# ADOPTION DETERMINANTS OF IMPROVED COOKSTOVE AND SOLAR ENERGY TECHNOLOGY AMONG RURAL HOUSEHOLDS OF ETHIOPIA INCASE ASSOSA WOREDA, BENESHANGUL GUMUZ REGIONAL STATE, ETHIOPIA

Msc THESIS

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HAWASSA UNIVERSITY, WANDO GENET COLLEGE OF FORESTORY AND NTURAL RESOURCE

JULY, 2020

WONDO GENET, ETHIOPIA

# ADOPTION DETERMINANTS OF IMPROVED COOKSTOVE AND SOLAR ENERGY TECHNOLOGY AMONG RURAL HOUSEHOLDS OF ETHIOPIA, THE CASE OF ASSOSA WOREDA, BENESHANGUL GUMUZ REGIONAL STATE, ETHIOPIA

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JULY, 2020

**Approval Sheet- I**

This is to certify that the thesis "***Adoption Determinants of Improved Cook Stove and Solar Energy Technology Among Rural Household of Ethiopia, Incase Assosa Woreda, Beneshangul Gumuz Regional State"*** submitted in partial fulfillment of the requirement for the degree of Master of Science with specialization in Renewable Energy Utilization and Management of the Graduate Program of the school of Environmental science , Wondo Genet College of Forestry and Natural Resources, and is a record of original research carried out **by Abishu Womber (Id number GPREUMR/002/11)**, our my supervision. No part of this thesis has been submitted for educational institutions for achieving any academic awards. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, we recommended to be accepted as fulfilling the thesis requirement.

Approved by**:**

Prof. Sam Adaramola — — 25/06/2020

Name of Major Advisor Signature Date

_____ _____ _____

Name of Co - Advisor Signature Date

**Approval sheet-II**

We, the undersigned, members of the Board of examiners of the final open defense **by** Abishu Womber have read and evaluated the thesis entitled ***"Adoption Determinants of Improved Cook Stove and Solar Energy Technology Among Rural Household of Ethiopia, Incase Assosa woreda, Beneshangul Gumuz Regional State"***, and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Renewable Energy Utilization and Management at Wondo Genet College of Forestry and Natural Resources.

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| _____ | _____ | _____ |
| Name of External Examiner | Signature | Date |

**Declaration**

I, Abishu Womber, hereby declare that this thesis is my own original work and has not been submitted for any other institution for the award of any academic degree, diploma or certificate in anywhere. Again, all the materials used in this thesis have been indicated and acknowledged duly with references.

Student Name and Signature: Abishu Womber_____

Place: Hawassa University, Wondo Genet College of Forestry and Natural Resource

Date of submission: _____

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

Name of major Advisor: Samuel Adaramola (Prof.)

Signature: _____

Date of Submission: _____

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**Abbreviations**

BGBOARD Beneshangul Gumuz Bureaus of Agriculture and Rural Development

CNISP China's national improved stove program

DCD - DAC-ENV Development Co-operation Directorate Development Assistance Committee on environment

DOI Diffusion of Innovation

ECO Energy Coordination Office

e.g. For example

FGDs Focused Group Discussions

GIS Geographical information system

HEC Household energy choice

HIV/AIDS Human Immunity Virus /Acquire Immune Deficiency Syndrome

HHs Households

IEA International energy Agency

ICs Improved cook stoves

KIFs Key Informant farmers

Km kilometer

MDGs Millennium Development Goals

MoWE Ministry of Water and Energy

MoARD Ministry of Agriculture and Rural Development

NCCSPE National Clean Cook Stoves Programme of Ethiopia

OR Odd ratio

PV photovoltaic

REUM Renewable Energy Utilization and Management

WHO World Health organization

**Definitions of some Common terms**

**Adoption:** is the act of changing something or changing behavior to make it suitable for a new purpose or situation.

**Household:** refers to a group of people who eat together regularly and/or who sleep under the same roof together.

**Family size:** is defined in terms of the number of husband, wife and children in the household

**Improved Cook stove:** is a stove that is more fuel efficient and releases fewer emissions as compared to a traditional "three-stone" fire.

**Kebele:** is the smallest level government administrative structure in Ethiopia.

**Inefficient**: refers to using cooking devices with high biomass consumption, low per-unit energy production and increased emissions of smoke and particulates.

**Injera:** is the traditional food in major Ethiopian households, and mostly prepared from "teff".

**Open-fire:** refers to traditional method that relies on a clay 'U' or three stones to support cooking that are highly inefficient in their use of fuel.

**Solar PV technology**: is a technology that converts sunlight (solar radiation) into direct current electricity by using semiconductors.

**Solid fuels:** refer to fuels which include biomass fuels (such as wood, crop residues, dung, charcoal) and coal.

**Woreda:** refers to government's administrative unit in Ethiopia which is equivalent to district.

***Abstract***

*In our countries plenty of projects and initiatives have been working to disseminate efficient cleaned burning improved cook stove and solar energy which have economic, social and environmental benefits. To this end, understanding factors affecting adoption of improved cook stoves and solar energy technology plays a key role. The purpose of this study was to examine the determinant factors that affect household's adoption decision of improved cook stove and solar energy technology in rural 'kebeles' of Assosa Woreda, Beneshangul Gumuz Regional State of Ethiopia by using mixed research methods. A survey was conducted with a structured questioners' which was employed purposively or judgmental non-probability sampling technique for 116 households that were randomly selected from five rural kebeles. Semi-structured interviews and focused group discussions were also held with a total of 15 key informants. Data from questionnaires were analyzed by using descriptive stastics and binary logistic model. Regarding on determinants of improved cook stove adoption decision: The regression result shows that educational level, marital status, price, family size, age and separated kitchen household were found to be significantly relation with the probability of Mirt stove adoption decision while source of wood were found to be not statistically significant with Mirt stove adoption decision. Furthermore, Age and family size of the household characteristics were providing services and support to the potential users and producers, denying access to open forest and decentralizing Mirt stove production sites were found to be institutional factors to influence Mirt stove adoption. Membership in social associations, active participation in social activity, informal information exchange and neighbors' influence were found to be social factors that affect Mirt stove adoption. Thus, an educated household head should be increased through adult education. Improved cook stoves programs should be targeted on rural areas where there is no open forest access. Regarding on determinants of adopting solar energy decision was found to be having positive effect on solar energy technology adoption. The findings of this paper establish that cash money saving, price, awareness and perceptions and educational level of the households were more likely statically significant to adopt solar energy technology. Other factors such as a gender, age and family size which statically insignificant. The main implication of this study is the policy makers could be target appropriate measures in order to improve household saving system, education and awareness and perception on solar energy system. In this way, there is a much higher chance for them to successfully promote solar use by rural households. Generally, in both case there should be more structured decentralization or policy maker in terms of assigning rural energy experts from woreda to kebele.*

**Keywords***: Adoption, Cook Stoves, Binary Logistic Model, Improved, Open- Fire, Solid –Fuel, Solar Energy, Technology Adoption, Determinants and Rural Households*

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# Chapter One

## 1. Introduction

### 1.1. Background of the study

Renewable energy is an essentially basic human need for lighting, cooking and boiling of water. According to Sameer (2011),open fires and primitive stoves have been used for cooking since the beginning of human history. These stoves had various sizes and styles, based on cultures and food preparation approaches (WHO, 2015) .As society has progressed, however, more sophisticated stove models have been developed, which uses various types of energy from traditional fuels (forest-based) to modern fuels (natural gas and electricity).

However, in many developing countries, more than half of the population energy consumption was dependent on traditional fuel sources such as wood, charcoal and animal dung with traditional stove technologies to meet household cooking needs (Kooser, Shannon H., 2014).These traditional stoves were inefficient at converting energy in to heat for cooking and therefore, the amount of biomass require for basic cooking was unnecessary huge. In addition to this wastage, these stoves generate substantial amount of smoke, which has been associated with chronic and acute respiratory illnesses such as bronchitis and pneumonia moreover. Furthermore, the use wood and/or charcoal is leading to high deforestation in most developing countries.

According to International Energy Agency (IEA, 2015), at global was projected that about 1.5 million each year could be died due to the pollution of indoor air from the use of fuel wood using inefficient cook stoves in 2030. In addition, burning of biomass emits of greenhouse gases, which contribute to climate change.

In Ethiopia in general, and Assosa Woreda (located in Beneshangul Gumuz regional state in western of the country) in particular, biomass resources are dominant source of cooking fuels. Currently, about 18.95% of the rural populations of the region have access to modern energy sources like electricity, solar energy and improved cook stoves (Woreda Annual Report, 2018). Despite this poor state of modern energy access in this region, the regional government and concerned stakeholders are not given enough attention to the adoption of improved cook stove in this community. Therefore, one of the aims of this research is to examine factors, which influences adoption of improved cook stoves with goal of investigate how these factors could improve adoption ICS in Assosa woreda community.

Another way to improve energy situation in this community is to use solar energy for lightning and charging batteries, which can in turn be used to run radio and televisions. Solar energy is one of the renewable energy resources which can be used to reduce negative impact of fossil fuels (Admasu,2010). Surprisingly, solar photovoltaic (PV) system is not currently used but used before in this community. Considering, the benefits of using solar PV and couple with adequate solar energy resources in Assosa Woreda, this study is examined the determinant factors that adoption decision on solar energy technology in the selected study area, identify barrier facing the adoption of solar PV in this woreda.

## 1.2. Statement of the problem

Ethiopia's population relied heavily on biomass energy with over 95% of the national energy supply was from fuel wood (DCD-DAC-ENV,2013).The dependence on traditional biomass fuels, which is being used by 80% of the population, leads to series of problems, such as forest degradation and indoor air pollution. This study will contribute to the existing knowledge on factors that determine households' decision on improved cook stove.

In Ethiopia, due to the scattered rural settlements, solar PV is highly attractive option energy source for off grid rural communities. However, in many kebeles in study area, these solar PV systems are not well adopted yet. For this, the challenges of clean energy access and the uptake of household adoption of solar energy technology was the main issues to undertake the problems (Guta DD, 2018). Hence, this study examines household adoption decision of solar energy technology and challenges to adoption solar PV system in the selected study area.

## 1.3. Research Questions

In order to achieve the objectives of this study, answers to the following questions would be sought in this research.

i. What is the status of improved cook stove adoption in study area?
ii. What factors determinant household's decision to adopt improved cook stoves?
iii. What are determinant factors affect solar energy adoption in the selected study area?
iv. What are the main challenges facing the adoption of solar PV in the study area?

## 1.4. Objectives of the Study

The overall objective of this study was to examine determinant factors that affect households' adoption decision on improved cook stove and solar energy technology in rural 'kebeles' of Assosa Woreda. In order to achieve this aim, the following specific objectives are pursued in this work:

1. To assess the status of improved cook stove adoption among households in the study area.
2. To investigate the determinant factors of improved cook stove adoption in the study area.
3. To examine determinant factors affect solar energy adoption in the selected study area
4. To identify challenges facing the adoption of solar PV systems in the study area.

## 1.5. Hypothesis

The validity of the following hypothesis is examined in this study:

Ho: There is no significant status of improved cook stove adoption in the study area.

Ha: There is significant status of improved cook stove adoption in the study area

Ho There is no significant determinant factors of improved cook stove adoption in the study area.

Ha: There are significant determinant factors of improved cook stove adoption in the study area.

Ho: There are no significant determinant factors of solar energy systems adoption in the selected study area

Ha: There are significant determinant factors of solar energy systems adoption in the selected study area

Ho: There is no significant Challenges facing the use of solar PV systems

Ha: There is a significant challenge facing the use of solar PV systems.

## 1.6. The Significance of the Study

The findings from this study could help local improved cook stove producers, solar PV users, Woreda water and energy office, Woreda agriculture office and regional water and energy bureau to identify determinant factors, challenges on intervention area and on how manage identified challenges. Hence, this study will contribute to the realization of Ethiopia's climate resilient green economy strategy. Moreover, the study will contribute knowledge to the existing empirical and theoretical literature in the studied area

## 1.7. Conceptual framework of the study

### 1.7.1. Conceptual framework for determinant adoption of the improved cook stoves

The conceptual framework of this study is based on three independent factors namely social, economic, environmental , cultural beliefs and practices of the members of the households' and the sensitization level of the members of the household. Figure 1 shows how the independent variables or outcomes influence the determinant adoption of the improved cook stoves.

