ADOPTION AND CONSTRAINTS OF IMPROVED COOK STOVE USE, THE CASE OF WALMARA WOREDA, OROMIA REGION, ETHIOPIA

M.Sc. THESIS

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APPROVAL SHEET-1

This is to certify that the thesis entitled **"Adoption and constraints of improved cook stove use in Welmara Woreda, Oromia Region, Ethiopia,** is submitted in partial fulfillment of the requirement for the degree of Master of Sciences in renewable energy utilization and management. It is a record of original research carried out by *TAYECH KEBEDE ID. No. MSC/REUM/R016/10*, under my supervision; and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the courses of this investigation have been duly acknowledged. Therefore, I recommended it to be accepted as fulfilling the thesis requirements hence hereby can submit the thesis to the department.

_____	_____	_____
Name of major advisor	Signature	Date

APPROVAL SHEET-2

We, the undersigned, members of the Board of Examiners of the final open defense by *TAYECH KEBEDE* have read and evaluated her thesis entitled **"Adoption and constraints of improved cook stove use in Welmara Woreda, Oromia Region, Ethiopia** 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.

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DECLARATION

I hereby declare that this Msc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been acknowledged.

Name: Tayech KebedeAnika

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LIST OF ABBREVIATIONS AND ACRONYMS

CRGE: Climate-Resilient Green Economy

EESRC: Ethiopian Energy Studies and Research Center

EPA: Environmental Protection Authority

EPAE: Environmental Protection Authority of Ethiopia

ESD: Energy for sustainable development

FGD: Focus group discussion

GHGs: Green House Gases

GIZ: Deutsche Gesellschaftfür International Zusammenarbeit

IAP: Indoor air pollution

ICS: Improved Cook Stoves

IPCC: Intergovernmental Panel on Climate Change

LPG: Liquefied petroleum gas

MoFED: Minister of Finance and Economic Development

NCAR: National Center for Atmospheric Research

NCCSP: National Clean Cook Stove Program Ethiopia

NGOs: Non-Governmental Organizations

Nhh: Number of households

RBA: Result based aid

RBF: Result based financing

SRM: Sector Reduction Mechanism

TWh: Tera watt hour

WHO: World Health Organization

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ADOPTION AND CONSTRAINTS OF IMPROVED COOK STOVE USE THE CASE OF WELMARA WOREDA, OROMIA REGION, ETHIOPIA.

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ABSTRACT

Developing world attempt various program and initiatives that enhance to work and disseminate improved cook stoves which have health, economic and environmental benefits. Therefore, understanding factors affecting adoption of improved cook stoves plays a key role. The main purpose of this study was to investigate factors that affect households' adoption of improved cook stove use in Welmara Woreda, Oromia Regional State of Ethiopia, by using descriptive and analytical research analysis. A survey was conducted with a structured questionnaire for 154 households that were randomly selected from two kebeles. Semi-structured interviews were conducted with the key informants of Mirt stove producers in each kebele, Woreda water resource and energy offices experts and kebele administration leaders. Focus group discussions were also held with 6 key informants. Data from questionnaires, interview and the focus group discussion were analyzed by using descriptive statistics /t-test and chi-square/ and binary logistic regression The t-test and chi-square test results shows that all households' socio economic characteristics were statically significant except marital status which was insignificant and the result obtained from logit model shows income, fuel wood and price were significant to mirt stove adoption decision. Income and fuel wood with charge were positively related and price was negatively related to mirt stove adoption decision. Providing credit services and supports to the potential users and producers, providing technical support to users, providing production sites for producers were found to be institutional factors to influence Mirt stove adoption. Social factors such as membership to local associations, active participation in social activities information exchange, early adopters' influence and neighbors' influence were also found to be important variables that affect Mirt stove adoption decision. Finally, the intervention government required to reverse this condition and needed to promote the technologies that enhance renewable energy use in order to realize green economy as well as environmentally friend and sustainable economic development is the recommendation of the researcher.

