firewood		Gas		Electricity	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Age of Household	-0.0168***	-0.0393***	0.0247***	0.0294***	-0.00306	-0.00959	-0.00119	-0.0966
	-0.00377	-0.00426	-0.00443	-0.0035	-0.0088	-0.0225	-0.0354	-0.136
Gender of Household head	-0.0889	-0.135	0.0781	0.195*	0.21	-0.656	-0.939	-
	-0.112	-0.128	-0.137	-0.113	-0.221	-0.827	-1.145	
Basic Education	0.162	0.365***	-0.18	-0.288***	-1.825***	-1.513	-0.694	-
	-0.105	-0.102	-0.127	-0.0932	-0.391	-1.041	-1.107	
Household Size	0.0824***	-0.217***	0.0955***	0.252***	-0.0626	-0.448***	-0.932**	-
	-0.022	-0.0292	-0.027	-0.0259	-0.0489	-0.172	-0.443	
Homeowner	-0.796***	-1.220***	1.141***	1.192***	-0.424*	-0.649	0.265	-
	-0.108	-0.102	-0.127	-0.0928	-0.249	-0.588	-1.478	
Non-Farm	0.257**	0.478***	-0.0418	-0.425***	0.565**	-	-1.171	-
	-0.104	-0.1	-0.125	-0.0888	-0.271		-0.868	
Household Income	1.92E-09	2.36e-07***	-4.33e-07***	-2.99e-07***	2.23e-08***	1.77e-07***	1.87E-08	5.11E-07
	-3.07E-09	-2.02E-08	-4.00E-08	-2.14E-08	-4.62E-09	-3.42E-08	-2.04E-08	-3.28E-07
Ubudehe	-0.0245	0.0779***	-0.0502	-0.0591***	0.144***	0.0796	-0.239	-0.465
	-0.023	-0.0216	-0.0314	-0.0202	-0.0372	-0.109	-0.25	-0.867
Type of Habitant	0.230***	0.275***	-0.319***	-0.215***	0.244***	0.269**	-	0.494
	-0.0196	-0.0273	-0.0239	-0.0259	-0.0546	-0.129		-0.417
Constant	0.125	-0.974***	-0.783***	0.751***	-4.440***	-4.158***	-1.412	-2.406
	-0.214	-0.22	-0.257	-0.196	-0.532	-1.105	-1.751	-4.14
Observations	2,524	12,048	2,524	12,048	2,524	5,715	1,523	109

*** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The purpose of this study was to understand socioeconomic factors which influence the Rwandan people to adopt modern fuels for cooking from the literature review the historical background showed that Around 2.8 billion people in the world depend on biomass as the primary energy source for cooking. Particularly in Sub-Saharan Africa, where adoption of modern energy is the least (Bonjour et al, 2013)

The increase in that traditional energy has led to cause several problems in the world such as deforestation, environmental degradation, and climate change.

Responding to the first research question, from literature lead to know the factors which influence the Rwandan society to use traditional fuels, especially fuels like firewood and charcoal, the research findings showed that the choice of using traditional fuels used for cooking depending on the age of household head, basic education, unwillingness, household size, homeowner, non-farm, household income, location, ubudehe category and type of habitant of the household

The research findings confirmed that the adoption of modern energy in Rwanda is still low where the dominant type of traditional fuels used for cooking is firewood and charcoal this is due to its accessibility and affordability and the urban area still uses traditional fuels but they try to adopt modern fuels even if it is still in low level

In a conclusion, the research findings showed that. Even if traditional fuels are most used at a level of 93 percent for cooking in both urban and rural are and modern fuels adopt as cooking fuels at a level of fewer than 10 percent the Rwandan people can adopt those modern fuels according to government support and others motivation mentioned in the recommendation

5.2 Recommendations

For a wider uptake of modern cooking fuels, attention should be on scheming a specific strategy to increase the adoption of modern and clean fuels by pursuing the more well-off households and specifically female heads of households to draw consideration to the health benefits of adopting

clean and modern cooking fuels. Putting emphasis on the multiple benefits (environmental, social, health, and economic benefits) of modern cooking fuels may not contribute to increasing the adoption rate of the poorer household classifications equally these households give primacies to other necessities and desires. Growing adoption rates need scheming a complimentary policy such as lower prices or subsidies to facilitate adoption associated with the following focuses:

- Increase of modern cooking fuels mobilization in both urban and rural areas
- The government can collaborate with financial institutions like SACCO, on how a household can get Credits for modern cooking fuels
- Mobilization of saving to households for getting money to buy LPG for cooking

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Suggested Citation: Ezeanya-Esiobu, Chika (2017): The rise of homegrown ideas and grassroots voices: New directions in social policy in Rwanda, UNRISD Working Paper, No. 2017-6, United Nations Research Institute for Social Development (UNRISD), Geneva

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