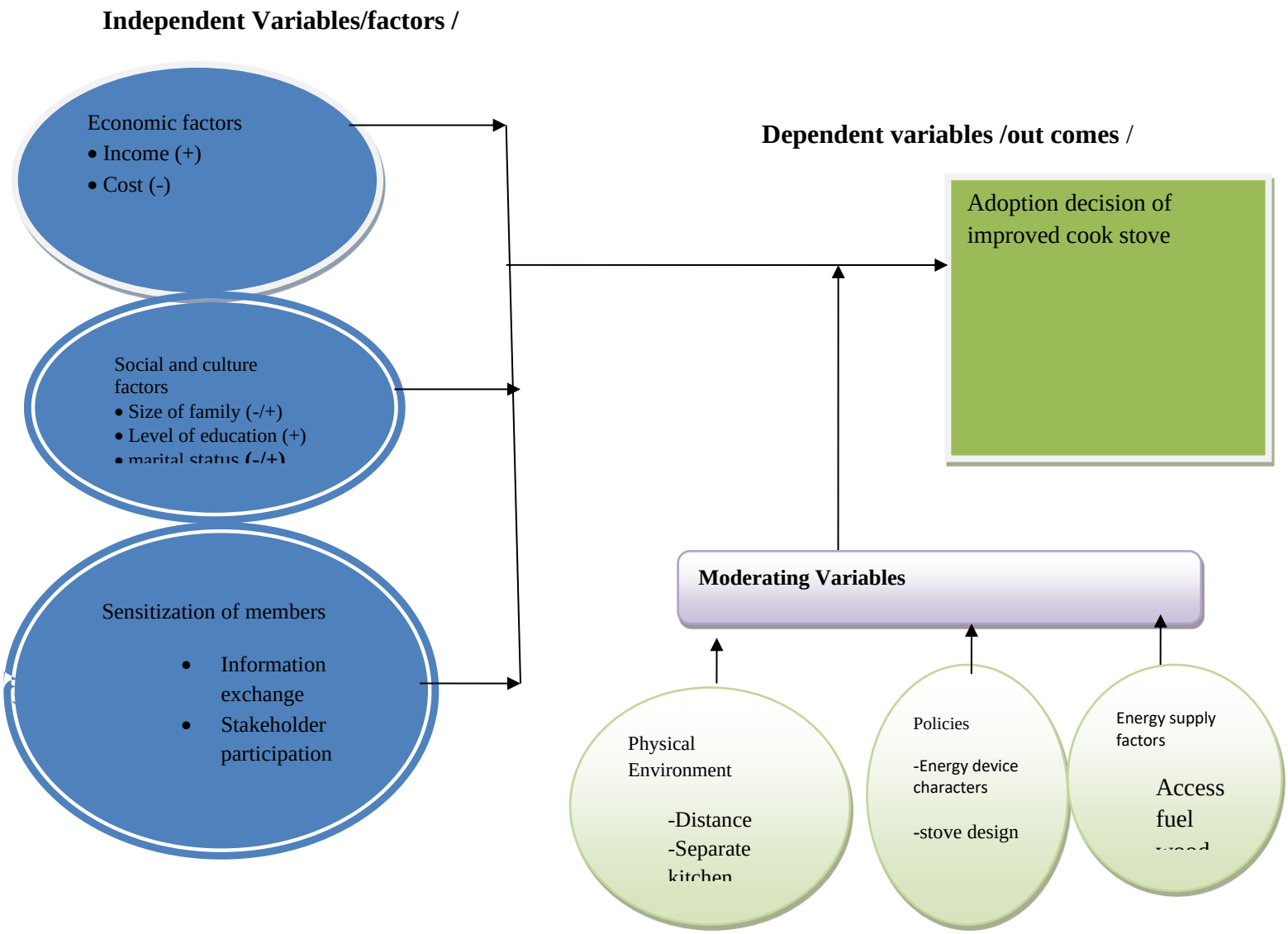



Figure 1 : Conceptual framework of the study of improved cook stoves adoption decision.

1.7.2. Conceptual framework for the determinants of solar energy technology adoption

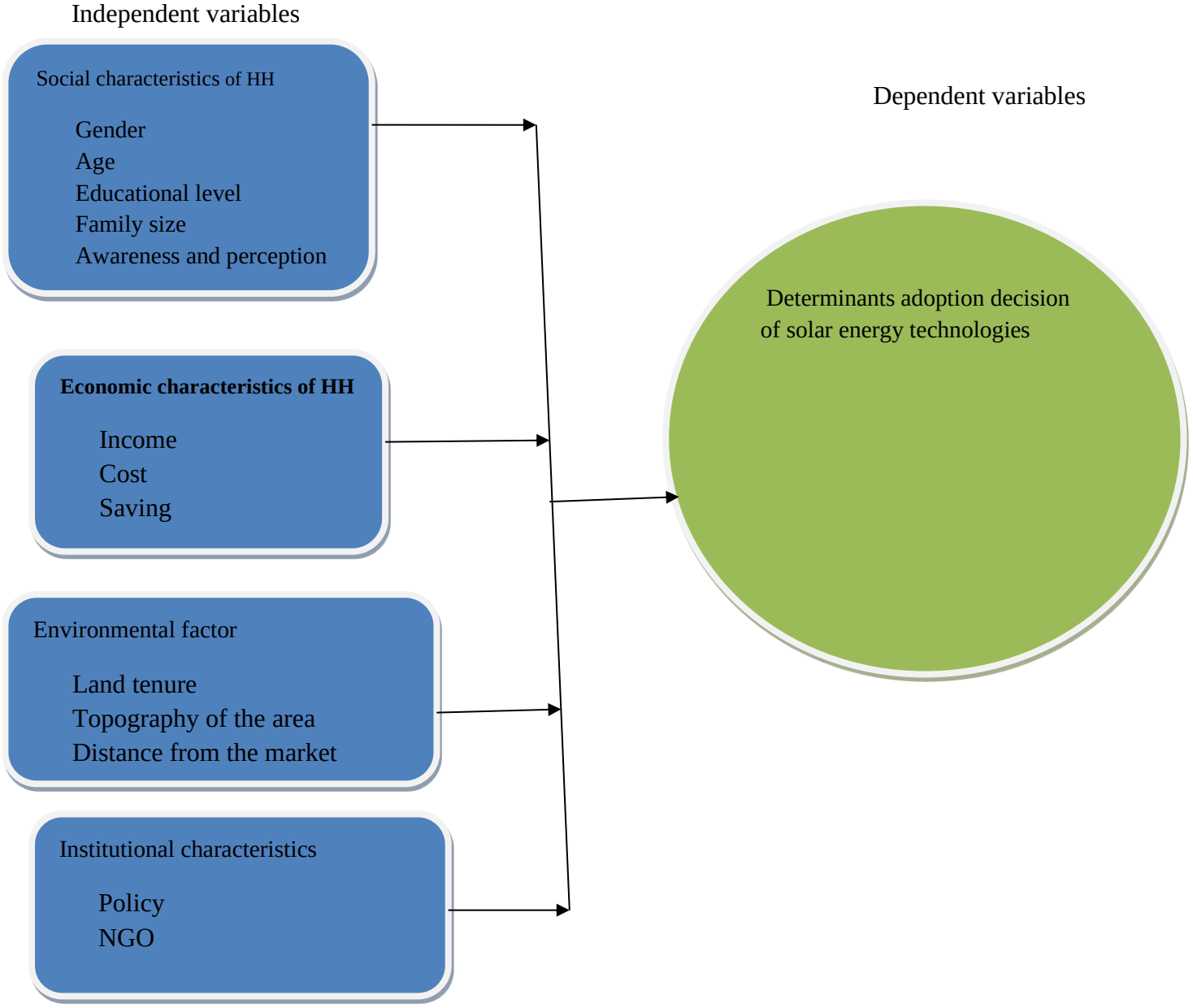



Figure 2. Conceptual framework for factors affects adoption of solar energy technology

Chapter two

# 2. Review

## 2.1. Determinants of adoption of improved cook stove

Clean cook stove is defined in different ways by different authors. For Improved cook stove (ICS) is a device that is designed to improve combustion efficiency of biomass, consume less fuel, save cooking time, convenient in cooking practice and creates smokeless environment in the kitchen or reduce the volume of smoke during cooking against the traditional stove. For Damte, & Koch, (2011), it is a solid fuel stove that improves on traditional baseline biomass technologies in terms of fuel savings via improved fuel efficiency that improves, or minimizes, the adverse health, environmental, and economic outcomes from cooking with traditional solid fuel technologies. Also, Kooser, Shannon, (2014) and World Bank group (2015), defined improved and advanced biomass cook stoves as stoves that reduce emissions, improve health and the environment. For Makori (2016), improve cook stove means a device constructed by artisans or household members that are energy efficient, safety, remove smoke from home, dramatically, improve the health and quality of life for poor people

### 2.1.1. Definition of Improved Cook Stove

Clean cook stove is defined in different ways by different authors. For alternative Energy program Center Improved cook stove (ICS) is a device that is designed to improve combustion efficiency of biomass, consume less fuel, save cooking time, convenient in cooking practice and creates smokeless environment in the kitchen or reduce the volume of smoke during cooking against the traditional stove.

For Damte & Koch (2011) it is a solid fuel stove that improves on traditional baseline biomass technologies in terms of fuel savings via improved fuel efficiency that improves, or minimizes,

the adverse health, environmental, and economic outcomes from cooking with traditional solid fuel technologies. More recently Kooser, Shannon, (2014) and World Bank group (2015), defined improved and advanced biomass cook stoves reduce emissions, improve health and the environment. For Makori (2016), improve cook stove means a devices constructed by artisans or household members that are energy efficient, safety, remove smoke from home, dramatically, improve the health and quality of life for poor people.

### 2.1.2. Benefit of Adopting Improved Cook Stoves

Energy saving project implanters such as regional, national, global programs initiatives, non-organization and organizations and also other mandatory can be achieved the least developing countries more powerful in maintain efficiently important for Mirt stove in enhancing communities economy and social health conditions, improving the livelihood of the poor, reduce environmental pollution and mitigate the climate change and reduce poverty (WHO, 2016: IEA, 2015:  and Kooser, Shannon, 2014).

### 2.1.3. Household Energy Choice (HEC) Theory

This study is conducted based on two theories, which are Household energy choice theory and Diffusion of innovation theories. Regarding household energy choice theory, there are two models that are commonly used and these are energy ladder model and energy stacking (International journal of Energy science, 2014). Energy ladder model, considered as classic and traditional, places heavy emphasis on income affordability in both explaining and determining a household's energy fuel stove choice, which implies that the household's income is taken as the only determinant factor that influences households fuel stove choice decision. One of the criticisms this model that there are multiple determinant factors, other than income, that influence households fuel stove adoption decision. These additional factors include family size,

land size, price, early adopter and gender. On the other hand, energy stacking is the term used to describe multiple-fuel use perspective of an household energy choice, which overcomes the drawbacks of the energy ladder hypothesis .There are various interacting economic, social and cultural factors (Warkaw, 2015: Amogne, 2014; Tigabu, 2014: Gebreegziabher, 2012), which are not captured by energy ladder model, that affect the adoption of cook stove. Energy stacking is based on empirical evidence and is more realistic than the classic energy ladder hypothesis.

### 2.1.4. The Diffusion of Innovations (DoI) Theory

According to Roger (2003), diffusion is the process by which an innovation is communicated through certain channels among members of given social. This theory states that individuals and early adopters in a certain social system can influence attitude and behavior of others informally either to promote or hinder the acceptance of a new technology. According to this theory, improved stove technologies are more likely to spread out in a certain population if the stoves first gain acceptance among early adopters. The diffusion process typically involves both mass media and international communication channels

### 2.1.5. Best Experiences

China; From this, one can understand that for the success of programs and projects, understanding the needs of the people and the most technical, social and cultural requirements, taking into account the national programs scheme, involving the target community in the production and providing training and education to the producers and potential users are crucial concerns (Makori, 2016).

Kenya: According to Win rock International (2011), Kenya has a good success story in Africa as compared to other countries and at country level 30%- 40% of households have an improved

stove of some type and 50-60 % in urban areas. According to Teodoro (2008), the success in Kenya has been attributed to an important focus on the issues of market, replication, mass production, low cost, efficiency, technology transfer, local production and commercialization as well as the stoves design was simple and small size Makori.M (2016).

2.1.6. Determinant Factors of Improved Cook stoves Adoption

Age: previous studies found that contradictory results of correlation between age and improved cook stove adoption. For instances, according to (Dawit, 2009: Inayatullah, 2011: Lewis and Pattanayak, 2012: Tigabu, 2014: Warkaw, 2015), the household's age is negatively and statistically significant determinant factor for adoption of improved cook stove. In contrary, Gebreegziabher*et al* (2010) found that household head's age to be positive and statistically significant determinant factor of cook stove adoption decision. Therefore, based on these previous empirical studies and with the assumption of older people may be somehow conservative in accepting new cooking technologies, in this study age will be expected to affect the householder's cook stove adoption decision negatively.

Marital status: Studies by (Damte& Koch, 2011; Tigabu, 2014; Markori, 2016) found that female headed household is more likely to adopt improved cook stove as compared to male headed household. These authors argue that in patriarchal society, husband has more power to make economic decisions in the household. That is married women's cook stove purchasing decision depends up on the willingness of their husband to pay. Having this understanding the study, will expect marital status in favor of single women affect cook stove adoption decision positively in rural households.

Education: Different studies conducted by (Inayatullah, 2011: Lewis and Pattanayak 2012: Amogne, 2014: Tigabu, 2014: Warkaw, 2015: Markori, 2016), found that household head's education is positively and statistically significant determinant factor on the adoption of improved cook stove. They argued that educated household is more likely to be aware of the benefit of improved cook stoves as compared to less educated households. Therefore, the study will be expected education is positive effect on rural households' improved cook stoves adoption decision.

Family size: Regarding to family size, previous studies reported that contradiction findings. Studies by (Gebreeziabher, 2010: Inayatullah, 2011: Lewis and Pattanayak, 2012: Warkaw, 2015) found that household size is positive and statistically significant determinant factor for improved cook stove adoption decision. These authors claim that large family size consume more fuel wood as compared to households with smaller family size. In contrary, (Zenebe, 2010: Koores, Shannan, 2014) found that family size is negatively and statistically significant determinant factor for adoption of improved cook stove decision. Those authors claim that households with more children, especially female children, have lower value for new stove technology because they have more people that participate in cooking and fuel wood collection. Moreover, with regard to the influence of a household size improved cook stoves adoption decision, work of Tigabu (2014) found inconsistency result among family size and improved cook stove adoption. Based on the previous literature findings, this study is expected that large family size positively affects households cook stove decision.

Income: The systematic work of (Dawit, 2009, Zenebe, 2011: Inayatullah, 2011: Lewis and Pattanayak, 2012: Amogne, 2014: Tigabu, 2014), found that household income level positively and statistically significant determinant factor in determining cook stove adoption decision.

These authors claimed that household income level and cook stove adoption decision are proportionally correlated. As the income of the household increased, the demand for modern cook stove also increased. Based on this understanding, this study will expect that household income level positively affect the adoption of improved cook stove adoption decision.

Separate kitchen: Previous studies found that separate kitchen house as one significant factor that has positive effect on a household's improved cook stoves adoption decision (Dawit, 2012; Damte& Koch, 2011; Tigabu, 2014). These works investigated the positive correlation between separate kitchen and improved cook stoves adoption. Those authors claim that having separate kitchen helps to households to fix or introduce improved cook stove and it needs additional place for installation. On the other hand, Warkaw (2015), found that indifferent result between the separate kitchen and cook stove adoption decision. Based on the existing literature, this study will expect a separate kitchen is positive effect on households' cook stove adoption decision. .

Source of fuel wood: A study by (Gebreeziabher, 2010: Tigabu, 2014: Warkaw, 2015), found that the free availability of fire wood are one of the determinant factor that lead to decision not to adopt improved cook stove. Access to free open forest is negatively correlated and statistically significant with the probability of improved cook stove adoption. Also they investigated that lack of access to open forest and improved cook stoves adoption have positive correlation. Those authors hypothesize that household that get fuel wood with charge to be more adopters as compared to households that obtain fire wood for free efficient use of wood may be not their concern while fuel saving is the priority for those buy wood. Based on this empirical evidence, from this study sour of fuel wood will expect negatively affect adoption of improved cook stove.

Price: A recent study by (Zenebe, 2010: Beyene and Koch, 2013: Tigabu, 2014: Makori, 2016) found that higher price of cook stove negatively and statistically significant on improved cook stove adoption decision. Those authors argue that inability of the poor to pay the cost of improved cook stoves is one of important barriers of cook stove adoption decision. And affordable cost for the poor is a positive determinant factor of household adoption decision. As a result the purchasing price of cook stove is important factor in influencing a household's adoption decision. Based on the previous studies, this study expects stove price will have negative effect on the households' purchasing decision of improved cook stove.

Stove Design: previous studies by (Addkins, 2010: Makori, 2016) found that suitable stove design are positively and statistically significant determinant factor on improved cook stove adoption decision. They argue that stove design deals with durability, easy to use and effectiveness on cooking time. In line with this Beryden (2002), the design of the stove should be reduces less smoke, limit the cool air, use heat sensitive material. Therefore, argue that Unsuitable stove designs reduce the efficiency and the willingness to adopt or use the new stove and Vis versa. Based on this understanding, from this study suitable stove design will affect positively households' improved cook stove adoption decision.

Access to credit: previous studies by (petter, *et al*. 2015), financial incentives, fuel costs and credit availability are consistently reported to be core drivers for sustained adoption of improved cook stoves stove adoption. Credit treatment with different payment arrangements, help households to buy improved stoves were particularly important in poorer rural communities that traditionally use foraged fuel wood or charcoal and indigenous low-cost cook stoves. Providing credit to low-income communities to ease their financial burden was also a popular choice. Other incentive included delivering cook stoves free of charge to poorer users. Therefore, this study

will be expected that relatively those who access to credit service households could participating in modern source of energy and using improved technologies than who had not access to credit households.

Distance from center: A previous study by (Adkins, 2010: Makori, 2016: petter, et al. 2015) it is a continuous variable measured in kilometers. It is expected that if the cook stove production center/site far from the household resident, accessibility of improved cook stove are not easy and take more time to adopt. They hypothesized that availability of cook stove production site near by area have positive effect on the improved cook stove adoption.

Other factors: From the empirical literature the other factors that are found to influence the adoption decision of improve cook stoves include institutional and social factors.

Extension worker Existence: A study conducted by (Tigabu, 2014: Warkaw, 2015: Amogne, 2016) found that the existing institutional set up is a key factor that influences the implementation, promotion and dissemination of improved cook stoves in a certain country through kebele extension workers. These authors found that training and information exchange, supply standard technology and decentralizing energy production site are institutional factors that influence positively the production, dissemination and adoption of improved cook stoves. Based on the previous studies, this study expects existence of extension workers will have positive effect on the households' purchasing decision of improved cook stove.

## 2.2. Lecture Reviews on factors affects adoption of solar energy technology

### 2.2.1. Solar energy potential in Ethiopia

Ethiopia is located in the solar belt with an average sunshine of up to 10 hours per day, equivalent to an averaged 5.5 kWh/$m^2$/day of solar radiation are observed almost throughout the year. Argued that the solar PV prices have been in steady decline in the recent years, dropping to approximately 50% compared to when it was first introduced years ago. This phenomenon was attributed to ramping up of solar PV productions in China and the technological breakthroughs experienced in the field. Solar energy is the stable and reliable source of energy that can be harnessed for the benefit of domestic and commercial purposes.

### 2.2.2. Key barriers to solar energy adoption in Ethiopia

The major impediments to the technology adoption are series of barriers which makes it hard to implement.

Table 1.Key barriers of solar energy adoption in Ethiopia (International Conference on Green Energy Technology, 2017))

| Barriers category | Barriers | Remarks |
|---|---|---|
| Technical Barriers | Lack of skilled personnel, lack of standard, lack of maintenance and operation, lack of training facilities and entrepreneur's development mechanism, lack of Reliability | The barriers lead to poor plans, poor standard, and constraints of the competitive market, inadequate knowledge to know-how about the technology and risk acceptance. All these barriers resulted in technology locked -up. |
| Social, Cultural | Lack of consumer awareness about the | The barrier, affect the market projection |

| | | |
|---|---|---|
| Behavior | product, lack of understanding of benefit of solar PV and public resistance to chance for new technology | negatively, cultural and religious faith controversies towards economic development and sustainability |
| Economic/Financial Barriers | Lack of access to capital, credit to consumers and financial instrument. Lack of support to R & D, high interest rate, import duties subsidies to support local manufacturing. | At the early stage, solar projects need incentives to encourage entrepreneurs. The barriers make it difficult to adopt and sustain due to financial constraints |
| Institutional/Legal barriers | Institutional barriers, legal framework, regulatory issues, non-integration of energy mix, non-participation of private sector, poor R & D culture and stakeholder's non-interference | The barriers cause risk of uncertainty in support of solar energy, lobbies against RET, poor communication mechanism to reach the institutional policy makers for improvement and negative perception about the technology |
| Political/Policies Issues | Lack of long term policies, lack of political will to diversify into clean energy, constantly changing of government and re-shuffling of institutions. | These barriers serve as a deterrent to future planning for solar and other renewable energy adoption and sustainability. There is the fear of uncertainty in government |
| Market Distortions Issues | Trade barrier for new product, energy sector controlled, lack of access to diversified technology, lack of facilities and backup technology, non-market oriented research for solar energy technology and application | The barriers cause hindrance to market penetration and hence new technology failed at some point. |

Source: International Conference on Green Energy Technology (ICGET, 2017)

### 2.2.3. Rural Electrification in Ethiopia

In rural areas, women and children spent their time in searching of firewood and the urban poor also spend a large amount of their income to satisfy their energy demand [Mulugeta, 2008].Ethiopia has a very low amount of electricity generation from hydro and diesel generator but this generated amount also will not fully operated due to constraints on fuel and maintenance costs of diesel generator [Tefera, 2002]. As most of the people live in rural areas, the development of these areas is a key for the whole country development. The government is taking actions to promote the electrification. For example, in 1996 investment proclamation the private investors are allowed to import all types of equipment related to electricity production, transmission and distribution free of tax and custom duties [Tefera, 2002]. There are two main reasons for the low level of electrification. These are economic resource constraints and low level of technological advancements. In the rural area, the relatively high cost of transmission and distribution due to the mountainous and scattered rural settlements makes it costly and the people are unable to pay for the electricity and installation [Stutenbaumer et al 1999; Wolde-Ghiorgis, 2002]. Rural energy problem in Ethiopia will be the cause of slow growth and poverty unless actions are taken to overcome this problem [Wolde-Ghiorgis, 2002]. Education, health, and rural road building programs are considered the main areas for building the necessary infrastructure for poverty mitigation. The development of modern energy in Ethiopia has got a considerable finance but the rural energy sector does not get a fair share of this allocation. One of the main problems for the national energy policy of Ethiopia is there is no organized responsible body for rural electrification except grid electricity and petroleum products. Without institutional and managerial structures and controls, it is impractical to realize that the stated solutions for the

problems of rural electrification like mini and micro-hydropower and PV systems [Wolde-Ghiorgis, 2002].

2.2.4. Benefits of Solar PV Based Rural Electrification

Solar PV electrification has several advantages for the user and for overall growth of a nation especially for the development of developing nations.

Education: Electrical light is good for students to perform homework at night, improve the quality of schools by allowing using electrical appliances and it also increase the quality and quantity of teachers [Cambclong et al, 2009; World Bank, 2008]. It also makes rural positions more attractive to teachers and this will be the main cause for improved school quality and higher level of education [World Bank, 2008].

Health: It is useful for the improvement of health facilities [Cambclong et al 2009; World Bank, 2008]. As the indoor air becomes clean due to reduced use of polluting fuels for cooking, lighting, and heating then the people also gets a better health. [World Bank, 2008] It also improves health knowledge through access to mass media [Cambclong et al 2009, World Bank, 2008].It is possible to get better nutrition from the improved knowledge and from the use refrigeration for food storage. The use of traditional fuels like wood fuel, crop residue and dung exposes the inhabitants to air pollution [Abdullah et al; World Bank, 2008] which causes health risks like acute lower respiratory infections, low birth weight, infant mortality, and pulmonary tuberculosis. Using these traditional fuels for cooking will increase the risk of premature death from two to five which can result a death of 1.6 to 2 million people each year due to the indoor air pollution. Rural electrification can result in a better health conditions even

though most of the electricity needed by the rural house hold is for lighting [World Bank, 2008].

Access to Water: In many rural villages there is no enough or pure drinking water they have to travel a long distance to get water. The solar PV based water pump can solve this problem. They can also clean their bodies in a regular basis and wash vegetables and dirty dishes [Mala et al 2009; SEF, 2009]. PV based irrigation pumps can also employed to increase rural agricultural productivity.

Environmental Benefit and Other Positive Impacts: It displaces the conventional energy sources and it preserves and protects our environment [World Bank, 2008; H. 28 Cambclong et al 2009]. Allowing good working conditions for economic or domestic activities; give opportunity for the improvement of basic services and increase of house hold income [Cambclong et al 2009; World Bank, 2008]. It reduces the migration of rural people to the urban areas by creating activities which can generate jobs and sources of income [Cambclong et al 2009]. For example, in Bangladesh as most of the people (about 81%) lives in rural areas, the markets of these areas are seen as a major growth center for the country. In addition they have a big bazaar known as “Hat” two times a week. In order to be successful in selling of their product they need to have electricity. If they do not have electricity they are forced to sell with a lower price. Most of the people use kerosene lamps for lighting and some shop owners also use the more expensive mantle lamps and some other rural markets have diesel generator but the quality of services is low. Using PV systems become successful for these areas and their working hour and income also increase directly. [Ibrahim et al, 2002]

2.2.5. Factors affect adoption of solar energy technology

*Family size* is expected to have either a positive or negative effect on solar PV adoption. Previous studies have indicated that larger households are more likely to adopt solar PV because they are larger consumers of electricity and they can spread the fixed cost over the members of the household (De Groote et al., 2016). The negative effect is likely related to the fact that with an increase in the household size, it is expected that expenditure on various commodities may increase.

*Gender* is playing a key role in influencing household's investment decision on renewable energy technology. Studies have indicated that women participate in environmentally friendly technologies more than men. For instance, one study indicated that support for new renewable energy development was supported by about 90% of women as compared to 60% of men (Patrick, 2009). By contrast, one study showed that males were more likely to adopt new technologies compared to female (Bollinger and Gillingham, 2012). In rural Ethiopia, the male is considered to be strong, resourceful, and autonomous decision maker in deciding the adoption of modern technologies, but women are most affected by the lack of access to clean energy. *Age* of the household head is assumed to influence household investment in solar energy technology either positively or negatively. Therefore, household demographic characteristics included in the model were household size, and the age of the household head, and gender.

*Household educational level* is considered a key driver of solar energy technology adoption, namely the educational status of the household head. Couples who are more educated tend to acquire a greater awareness regarding the benefits of solar energy technology; these benefits include health, environmental, economic, and social welfare. However, regarding the effect of education, there is mixed evidence in the literature. In developed countries, a study

found a positive effect of education on household solar panel adoption (Rahut et al., 2017; Kwan, 2012). On the contrary, another study found no positive effect of education of solar PV technology adoption rate (De Groote et al., 2016). Therefore, the model is controlled for the educational status of both the head and the spouse, and it is proposed that both positively influence the household's decision on solar energy technology adoption.

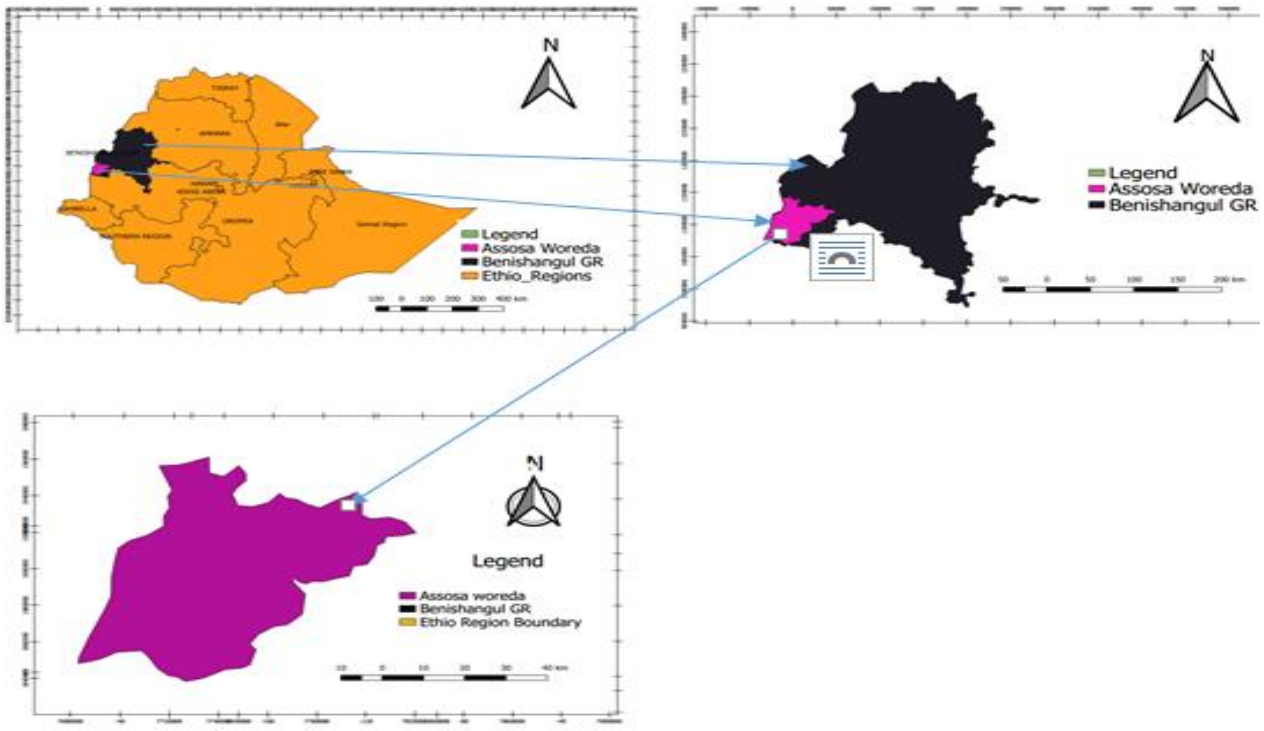
Chapter Three

# 3. Methodology of study

## 3.1. Description of the Study Area

Assosa Woreda is located at about 642 km west of Addis Ababa, the capital city of Ethiopia and it is near Assosa town, the capital city of Beneshangul Gumuz regional state. Assosa woreda is located within $9^0$50'N to $10^0$10'N latitude and $34^0$10'E to $34^0$50'E longitude , with the altitude ranging from 600 to 1400 m above sea level and has area coverage of 2903.06 hectares (ha). The area receives an average annual rain fall ranging from 860 to 1600 mm and average daily temperature from 25 to 45C$^o$(Beneshangul Gumuz Metrological station data,2019) . The agro-climatic zones of the woreda are lowlands that covers 75% of the area and the remaining 21% midland or 'Woyina Dega' and 4% highland 'dega'. About 80% of the woreda's economy depends on agriculture activities and the remaining 20% is on gold mining activities (BGBOARD annual report, 2019).

The study area is divided to 20 rural 'kebeles'. Based on the national censes (Gutu, 2007), population of Assosa woreda is 104,147, of whom 52,968 are males and 51,179 females.




(Source: Ethio-GIS)

Figure 3: Map of the study area

3.2. Research Design and Strategy

3.2.1. Research Design

The research employed descriptive survey research design. Descriptive statistics can be useful for two purposes: 1) to provide basic information about variables in a dataset and 2) to highlight potential relationships between variables can be displayed by graphically or pictorially and also conclude about the existing condition at a time. In addition, descriptive statistics is also made a general conclusion about the whole population based on the data which were collected from sample respondents. And found this method important as the required data were collected from samples of respondents, focused group discussion and key informants. Besides, survey method enabled to effectively manage all the necessary activities that were taken place in the study area.

I had also used cross-sectional method, because the study was conducted in a manner that a small portion of a population was sampled only at a time.

### 3.2.2. Research Approach

Mixed research approach was employed. By mixed methods the weaknesses of the qualitative method would be tackled by the quantitative method and the weaknesses of the quantitative method would be overcome by the qualitative method; and thus, employing mixed methods strengths the study (Onwuegbuzie & Leech, 2004). Puzzolo et al (2013) recommend that studies designed specifically to strengthen the understanding of factors affecting improved cook stoves adoption and solar energy technology and also sustained use need to draw on a combination of quantitative and qualitative research strategies.

## 3.3. Data Type and Source

For this study, both quantitative and qualitative data were collected with reasons. The quantitative data were employed in order to address research questions and objectives that could be better addressed quantitatively. The data about respondent's Age, Distance from source of fire wood, Educational level, income, land hold, Family size and Price were gathered numerically.

The qualitative data such as marital status, gender, educational level, saving money, extension worker and separated kitchen were used to address research objectives which could be better addressed qualitatively. With regard to the data sources, used both primary and secondary sources.

The primary sources of this study were mothers or wife of households and the key informants of local ICS producers (cooperatives ), local solar pv producers , Woreda agricultural office,

kebele agricultural offices (specifically natural resource management experts), and Woreda water and energy office (specifically rural energy experts)

The secondary sources of data were the regional water and energy bureaus reports; Woreda's water and energy office IC stove and solar energy dissemination report.

Women are the main expected beneficiaries of the ICS (Mirt stove), as in many cases they are the ones in charge of firewood collection, food preparation and usually spend higher amount of time inside the dwelling place, benefiting significantly from reductions in indoor pollution.

3.4. Sampling Techniques and Sample Size

A multistage sampling technique was employed. In the first stage, Assosa Woreda was selected purposely among 20 woredas in 3 zones of the region have more effective regarding on the use of improved cook stove and solar energy technology than the other zones/districts and the determinant factors that adopted improved cook stoves and solar energy and also the main challenges to adopt solar PV energy system in the selected area. In the second stage, 5 kebeles were selected purposively from 20 Kebeles due to diversity of agro ecology, geographic distribution and culture of community and also kebeles are model from the other kebele of districts (NRM and community participation). Thirdly, the households' were selected using simple random sampling proportionate to total number of households in each Kebele.

Regarding the sample size, this study used a simplified formula provided by Yamane (1967) to determine the required sample size at 92% confidence level and 8% level of precision

$n = \frac{N}{1+N(e)^2}$ = 1457 ÷ 1+1457× $(0.08)^2$ = 141

Where *n* is the sample size, *N* is the population size (total number of households), and *e* is the level of precision (sampling error) at 8% significance level. Then total sample size of each kebele was (PPs) = THH × n ÷ N

⇨ PPs = THH × 141 ÷ 1457

⇨ Sample size of HH from each kebele (PPs) $= \frac{\textbf{Total no,HH in each kebele} * \textbf{Total sample size}}{\textbf{Total no,of HH}}$

Table 2: The distribution of sample sizes of household heads from each selected kebeles

| No | List of kebeles | Total households | Sample households from each kebele |
|---|---|---|---|
| 1 | Amba 14 | 280 | (280*141/1457) = 27 |
| 2 | Selga 21 | 274 | (274*141/1457) = 26 |
| 3 | Megele 30 | 237 | (237*141/1457) = 23 |
| 4 | Abramo | 315 | (315*141/1457) = 30 |
| 5 | Gambela | 351 | (351*141/1457) = 35 |
| | | 1457 | 141 |

Source: own computation (2020)

The final sample size was included 141 households from the five *kebeles*. And Cross-sectional data would be collected based on different variables including family size ,age, marital status ,education .income , separated kitchen, source of fuel wood, cost of solar PV and improved CS , saving, distance to local markets and access to extension services using structured questionnaires. In addition to this the researcher employed purposive or judgmental non - probability sampling technique in order to get information from office and bureau employees and leaders because all do not have equal chance of selection to get main information from the key informant

Table 3 Selections of key Informants person (KIP) from Different Offices and Bureaus for Interviews

| No | Offices from where the key informants was selected | No. of selected key informant |
|---|---|---|
| 1 | Assosa woreda water and energy office | 1 |
| 2 | Assosa woreda Agriculture office | 1 |
| 3 | Assosa woreda health office | 1 |
| 3 | Beneshangul Gumuz water and energy bureau (energy core process owner and energy expert ) | 2 |
| 4 | kebele administration office(from each one ) | 5 |
| 5 | Local energy producers (from each one ) | 5 |
| | Total | 15 |

Sours: own computation (2020)

3.5. Data collection Methods

Primary data was collected by questionnaires to each selected household's women or head and also interviews with government office.

Questionnaire is made easy to understand by respondents as well as it gives better information about the issue under study, will be used to collect primary data. The questionnaires will include structured and unstructured as well as closed-ended and open-ended question

Interview with key informants, will be used to explore variable under investigation in a greater detail. The key informants will be selected from solar energy retailers, cook stove producers, government officials from Woreda water and energy, agriculture and health

The focus group discussion with key informant's person will include determinants factors of cook stove dissemination, barriers of stove production and adoption, factors of solar energy systems adoption and challenges facing the solar energy systems adoption in respective Kebeles.

A total of 15 individuals key informant were interviewed and participated in the focus group discussions; from these 5 individuals (natural resource management experts) from the five selected kebeles agricultural office, one person from the Woreda agricultural office, Two person from Bureau's of water and energy core process owner and energy expert, one person from woreda healthy office, one person from Woreda water and energy office (the rural energy electrification expert) and 5 producers of local ICS and solar energy producers from the selected kebeles (one from each kebele). These discussions were conducted in the morning for 10-15 minutes for each by using the opportunity of a meeting that has been conducted for three consecutive days for Woreda and kebele agriculture development agents at Assosa town and a two days training for Improved cook stove producers and solar energy by Woreda rural energy experts.

### 3.6. Data processing and Analyzing

The collected data were processed and analyzed. These data processing and analyzing procedures are discussed below.

#### 3.6.1. Data processing

To reduce incompleteness and make it useful in the analysis, the raw data were filtered. So that the raw data was edited, coded, tabulated and summarized with the help of SPSS software version 25.

#### 3.6.2. Analyzing Procedures

Descriptive Analysis: - Quantitative and qualitative data collected via household survey, key informant interviews, focus group discussions were analysed by using descriptive statistics in the

form of frequency, percentage, means and standard deviation were used by using the SPSS software version 25 in analyzing the data collected.

Descriptive statistics was employed to determine and assess the following aspects of respondents' demographic and socioeconomic characteristics and examine the determinant factors that affect households' adoption decision of improved cook stove and solar energy technology adoption in rural 'kebeles' of Assosa Woreda.

Binary logistic Model: Together with the descriptive statistics, empirical investigation was employed to confirm the existence of the relationships among adoption and explanatory socioeconomic variables. The most commonly used econometric models in adoption or use studies are the limited dependent variable models such as logit and probit which was analyzed using SPSS version 25. The dependent variable (adoption of improved cook stove and solar energy technology) was in dichotomous (dummy) form. Hence, binary logistic regression was used to predict the effects of the explanatory (predictor or independent) variables on the dependent (outcome) variable .Binary Logistic regression is used to model the probability of a positive outcome for a binary 0 or 1 outcome variable as a function of covariates (Gujarati, 2004)

In the current study, the observations will be coded "1" for adopters and "0" for non-adopters will be used as a dependent variable.

3.7. Operational Definitions and Descriptions of Variables

Dependent variable: Determinants adoption decision of improved cook stove and solar energy technology will be given value '1' if the household adopters while '0'assigned to non-adaptors. To assess the status of cook stove adoption by rural households, respondents will be asked

whether they purchase cook stove in the form of yes or no questions. Similar studies conducted, for instance (Tigabu, 2014: Warkaw, 2015: Amogne, 2014) used similar approach.

Independent variable: The independent variable are selected based on the existing theories and empirical studies (Warkaw, 2015: Damte and Koch, 2011: Tigabu, 2014: Amogne, 2015: Gebgeeziabher, 2010, Guta DD, 2018).

Table 4 Operational Definition and Description of variables with expected result

| S/N | Variables | Operational Definition | Expected result |
|---|---|---|---|
| 1 | Age (age): | it is a continuous variable measured in years | Indeterminate |
| 2 | Marital status (MAST) | Marital status is a dummy which refers to respondent's states of being single or married. A value of '1' will be given to married '0' for | Negative ( -) |
| 3 | Educational status level HH head (EDLEVEL) | Literacy level is a dummy which refers to whether the respondent is literate (can read and write) or illiterate (cannot read and write). A value of '1' will be assigned for literate and '0' | Positive (+) |
| 4 | Family size (FMSIZE): | it is a continuous variable, the number of family size live in the same household | Indeterminate +/- |
| 5 | Separate kitchen (SPKCHN) | It is about whether the household has separate kitchen or not. Separate kitchen is a dummy valued '1' for house holed that has separate | Indeterminate +/- |
| 6 | Source of Fuel wood (SOFW) | It is a dummy that refers to whether households get fuel-wood without charge or with charge. A value of '1' for households that gets wood without charge and '0' for with charge. | Negative ( -) |
| 7 | Cost | It is a continues variable price refers to the end users cost to buy cook stove or solar Pv in Ethiopia birr | Indeterminate +/- |
| 8 | Saving of | It is the dummy variable 1 or 0 of the household | -/+ |

| | | | |
|---|---|---|---|
| | money(SAM) | | |
| 9 | Distance from source (DSC) | I t also dummy variable 1 for near and 0 for far from the source | -/+ |
| 10 | Perception and awareness of households | It dummy variables 1 for yes and 0 for no | -/+ |

Sources own completion (2020).

3.8. The model specification (Binary Logit Model)

A household adoption of improved cook stoves and solar energy technology are modeled as a dichotomous variable with values 1 'if a household adopts/use improved cook stoves and solar energy or' and 0 'if otherwise'. The probability of a household adoption of improved and solar energy devices are formulated as a function of individual and household level characteristics. Summary statistics of the predictor variables hypothesized to influence a household willingness to adopt or use improved cook stoves and solar energy technology are given in Table The predictor variables in the model include attributes of individual and household characteristics that could influence a household decision to adopt improved cook stoves and solar energy.

Where, $Y_i$ is binary dependent variable denoted as "1" if the household adopted improved cook stove or solar energy technology and "0" otherwise "$ß_i$" is vector parameters to be estimated. "$ß_0$" is the constant term. "$e_i$" is the error term.

Chapter Four

# 4. Result and Discussion

## 4.1. Determinants on adoption of improved cook stove decision

### 4.1.1. Status decision on improved cook stove adoption

From table 5 below the totals of 116, 84 respondents (72.4%) were found adopters of Improved cook stove while 32 respondents (27.6%) are non-adopters. This implies the majority of the households were found to be adopters of improved cook stoves

Table 5 Status of Improved Cooks Stove Adoption

| Improved Cook Stove adoption | | |
|---|---|---|
| | N | Percent |
| Adopter | 84 | 72.4 |
| non-adopter | 32 | 27.6 |
| Total | 116 | 100.0 |

Source: Own survey data (2020)

### 4.1.2. Improved cook stove Adoption and Household Characteristics

Household characteristics are those variables that explain information about the household gender, age, marital status, level of education and occupation of respondent's. But, for this study, household characteristics include only variables of the respondent's gender, age, marital status, educational level, family size, Price and source of firewood, price and household's separate kitchen.

These factors are explained below:

4.1.2.1 .Improved cook stove adaption and Gender

From table 6 below implies that gender of the household head is mostly male headed 81 (69.81%) which have been taken during the data observation to adopt improved cook stove. Because of male household headed more powerful in making economic decision and more influence women to participate on Mirt stove adoption. The finding of this study is different/ opposes/ the previous studies (Abebe Damite 2011, Adrianzen 2009 and Tigabu 2014) that found that female headed household to be more likely in adopting improved cook stove technology than male headed household. This study which means that male headed household which is more influence their wife to participate on Mirt stove adoption and more economic to buy Mirt stove.

Table 6 Improved cook stove Adoption and Gender

| Decision of HH head | | N | Percent | mean | Sta.dev. | p-value |
|---|---|---|---|---|---|---|
| Adopter | Male | 81 | 69.81 | 1.01 | 0.109 | 0.000*** |
| | Female | 3 | 2.59 | | | |
| | Total | 84 | 72.4 | | | |
| Non-adopter | Male | 32 | 27.6 | 1.00 | 1.00 | |
| | Female | 0 | 0 | | | |
| | Total | 32 | 27.6 | | | |
| Total | | 116 | 100 | | | |

Source: Field Survey (2020), Note: *** indicate 10% level significant

4.1.2.2. Improved cook stove adaption and Age

As shown Table 7 below the minimum and maximum years of the respondents are 25 and 50 while the mean and standard deviation are 40.695 and 8.521, respectively. The minimum and maximum years of the adopters are 29 and 40 while non-adopters are 25 and 50 years respectively. And also, while the means for adopters and non-adopters is 38.33 and 43.06, the standard deviations for adopters and non-adopters are 8.271 and 8.777, respectively. This finding reveals that there is mean variation between the Mirt stove adopters' and the non- adopters' household age. The average age of adopters is less than the average age of non adopters. This implies that the younger the age, the more likely to be Mirt stove adopter. In addition, this mean variation was found to be statistically significant with t-value of -2.706. This t-value suggests that there is significant difference between the mean of Mirt stove adopters and the mean of non-adopters at (P=0.007) level of significant.

This implies that the younger the age, the more to be Improved Cooks Stove adopter and the older the age the more to be Improved Cooks Stove non-adopter and vice versa. This may be because of older people are found to be more conservative towards accepting new technologies and instead they prefer to continue using the technology they are habituated. This finding is in harmony/similar with the works of Lewis and Pattanayak (2012), Gebreegziabher et al (2010) and Tigabu (2014) that found statistically significant relationship between age and Improved Cooks Stove adoption decision

Table 7 Improved Cook stove adoption and age of the respondents

| Improved Cook Stove adoption | N | Min. | Max. | Mean | Std. Dev. | t-value | P-value |
|---|---|---|---|---|---|---|---|
| Adopter | 84 | 29 | 40 | 38.33 | 8.271 | -2.706 | 0.007*** |
| non-adopter | 32 | 25 | 50 | 43.06 | 8.777 | | |
| Total | 116 | 25 | 50 | 40.695 | 8.524 | | |

Source: Field survey (2020), Note: ***indicate 10% significant level

4.1.2.3. Improved cook stove adaption and Family size

As it can be seen from Table 8 below the minimum and maximum family size is 6 and 7 respectively while the mean and standard deviation are 5.275 and 1.896 respectively. And also, the minimum and maximum family size for Mirt stove adopters and non-adopters were 8 and 3 and 6 and 7 persons, respectively. The mean of adopters (4.61) is less than the mean of non-adopters (5.94) and the standard deviation of non-adopters (2.271) slightly exceeds the standard deviation of adopters (1.521). Though there is mean difference in family size between the adopters and non-adopters, the t-value shows that there is significant relationship between the family size of the adopters and non-adopters decision to adopt Mirt stove which means p value <0.01.which means that P-value is 0.001 significant level.

Different work with the study Tigabu,.2014. Shows that there is insignificant relationship between the family size of the adopters and non-adopters decision to adopt Mirt stove

Table 8 Improved cook stove adoption and family size

| Improved Cook Stove adoption | N | Min | max | Mean | Std. Deviation | t-value | P-value |
|---|---|---|---|---|---|---|---|
| Adopter | 84 | 8 | 3 | 4.61 | 1.5 | -3.645 | 0.001*** |
| non-adopter | 32 | 6 | 7 | 5.94 | 2.3 | | |
| Total | 116 | 6 | 7 | 5.275 | 1.9 | | |

Source: Own survey data (2020), Note: *** indicate 10% significant level

4.1.2.4. Improved cook stove adoption and marital status

Table 9 Shows that out of 116 surveyed household 113 are married in which 81 households are Mirt stove adopters and 32 households of them are Mirt stove non-adopters .The majority (71.68%) of married women were found to be Mirt stove Adopter in the study area. These figures indicate that a greater proportion of married women tended to adopt Mirt stove as compared to separated or divorced women counterparts. In addition, the chi-square statistic showed this to be statistically significant with P-value of 0.079. Therefore, it can be concluded that there is significant relationship between marital status and Mirt stove adoption decision at ($p<0.1$) level of significance

One plausible explanation for this may be because of married women has the full confidence to make economic decision in the household as compared to separated ones. This implies that the husband is more powerful in making economic decisions and more to push his wife to participate in Mirt stove adoption.

Table 9 Improved Cook Stove adoption and marital status

| Marital status | | Decision Improved Cooks Stove | | | Ch-square test |
|---|---|---|---|---|---|
| | | Adopter | Non-Adopter | Total | P-Value |
| Married | Number | 81 | 32 | 113 | 0.079* |
| | Percent | 71.68 | 28.32 | 100 | |
| Separated | Number | 3 | 0 | 3 | |
| | Percent | 100 | 00 | 100 | |
| Total | | 84 | 32 | 116 | |

Source: own survey data (2020), Note: * indicate 1% significant level

4.1.2.5. Improved cook stove adoption and Educational level

Education is very important for the household to interpret the information coming to them from any direction .A better educated person can easily understand and interpret the information transferred to them by extension workers.

As Table 10 shows, from the total of 116 respondents, 86(74.14 %) were found literate in which 75 of them are found to be Mirt stove adopters and 11 of them are non-adopters. On the other side, 30 (25.86 %) are found illiterate in which 9 are found to be Mirt stove adopters and 21 of them are non-adopters. And also the proportion of literate Mirt stove adopters 75 (89.29 %) largely exceeds the proportion of literate Mirt stove non-adopters (34.38%) while the proportion of illiterate Mirt stove adopters (10.71 %) much less than the proportion of illiterate Mirt stove non-adopters (65.62 %). This percentage difference was indicated to be significant with P-value of 0.000. Therefore, it can be generalized that there is significant relationship between women educational status and the probability of Mirt stove adoption decision at ($p<0.1$) significant level.

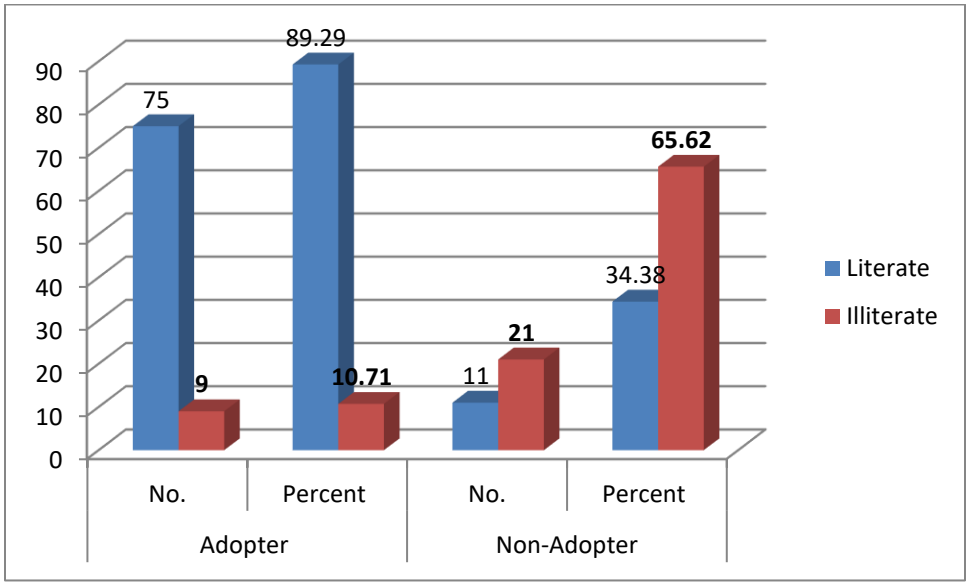
From this finding one can realize that literate women households are found to be more Mirt stove adopters as compared to the illiterate women. This may be because literate women are more likely to be aware of the social and economic use of Mirt cook stove as compared to educated household. This finding is similar to the previous empirical works of (Puzzolo et al, 2013; Damte & Koch, 2011; Inayat, 2011; Tsangaris, 2010 and Tigabu ,2014) that found the higher education level of woman (wife) in a household has a positive effect on the likelihood of the household to adopt improved cook stove technologies

Table 10 Improved Cooks Stove adoption and educational level

| Categories | Improved Cook Stove adoption | | | | | | Chi2 – test P-value |
|---|---|---|---|---|---|---|---|
| | Adopter | | Non-Adopter | | Total NHHs | Percent | |
| | NHHs | Percent | NHHs | Percent | | | 0.000*** |
| Literate | 75 | 89.29 | 11 | 34.38 | 86 | 74.14 | |
| Illiterate | 9 | 10.71 | 21 | 65.62 | 30 | 25.86 | |
| Total | 84 | 100 | 32 | 100 | 116 | 100 | |

Source: Own survey data (2020) Note: *** indicates 10% level of significance.

Figure 4: Improved Cook Stove adoption and educational level




4.1.2.6. Improved cook stove adoption and separated kitchen

Table 11 Shows, out of surveyed 116 household respondents, 82 (69.83 %) have separate kitchen house in which 76 of them are Improved Cooks Stove adopters and 4 of them are non-adopters. On the other side, 35 (30.17 %) have not separate kitchen in which 8 of them are found to be Improved Cooks Stove adopters and 28 of them are non-adopters. These imply that households that have separate kitchen house are found that Improved Cooks Stove adopters as compared to persons that have not separate kitchen. This may be because of its fixed nature and larger in size which requires larger space. This result is consistent with the previous works of (Puzzolo et al, 2013; Axen, 2012 and Tigabu 2014) that found households that have separate kitchen house are more likely to adopt improved cook stove technologies as compared to households that have not separate kitchen.

Table 11 Improved Cook Stove adoption and Separate Kitchen

| Categories | Improved Cooks Stove adoption | | | | | | Chi2 – test P-value |
|---|---|---|---|---|---|---|---|
| | Adopter | | Non-Adopter | | Total No. | | |
| | No. | Percent | No. | Percent | | | |
| Yes | 76 | 90.5 | 4 | 12.5 | 82 | 69.83 | 0.008* |
| No | 8 | 9.5. | 28 | 87.5 | 36 | 30.17 | |
| Total | 84 | 100 | 32 | 100 | 116 | 100 | |

Source: Own survey data (2020). Note: * **indicates 10% level of significance.

The above table11 shows that the proportion of Improved Cook Stove adopters (90.5 %) who have separate kitchen largely exceeds the proportion of Mirt stove non-adopters (12.5%) who have separate kitchen. On the other hand, the proportion of Improved Cook Stove adopters (9.5 %) who have not separate kitchen largely less than the proportion of Improved Cooks Stove non-adopters (87.5 %) who have not separate kitchen. Moreover, the chi-square statistic revealed that there is significant relationship between separate kitchen and the probability of Mirt stove adoption decision at ($p<0.1$) significant level at P- value 0.008 .The main reason absorbed from the respondents household during data collection are Improved Cook Stove can need large space and have fixed in nature for the need of separate kitchen to adopt.

Figure 5 Amba14 Mirt stove at separated kitchen

4.1.2.7. Improved cook stove adoption and price

Table 12 shows the minimum and maximum prices are 200 and 320, respectively. And also the mean and standard deviation is 260 and 103.893, respectively. In addition, t-value of 16.346 indicates that the price of Improved Cook Stove is found to be significant for the adoption decision at ($p < 0.1$) level of significant at P-value 0.007.

Table 12 Improved Cook Stove adaption and price

| Variable | Minimum | Maximum | mean | St.dev. | t-value | p-value |
|---|---|---|---|---|---|---|
| Price of Mirt stove | 200 | 320 | 260 | 103.893 | 16.346 | 0.007*** |

Source: Own survey data (2020) Note: *** is represents 10% level of significance

From table the 12 above one can understand that the cheaper the price of Mirt stove, the more likely households to adopt Mirt stove and vice versa. In addition, t-value of 16.346 indicates that the price of Mirt stove is found to be significant for the adoption decision at ($p<0.01$) level of significance. This finding is similar with the empirical work of Axen (2012) and Tigabu (2014)

that found positive perception about the improved cook stoves' price is one important factor that affects the adoption decision

4.1.2.8. Improved cook stove adoption and source of fuel wood

As it is presented in Table 13, below from the total of surveyed 116 respondents, 114(98.3 %) get fuel-wood free charge in which 82 of them are found to be Mirt stove adopters and 32 of them are found to be non-adopters. On the other hand, 2 (28.1 %) get fuel-wood with charge in which only 2 are found to be Mirt stove adopters. And also, the proportion of those who get their fuel-wood with free charge Mirt stove adopters (71.9 %) largely exceeds the proportion of those who get their fuel-wood with charge Mirt stove non-adopters (0.7 %). On the other side, the proportion of those who get fuel-wood free charge Mirt stove non-adopters (100%) largely exceeds the proportion of those who get fuel-wood with charge Mirt stove adopters (28.1 %)..

The chi-square statistic showed that one to be insignificant with p-value of 0.369. This p-value implies that source of wood and Mirt stove adoption decision are found to be not related because ($p>0.1$). This implies that the more a household's source of fuel-wood is free charge, the more likely to be found Mirt stove adopter and vice versa. The more likely reason is that for households that get wood from free charge can be fuel-wood saving or efficient use of wood may not be their concern or more forest degradation is take place in real case. This finding is similar to the works of (Puzzolo et al, 2013; Axen, 2012; Damte & Koch, 2011; Inayat, 2011 and Tigabu , 2014; ) that found those who get their fuel-wood with charge are found to be more improved cook stoves adopters as compared to those who get fuel-wood free of charge

Table 13. Improved Cook Stove adoption and Source of fuel wood

| Source of fuel wood | Adopter | | Non-Adopter | | Total | | P-value |
|---|---|---|---|---|---|---|---|
| | N | Percent | N | Percent | N | Percent | |
| Free charge | 82 | 71.9 | 32 | 100 | 114 | 98.3 | 0.369 |
| With charge | 2 | 28.1 | 0 | 0 | 2 | 0.7 | |
| Total | 84 | 100 | 32 | 100 | 116 | 100 | |

Source: Own survey data (2020)

4.1.3. The main barriers of improved cook stove adoption

As it is observed from Table 14 below, majority of the respondents, 50(43.1 %) replied that higher price is the most likely barriers of Mirt stove adoption. For 36 (31 %) respondents is shortage supply were found the second barriers of Mirt stove adoption in the study area and lack of awareness is the third likely barriers 30(25.9%) .

To generalize, lack of awareness (about its health, economic and environmental benefits), higher price and shortage of supply were found to be the three most likely barriers of Mirt stove adoption in the study area

In the woreda water and energy annual report of 2019, it can be recognized that the main barriers for adoption of improved cook stove adoption are shortage of Mirt stove availability or supply was attributed to shortage of inputs of production such as sand and cement. Unwillingness of individuals who are trained to produce Mirt stove timely as per the agreement was also reported as one barrier of mass production.

The finding of the study is in agreement with the works of Puzzolo et al (2013) and Tigabu (2014) that found the high cost of the stove was the main reason for not adopting the improved cook stoves. This study's result is again similar to the study of Inyat (2011) that found lack of

awareness about the relative benefits of improved cook stove technologies important barrier of adoption.

Table 14. Barriers of Improved Cook Stove adoption

| Barriers of Improved Cook Stove adoption | N | Percent |
|---|---|---|
| Lack of awareness on benefits or use | 30 | 25.9 |
| High cost of ICS | 50 | 43.1 |
| Shortage of ICS Supply | 36 | 31 |

Source: Field survey (2020)

4.2. Descriptive statistics on determinants of household solar energy adoption

The factors which influences adopt decision to a Solar PV technology are included in the empirical model alongside their theoretically anticipated effects of the explanatory variables that were also considered in the econometric model for investigating the decision for household solar energy adoption. Such as Saving, Gender, Age, Educational level, martial status, Family size and price solar PV factors were controlled to analyze their effect on the adoption of solar energy technology.

Table 15. Definition of explanatory variables explain household adoption of solar PV energy

| Variables | Descriptions of variables | Expected sign |
|---|---|---|
| Saving | Household has saved money (1=yes, 0 otherwise) | + |
| Gender | Gender of the head (1=Male, 0=Female) | + |
| Age | Age of the household head (in Year) | +/- |
| Marital status | Marital status HH (1= married. 0=separated ) | +/- |

| | | |
|---|---|---|
| Educational level | Household respondent(1= literate, 0=Illiterate) | + |
| Family size | Number of family member (number) | +/- |
| price | price of solar PV( 1=Cheap , 0=Expensive ) | - |

Source: own computation (2020)

4.2.1. Descriptive statistics of variables and test of mean differences for adopters and non-adopters of solar energy

As shows a summary of descriptive statistics, and the table compares households who adopted solar energy technology (i.e., adopters) and households who do not (i.e., non-adopters) . The results show a statistically significant variation of a number of variables for the two groups. The results indicate that around 39% of the households' adopted and 61% of household's non-adopter of solar energy technology.

With regard to household demographics, economics and household characteristics as shows bellows

1. Solar PV adoption and Gender: - About 43(38%) of households who adopted solar energy technologies were male headed, which is relatively low compared to non-adopter households 70(62%) because non-adopter male household head more than adopter male household head. So that its P-value was 0.046 which shows that gender in household was insignificant level relation with solar PV adoption because PV value is greater than 0.01 level of significant. The finding corresponds with the previous study that found male household head to be more willing to pay for or support renewable energy technologies Rahut et al. (2017), but it contrasts with the finding of Patrick (2009)

Table 16 Descriptive statistics on Solar PV adoption decision and Gender

| Solar PV decision | Gender of household head | | | percent | P.value |
|---|---|---|---|---|---|
| | Male | female | Total | | |
| Adopter | 43 | 2 | 45 | 37.2 | 0.046 |
| Non adopter | 70 | 1 | 71 | 62.8 | |
| Total | 113 | 3 | 116 | 100 | |

Source: field survey (2020)

**2.** Solar PV adoption and Family size: - Adopter households having about 5 inhabitants on average family number compared to 8 inhabitants for non-adopters. This show that it is insignificant level at P value 0.035 which less than 0.01.From this the researcher conclude that, as household is small in size the well being of using is less need to bought. Similar study with work of De Groote et al., (2016).

Table 17 Descriptive statistics on Solar PV adoption decision and family size

| Variable | Decision on solar Pv adoption | N | percent | mean | Sta.dev. | P.value |
|---|---|---|---|---|---|---|
| Family size | Adopter | 45 | 37.2 | 5 | 1.561 | 0.035 |
| | Non adopter | 71 | 62.8 | 8 | 13.690 | |
| | | 116 | 100 | 6.5 | | |

Source: field survey (2020)

**3.** Solar PV adoption and Educational level:-.71.1 % of household heads was literate as compared to illiterate one (28.9%) from this 46 household respondents' were adopter and 40 non adopter of the solar energy technology. The PV value is 0.004 which less than 0.01 level

of significant that means that Households who adopted solar energy technology had more educated household heads than non-Adopter one( which means more awareness to accept new technology to use).

The finding is consistent with finding of previous studies .for instance, study found that with educated house hold are more willing to pay more to adopt solar energy technology (Rahut et al., 2017; Kwan,2012; Guta DD, 2018)

Table 18 Descriptive statistics on Solar PV adoption decision and Educational level

| Solar PV decision | Educational level | | | percent | Mean | P.value |
|---|---|---|---|---|---|---|
| | Illiterate | Literate | Total | | | |
| Adopter | 5 | 46 | 51 | 43.8 | 0.65 | 0.004*** |
| Non adopter | 25 | 40 | 65 | 56.2 | 0.86 | |
| Total | 30 | 86 | 116 | 100 | 0.755 | |
| Percent | 28.9 | 71.1 | 100 | | | |

Source: field survey (2020), ** * Significant level at 10%

**4.** Solar PV adoption and Age

The household head of adopters of solar energy technology were relatively older (on average 49.98 years) compared to non-adopters (about 42.42 years). So that it's P-value was 0.247 which shows that household age was insignificant level on solar PV adoption because PV value is greater than 0.01 level of significant because older people are conservative to adopt solar energy.

Similar study was took place by Guta DD, 2018: household who older in the age adopted solar energy technology less than non-adopter household

**5.** Solar PV adoption and price: - Averagely 0.81(81%) household adopter said, the price of solar PV were more cheap to bought than non- adopter of averagely 0.33(33%). It means that the P- value is 0.000 which less than 0.01 level of significant. From this we assumed that price of solar PV is cheaper to buy by household and makes easy to adopt by household.

The finding is consistent with finding of previous studies .for instance, study found that price of solar which was cheap could be increased household are more willing to pay more to adopt solar energy technology (Guta DD, 2018)

Table 19 Descriptive statistics on Solar PV adoption decision and Price

| Solar PV decision | Price of solar Pv | | | | Mean | St. dev. | P.value |
|---|---|---|---|---|---|---|---|
| | Cheap | Expensive | Total | percent | | | |
| Adopter | 71 | 1 | 72 | 61.2 | 0.81 | 0.149 | 0.000*** |
| Non adopter | 1 | 43 | 44 | 38.8 | 0.33 | 0.001 | |
| Total | 45 | 72 | 116 | 100 | | | |

Source: field survey (2020), ***indicate that 10% Significant level

**6.** Solar PV adoption and saving money: Averagely 0.56(56%) of household head respondents' adopter can be saved their money which more than Non-adopter household head respondents 0.22(22%). So P-value is 0.003 which less than 0.01 significant levels and shows that significant relationship between them. It means that many adopter household were more participate in saving their money which makes them more welling to use (adopt) solar PV than non- adopter.

Similar study with work of Guta DD,2018; households who save cash money are considered rich or affluent, and they are likely to have a high financial ability to invest in solar energy technology adoption.

Table 20 Descriptive statistics on Solar PV adoption decision and saving money

| Solar PV decision | Saving money | | | | Mean | P.value |
|---|---|---|---|---|---|---|
| | yes | No | Total | percent | | |
| Adopter | 50 | 21 | 71 | 61.2 | 0.560 | 0.003*** |
| Non adopter | 35 | 10 | 45 | 38.8 | 0.220 | |
| Total | 85 | 31 | 116 | 100 | | |

Source: field survey (2020) ***indicate that 10% Significant level

**7.** Solar PV adoption and Awareness' and perception of respondents: - The table shows that average respondents' which have taken awareness' and perception on solar PV technology adopter 0.78(78%) more compared to the non- adopters, while that of the non-adopter head was 0.58(58%). The PV value is 0.003 which less than 0.01 level of significant .It means that there is significant relation b/n solar PV technology adoption and awareness and perception of household to adopt it. This shows for household respondents' awareness and perception on solar PV technology adoption decision very important.

Table 21 Descriptive statistics on Solar PV adoption decision and awareness and perception

| Solar PV decision | Awareness and perception on solar Pv | | | | Mean | P.value |
|---|---|---|---|---|---|---|
| | yes | No | Total | Percent | | |
| Adopter | 51 | 10 | 61 | 52.6 | 0.78 | 0.007*** |
| Non adopter | 25 | 30 | 55 | 47.4 | 0.58 | |
| Total | 76 | 40 | 116 | 100 | | |

Source: field survey (2020) ***indicate that 10% Significant level

Generally, descriptive stastics confirm that there is a significant difference between solar energy technology adopter households and non-adopters in terms of their education level, age, price, gender, saving money, awareness and perception and Family size factors. Hence, the econometric analysis based on the logistic regression model is used to determine factors affecting the decision for household solar energy technology adoption while controlling for unobserved variables.

4.3. Econometric Analysis and Discussion

In this study logistic binary regression model to estimate the potential effect of each explanatory variable on the dependent variable of improved cook stove and solar energy adoption. The results of these tests shows that no problems of sever multi-collinearity model specification bias and normality as well as the model well fitted the data. In addition to these tests, robust was run to get better estimations.

4.3.1 Binary Logit Model on determinants of improved cook stove Adoption and solar energy technology

In the previous section, determinant factors affecting rural households' decision on improved cook stove and solar energy adoption decision were analyzed using descriptive statistics.

To understand the extent to which these determinants factors affect improved cook stove and solar energy adoption decision analyzed by binary logistic model was employed. The explanatory variables included and analyzed in the model are summarized in Table 23

As Table 23 shows that explanatory variables to determine rural households improved cook stove adoption decision:-

- ⇨ The analysis shows that important factors that estimate explanatory variables to determine rural households improved cook stove adoption decision in the study area at 10 percent and 1% level of significant. This regression result shows that Mirt stove adoption decision is positively related with Gender, family size, age, price, educational level, marital status and separated kitchen house. However, the result reveals that Mirt stove adoption is negatively correlated with marital status and source of fuel wood. These correlations are determining improved cook stove adoption decision.

Table 22: Summery of Explanatory and Responsive Variables Included in Binary Logit Model

| Variables | Type | code | Descriptions |
|---|---|---|---|
| Mirt stove Adoption | Dummy | MSA | 1 if the HH respondents adopt ,other wise 0 |
| Marital status | Categorical | MRTSA | 1 if married ,0 if divorced or separated |
| Gender | Dummy | GNDR | 1 if male and o if female |
| Age of respondents | Continues | AGR | Number of year |

| | | | |
|---|---|---|---|
| Educational level | Dummy | EDLEVEL | 1 if literate and 0 if illiterate |
| Family size | Continues | FMSIZE | Total number of persons in the HH |
| Price of Mirt stove | Continues | PRCMT | The price of Mirt stove |
| Separated kitchen | Dummy | SPRKCH | Used separated kitchen or not |
| Source of fuel wood | Dummy | SOFW | 1 if respondents for free charge and 0 if with charge |

Source: Own Survey (2020)

4.3.2. Logistic Regression Estimation Result for improved cook stove adoption decision

Table 23: Logistic Regression Estimation Result

| Variable | Coding | Odds Ratio(Exp(B)) | P-value |
|---|---|---|---|
| Educational level | EDLEVEL | 11.07040 | 0.000*** |
| Gender of respondents | GNDR | 6.4440 | 0.000*** |
| Age of the respondents | AGR | 1.1130 | 0.007*** |
| Family size | FMSIZE | 8.0000 | 0.001*** |
| Separated kitchen | SPRKICH | 68.3380 | 0.008*** |
| Price of Mirt stove | PRCMT | 1.0440 | 0.000*** |
| Marital status | MRTSA | 1.0915 | 0.079* |
| Source of fire wood | SOFW | 0.5499 | 0.369 |

Source: Own survey data (2020) Note: *** and * indicate the level of significance at 10 % and 1% respectively

Table 24. Over all Statistics of improved cook stove adoption:

| Variables in the Equation | | | | | | |
|---|---|---|---|---|---|---|
| Constant | B | S.E. | Wald | df | Sig. | Exp(B) |
| | .965 | .208 | 21.582 | 1 | .000 | 2.625 |

Number of obs. = 116 Prob > chi2 = 0.000

Wald chi2 (8) = 21.582 Odd ratio=2.625

According to this Logistic Regression Estimation, in the study area, family size, educational level, Gender, age, separate kitchen, marital status and price significantly influence households' Mirt stove adoption decision. The other variables of source of fuel-wood are insignificant in determining the likelihood of Mirt stove adoption decision.

4.3.3. Regression Result Interpretation on determinant decision on improved cook stove adoption Variables that have significant explanatory power in determining the Mirt stove adoption decision are interpreted in this section.

The odd ratios (OR) of these powerful explanatory variables are interpreted:-

1. Age: As Table 23, shows age of the respondent significantly affects on the probability of Improved Cooks Stove adoption with p-value and odd ratio of 0.007 and 1.1130 respectively. This odd ratio indicates that the probability of Improved Cooks Stove adoption is 1.1130 times higher for young age household respondent than old aged. As it was expected, this finding reveals that Younger women were found more likely to adopt Improved Cooks Stove than old Women's of their counterparts. This might be because of young aged women's household may have more in adopt in improved cook stove adoption due to mature in thinking and can easily

understand bad and good effect to adopt Mirt stove and also mature in economic decision . The result of this study was similar to concepts with empirical studies of Adrianzen (2009) and Damte and Koch (2011) and Tigabu (2014) that found than less age Women's (young) are more likely to adopt fuel efficient new technologies as compared to old one because old person is conservative in accepting new technology.

2. Educational level: As it was expected in table 23, educational level was found significant factor in that affect positively rural household's Improved Cooks Stove adoption decision with p-value of 0.000 and odd ratio of 11.0704. The odd ratio result indicates that the likelihood of adopting Improved Cooks Stove for literate woman is 11.0704 times higher than illiterate woman. The findings of educational level affect a household's fuel and/or technology switching and/or adoption decision. This study is similar to previous works (Puzzolo et al, 2013; Damte & Koch, 2011; Inayat, 2011; Tsangaris, 2010 and Tigabu 2014) that found the higher education level of woman to be significant positive factor in determining a household's improved cook stoves adoption decision.

3. Separate kitchen: As Table 23 shows, as it was expected separate kitchen house was found positive significant factor that affects Mirt stove adoption decision with p-value of 0.008 and odd ratio of 68.3380, respectively. This odd ratio indicates that Mirt stove adoption probability for a household (woman) that has separate kitchen house is 68.34 times higher than a household (woman) that does not have separate kitchen house. As it was discussed in descriptive analysis part, the fixed nature of Mirt stove is one reason for the need of separate kitchen to adopt it. The other explanation may be because of its larger in size and Mirt stove requires larger space.

The finding of this study is in line with previous studies (Puzzolo, 2013; Axen, 2012; Damte & Koch, 2011; Adrianzen, 2009 and Tigabu, 2014) that found that separate kitchen house has significant positive effect on a household's improved cook stoves adoption decision. But, this study's finding is inconsistent with the work of Dawit (2008) that found the effect of separate kitchen house insignificant in determining the improved cook stoves adoption decision in rural areas.

4. Price of Mirt stove: As it was expected the price of Mirt stove was found to be positive significant factor that determines a households' Mirt stove adoption decision. This variable has p-value and odd ratio of 0.007 and 1.0440 respectively. The odd ratio 1.0440 for price of Mirt shows that the probability of Mirt stove adoption increases by 1.0441 times increment in birr of the price of Mirt stove. This finding confirms household energy ladder theory which asserts that a household's socio economic status (in here the ability to pay the price of Mirt stove) determines the adoption decision. This study came up with different findings of Puzzolo et al (2013), Gebreegziabher et al (2010) and Makame (2007) and Tigabu (2014) that found price as one determinant factor that affects improved cook stoves adoption decision. The result of the study also similar to the work of Slaski and Thurber (2009) that found high affordability of the price improved cook stoves as one factor that positively determines the adoption decision and the opposite also true.

5. Family size : As it was expected in table 23, family size was found significant factor in that affect positively rural household's Mirt stove adoption decision with p-value of 0.001 and odd ratio of 8.0000. The odd ratio result indicates that the likelihood of adopting Mirt stove for more family size is 8.0000 times higher than less family size. The findings of family size affect a household's fuel and/or technology switching and/or adoption decision positively.

6. Gender : As it was expected in table 23, gender was found significant factor in that affect positively rural household's Mirt stove adoption decision with p-value of 0.000 and odd ratio of 6.0000. The odd ratio result indicates that the likelihood of adopting Mirt stove which is male head household 6.0000 times higher than less female headed household. The findings of gender affect a household's use and/or technology switching and/or adoption decision positively.

4.3.4. Logistic regression for determinants of solar PV adoption decision

Table 25.presents the results of was analysis by logistic regression model on the determinants of solar PV technology adoption. The Wald test shows the overall model fit or the joint significance of explanatory variables in the model. The results show that the model is fit and highly significant at the 0.01 level of the statistical significance. From among the 7 variables included in the model, a total of 3 variables were significantly affecting the adoption of solar energy technology of rural households. A number of variables for households in which were found to be positively and significantly affecting the adoption decision:- price , Educational level, Awareness and perception and cash money saving of the respondents but the other factors such as family size, age and gender were found to have insignificant (a negative) effect on the adoption decision on solar PV technology.

Table 25-logistic regression on determinant that adoption solar energy technology

| Variables in the Equation at 90%C.I | | | | | |
|---|---|---|---|---|---|
| Variables | Odd ratio(exp(B)) | S.E. | Wald | Df | Sig |
| Gender | -66.104 | 44855.391 | .000 | 1 | 0.046 |
| Age | -4.724 | 407.766 | .000 | 1 | 0.247 |

| | | | | | |
|---|---|---|---|---|---|
| Educational level | 8.405 | 5974.568 | .000 | 1 | 0.004 |
| Family size | 14.876 | 1200.264 | .000 | 1 | 0.035 |
| Price of solar PV | 177.592 | 11972.344 | .000 | 1 | 0.000 |
| Saving money | 36.775 | 6503.477 | .000 | 1 | 0.003 |
| Awareness and perception | 23.777 | 6826.818 | .000 | 1 | 0.007 |
| Constant | 259.836 | 20018.475 | .000 | 1 | . |

Source: Field survey (2020)

4.3.5. Regression Result Interpretation on determinants adoption decision of solar energy

Depending on table 25 above, educational level, price, saving money and awareness creation and perception are significantly or positively affect the adoption of solar energy adoption. So that they are interpretation as follows:

1. Educational level

Solar PV adoption by household whose attended education is significantly effect by ($P<0.01$) which was P-value 0.004 higher compared to household with uneducated .From this education improved household awareness and expands the opportunity for attainment by the household head is expected to increase the livelihood of solar energy technology. This finding is consistent with the relevant theory because more educated head household may have a better knowledge of solar energy technology because better educated more agreement on regarding adoption of solar PV. In general, the plausible explanation for the positive effect of increasing awareness of the household regarding health, environmental, education and societal welfare benefits of solar energy technology adoption.

The finding is consistent with finding of previous studies .for instance, study found that with educated house hold are more willing to pay more to adopt solar energy technology (Guta DD, 2018: Wiser, 2007 and Aini and Ling, 2013 )

2. Price

Price of solar energy technology was positively affects the adoption of solar energy technology adoption at p- value 0.000 which is less than 0.01 confidence levels. This implies that solar energy adopter household respondents which willing to buys can be provided with effective and affordable price. So that it shows positive relation between solar energy technology adoption and price well being to buy (Guta DD, 2018).

3. Money saving

Household cash money saving capacity was found to have significant influence P-value 0.01 on solar energy technology adoption of household .Households who have cash saving adopter household higher by P-value 0.003 compared to those who no cash money saving as shows in table 25 above . Household who save cash money are considered rich, and they are likely to have a high financial ability to invest in solar energy technology adoption.

The finding is consistent with finding of previous studies. For instance, study found that with cash money saving house hold were more willing to adopt solar energy technology (Guta DD, 2018)

4. Awareness creation and perception of respondents

Awareness creation and perception is an important activity for developing renewable energy technology. From the data survey, household solar energy technology adoption was positive or significant relation with awareness creation and perception respondents' .which it implies that those households who have awareness on the solar energy can be easily adopt solar energy

technology because p-value 0.007 for awareness creation and receptions of solar energy technology is significantly affect household adoption

4.4. Main challenges of facing the adoption solar energy

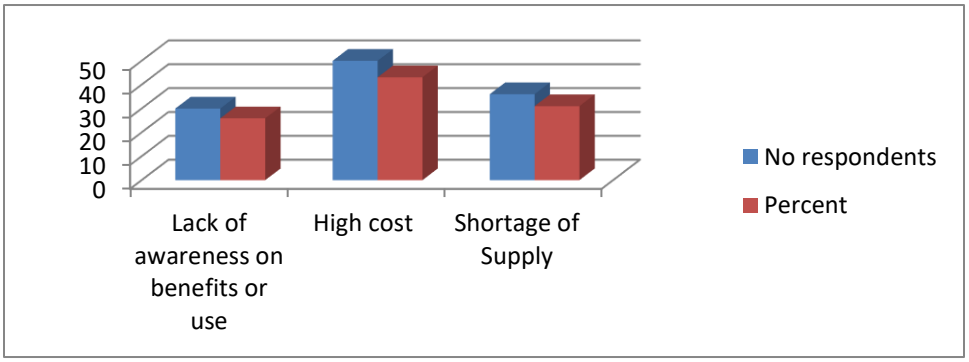
As shown in the determinants adoptions of improved cook stove adoption the main challenges to use solar energy technology was, lack of awareness (about its health, economic, technical and environmental benefits), higher cost and shortage of supply were found to be the three most likely barriers of Mirt stove adoption in the study area

In the woreda water and energy annual report of 2019, it can be recognized that the main barriers for adoption of solar energy technology adoption are shortage of solar PV availability or supply was attributed to shortage of inputs of production. Unwillingness of individuals who are trained to produce solar energy technology timely as per the agreement was also reported as one barrier of mass production

The other three major challenges: low quality of products (and services), lack of consumer awareness about additional benefits of quality products as well as lacking access to finance for end users (National Electrification Program (NEP). 2017).

In general, to adopt the solar energy in addition to the above challenges policy instrument or decision was the main important to adopt solar energy technology.

Figure 6.Barriers of solar energy adoption




Source: Field survey (2020)

Chapter Five

# 5. Conclusion and Recommendation

## 5.1. Conclusion

This study examined the adoption determinants of improved cook stove (Mirt stove) and solar energy among rural household of Assosa woreda by taking 116 household respondents randomly selected from the households frame.

### 5.1.1. Adoption determinants of improved cook stove (Mirt stove)

The study first assessed the gender-based responsibility mostly based on assess the status of improved cook stove(Mirt stove) adoption and Investigate the determinant factors of improved cook stove (Mirt stove) adoption in the study area. For the purpose of assessing the determinate factors of Mirt stove adoption decision of household respondents such as age, gender, family size, marital status, educational level, separated kitchen, source of fuel wood and price of Mirt stove were analyzed. In the study area, females are the ones responsible for adopt/use/ and supply of fuel wood for their own consumption purpose. This implies that females are the fatalities of the adverse effects during preparing food and collecting fuel wood as compared to male's counterparts. On other hand; females are the first users of improved cook stove as compared to male household members.

In assessing the status of improved cook stove (Mirt stove) adoption in the study area, the totals of 116, 84 respondents (72.4%) were found adopters of Improved cook stove (Mirt stove) while 32 respondents (27.6%) are non-adopters. The most likely barriers of Mirt stove adoption were High cost of ICS, Lack of awareness creation, Shortage of ICS Supply and technical person for maintenance,

The sources of fuel wood were not found to be statistically significant to determine households' Mirt stove adoption decision. On other hand, married women were found to be more Mirt stove adopter than the separated or divorce women counterparts. This implies that the probability of Mirt stove adoption for married woman increased as compared to divorced or separated woman. One plausible explanation for this may be because of married women has the full power to make decision due to high in economic or in income due to working together and more share of ideal with her husband as compared divorced or separated ones. This means that married women have the power to make economic decisions in the household, since the husband is more powerful. In addition, educated women (literate women) were found to be more Mirt stove adopter than the illiterates. This investigation indicates that the probability of Mirt stove adoption for educated household increased than as compared to uneducated (illiterate) house hold respondent's woman. This may be resulted from that literate women are more likely to aware about the benefits of Mirt stove as compared to uneducated.

5.1.2. Adoption determinants of solar (PV) energy technology

Solid bioenergy is the main cause of indoor air pollution, which poses a significant health risk. Hence, a transition from traditional (pollutant) energy resource towards modern alternative energy is paramount to ensure household energy security and address health and environmental concerns. In light of these concerns, this study analyzed determinants of household solar PV technology adoption in five rural kebeles in Assosa woreda of Beneshangul Gumuz region. In this area, households have no access to grid electricity. In recent years with high cost and lack of awareness on solar energy and its low availability, many households have not adopt it, and many have switched towards to kerosene and fuel wood for lighting. Of 116

sampled households, around 45(38.8%) of them has solar PV Adopter and 75 (61.2%) have non Adopter of it.

This paper used an econometrics binary regression model to examine the adoption of solar energy technology systems and identifies challenges facing the use of solar PV systems in the study area through evaluating the effect of household demographic, economic and environmental factors on their adoption decision on solar PV adoption for residential purposes. The econometric result shows that educational level, price, household awareness and perception and saving money are all positive and significant on determinants of solar PV adoption decision. Likewise gender, family size, age and marital status were found to be insignificantly affects the adoptions of solar PV decision. The result is consistent with the relevant capacity development theory, which states that the increase in educational status and awareness and perception on solar energy technology promotes household solar energy technology adoption (Rahut et al., 2017; Smith and Urpelainen (2014)).

Furthermore, the findings of this study elucidates that with an increase in the education level of the household head is likely to lead households to adopt solar energy technology in rural area of study. Education plays a key part in socio-cultural changes, namely changes that favor the choice of clean energy, create awareness on the negative consequences of fuel wood use, and generate diverse income earning opportunities. Thus, such an education would contribute to an increase in household adoption solar energy technology.

## 5.2. Recommendation

### 5.2.1. Adoption decision on determinants of improved cook stove (Mirt stove)

Based on the conclusion of the study, public awareness creation effort should be strengthened and targeted on religious places, natural resource works, meeting places and market places through, for instance rural energy experts, natural resource management experts and others. This study reveals that literate women are more likely to adopt Mirt stove than the illiterate women. This suggests that adult education in rural areas should be strengthened and continued. Again, improved cook stoves disseminating initiatives, programs and/or projects should target on localities that depends fuel-wood for the households' consumption. Likewise, in localities where fuel-wood is collected from local forests for free the government should strengthen the work of local forest.

### 5.2.2. Adoption decision on determinants of solar energy

From the study area, examine that households are depends on traditional fuel for lighting and cooking due to lack of awareness ,supply and cost of solar PV and also no more economically enhanced local distributor of solar energy technology. So that solves such limitation more done on capacity developments for house hold.

Therefore, future studies should take into account these aspects in order to achieve a better understanding of the dynamics and spatial heterogeneities of rural renewable energy demand. This will help in the design of better strategies and policy instruments to address widespread rural energy sector problem

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7. Appendixes

6.1 Questionnaires

QUESIONAIR FOR DETERMINANETS OF IMPROVE COOK STOVE ADOPTION

Questionnaire for key informant person

Name of Organization ……..……

When did the organization start disseminating improved cook stove technology … (Year?)

Is there any other organization in this Region dealing with technology?

Yes/ No ----If yes, mention them; ----------

How many villages in this region have you reached for improved cook stove technology? ----

Do you think many people are aware of improved cook stove technologies in this area?

What percentage of population? ……..…….

How many cook stoves have been installed in this Region? .....

How much does the cook stove (family size) cost in birr…….

If the adopters' percentage is small compared to the expected, what do you think are the factors for people not adopting improved cook stove technology?----------

Are people willing to switch to other improved cook stove fuels? ----------

What are the major complains received from cook stove technology users on the technologies? ----------

Did your organization give any support/ contribution to people who adopted or who intend to adopt improved cook stove technologies? ----------

What are the strategies your organization use to disseminate improved cook stove technologies? ----------

What are the problems facing your organization in disseminating the technologies? ----------

**Questionnaire for Household survey**

Put (x) marks in space provided for closed-ended questions and write your response on space provided for open ended questions.

Social status of the household

Household head, male () or female ()

What is your age in years? ---------- Marital status---------

What is your highest level of education? ----------

What is your main occupation? ----------

Is there early adopter neighbors on social activity on cook stove technology adoption decision in your area? a. Yes----------b. No----------

How many km far from the center of source ----------

Household characteristics and Demographics

What is the type of this household headship?

(1) Male headed ( ) (2) Female headed ( ) (3) Child headed ( )

How many members are there in this household? Males…..…Females……..Total……...

Economic status of household

What is the source of the household income?

*Income source*

(1) Farming-crops (2) Livestock keeping (6) Casual work (7) Remittances
(3) Business (4) Salaried employment (8) Social networks
(5) Pension

**Income range (monthly)

| No. | Income source | Monthly Income range | Rank | Remark |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

Is there access to credit institution in your area? Yes or No ----------

Have own an improved cook stove? (Yes or No )----------

If your answer **no** what is the your reason ----------

What determinants factors for your Adoption? ----------

Cost of improved cook stove

Nutrition and health

What are the common foods cooked it in the household and what are their sources

Do you ever face fuel shortages? (Yes No)-----If yes, for which fuel types? ----------
What do you do in times of this shortage----------?

Are you using separated kitchen for cooking food? Yes/No ---------If no resean out -----

What kinds of extension approach b/n you and your extension worker

Part time with you or Fuel time work with you? ----------
What type of fuel do you use and what are the sources
*Sources

(1) Forest (2) Vendors (3) Farm (4) Others Specify

| No. | Type of fuel | Source | Cost (in Birr) |
|---|---|---|---|
| 1 | Firewood | | |
| 2 | Charcoal | | |
| 3 | Biogas | | |
| 4 | LPG gas | | |
| 5 | Kerosene | | |
| 6 | Farm residue | | |

Why do you like using the cook stove? ----------

Do you know of other biomass fuels? (Yes or No

If yes, which ones? ----------

Why don't you currently use them? ----------

What are the main uses of your land?

| No. | Use | Estimated size of land (acres) |
|---|---|---|
| 1 | Housing structures | |
| 2 | Crop farming | |
| 3 | Livestock keeping | |
| 4 | Forest/woodlot | |
| 5 | Other (specify) | |

PROMOTION AND LEVEL OF SUPPORT

Have you ever heard of the improved energy technologies in your area? What are they? -----

. If there, from whom did you get the information from? ----------

Why do you like using the cook stove? ----------

Is this the only stove available for firewood? (1) Yes (2) No

If No, which one (s) are available? ----------

Why don't you use them? ----------

What are the current limitations associated with firewood? ----------

What are the current limitations associated with charcoal? ----------

Focused Group Questions

What do you think about cooking with charcoal, firewood, farm residue? Advantages & disadvantage.

Are you looking for an alternative for the current fuel you are using?

What is the biggest barrier for buying an improved cook stove?

(1) High investment cost of stove (2) Lump-sum payment of technology.

Why do you think people would use improved cook stoves if money weren't an issue?

Why are you using more than one fuel at the same time? Why don't you fully switch?

Are there any cultural reasons behind that? What foods do you always cook using charcoal, firewood, biogas, Liquid biofuel, farm residue? Why?

Are there any foods that cannot be cooked using charcoal/firewood/farm residue?

QUESIONAIR FOR DETREMINANT FACTORS THAT AFFECT SOLAR ENERGY TECHNOLGY ADOPTION AMONG RURAL HOUSEHOLD

Questionnaire for household survey

Do you know about solar energy system?(yes/no)

If yes, do you have any in your house?

Do know any other person that are using solar energy system?(yes/no)

Why you are not using solar PV system for you home?

| No | Causes | Tick it | Ranking | remarking |
|---|---|---|---|---|
| 1 | cost | | | |
| 2 | Technical issues for maintains | | | |
| 3 | Market problem | | | |
| 4 | Distance from source | | | |

Are you interested to use solar energy system? (Yes/No)

If your answer yes, for what purpose?

| No | Purpose | Tick it | Ranking | Remarking |
|---|---|---|---|---|
| 1 | For lighting | | | |
| 2 | For cooking | | | |
| 3 | For water pumping | | | |
| 4 | For charging mobile | | | |
| 5 | For TV and radio | | | |

What are main constraints/challenges that can prevent solar energy use?

| No | constraints/challenges | Tick it | Ranking | Remarking |
|---|---|---|---|---|
| 1 | Durability of materials | | | |
| 2 | Cost to buy | | | |
| 3 | Lack of spare part | | | |
| 4 | Maintains cost | | | |
| 5 | Cos and benefits are not balanced | | | |
| | | | | |

Social factors

Have you awareness or understanding of solar PV technology----------

Have you past experience on the solar energy use system in you and your area? ----------

What is your main challenge to adopted solar PV / incase of social factors/----------

What are technical factors to promote solar PV system for your own?

How the financial factors affect the installation of solar PV system? ----------

Resean out them----------

What are environmental factors affects solar PV installation? ---------List out them----------

Questionnaire for key informant person

What are main challenge to use solar PV system to supplied----------

List major or prominent factors influencing the decision of individuals to use a solar PV system----------If NO, Justifying them----------