Key words: *Household Energy, Adoption, Mirt stove, Open-fire, fuel-wood*

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Globally around 2.6 billion people – 40% of the world's population – still rely on traditional biomass (wood, crop residues, dung, etc.) to meet household cooking needs (IEA 2012). Nearly three-quarters of these biomass users are in developing Asia, one-quarter in Africa, and the rest in Latin America and the Middle East; in some countries, such as Ethiopia, the Democratic Republic of Congo, Tanzania, Uganda and Bangladesh, over 90% of the population relies on these traditional cooking fuels (IEA 2012). Most of these people cook on open fires, which burn poorly thus leading to low fuel efficiency and high pollution emissions .The current patterns of use causes significant negative impacts of several types, including human morbidity and mortality, outdoor air pollution, climate change and deforestation (Smith *et al*., 2004**).**

Inefficient cooking technologies can reduce the scope for sustainability by increasing demand. More efficient biomass burning can substantially reduce these emissions (Smith *et al*., 2004).Using fuel wood saving stoves enables to reduce greenhouse gas (GHG) emission (CRGE, 2011: 30). Introducing efficient stoves has two distinct effects on GHG emissions "it reduces forest degradation, with an impact of around 0.9 tones biomass/year per households; and woody biomass acts as carbon sink amounting to 2.1 tons per year per household (if it is not burned)" (CRGE, 2011).

Ethiopia is experiencing the effects of climate change such as increase in temperature, change in rain fall, drought health effects and environmental effects. Besides these direct effects,

climate change also presents the necessity and opportunity to switch to a new, sustainable development model. The Government of the Federal Democratic Republic of Ethiopia has therefore initiated the Climate-Resilient Green Economy (CRGE) initiative to protect the country from the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle-income status before 2025(CRGE, 2011). The Climate-Resilient Green Economy (CRGE) initiative follows a sectoral approach and has so far identified and prioritized more than 60 initiatives, which could help the country achieve its development goals while limiting 2025 GHG emissions to around today's 150 Mt CO2e – around 250 Mt CO2e less than estimated under a conventional development path. The Climate-Resilient Green Economy plan is based on four pillars:

- Improving crop and livestock production practices for higher food security and farmer income while reducing emissions
- Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks
- Expanding electricity generation from renewable sources of energy for domestic and regional markets
- Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

In Ethiopia, fuel wood is the major energy source and over 90 percent of the country's total energy for household cooking comes from biomass fuels, of which wood provides 78 percent. Deforestation is a major problem and many peasants have switched from fuel wood to dung for cooking and heating purposes. Such burning of dung and crop residues that were sources

of soil humus and fertility has brought about a decline in land quality, reduction of soil fertility and agricultural productivity (FAO, 2003). Regarding this issue, Woldegabreil (2003) has indicated that "firewood and dung cakes are the major sources of fuel in most parts of the country and absence of alternative source of energy force local communities to deplete the scanty wood resources of the forest." This high biomass energy consumption, according to FAO (2003) and EPA (2004), has aggravated the rate of deforestation, biodiversity loss and land degradation.

According to the climate resilient green economy (CRGE) strategy of the country (FDRE, 2011:24), despite their economic and environmental value, Ethiopian forests are under threat due to: The growing population requires more fuel wood and more agricultural production, in turn creating needs for new farmland-both of which accelerate deforestation and forest degradation. Projections indicate that unless action is taken to change the traditional development path, an area of 9 million hectare shall be deforested between 2010 and 2030. Over the same period, annual fuel wood consumption will rise by 65%-leading to forest degradation of more than 22 million tons of woody biomass." CRGE also adds that, Fuel wood usage – by far the largest source of rural energy and the second-largest contributor to GHG emissions – can be reduced with efficient stoves. With a sufficiently large scale-up, the use of efficient stoves will have a massive impact on the green economic development by increasing rural household income by 10%, creating an industry worth USD 15 million in gross value added (GVA), decreasing GHG emissions by 50 Mt $CO2e^{8}$ in 2030, and increasing health and gender equality.

In Ethiopia, a unique mode of cooking (Injera baking) requires the bulk of domestic energy demand. In most of the households of the country, this Injera baking is carried out using an open fire /three stone/ system. As it is known this technique is inefficient and wasteful. To address this problem, many efforts have been and are being made by the government and non-government organizations since the early 1990s (Yosef, 2007). The development of 'Mirt' biomass Injera stove is one of the results of these efforts in the country. These days this stove is being widely promoted due to the fact that it can achieve fuel efficiency up to 50% as compared to the open fire system. It can also improve the kitchen environment by reducing indoor air pollution and other problems such as burn and exposure to excessive heat. According to EPAE (2004), improved charcoal stove (Lakech) and biomass closed Enjera stove (Gounzie) can save up to 25 percent and 47 percent over traditional stove and open fire stove respectively and are currently being promoted in the country. Improved fuel efficient stoves, therefore, help to reduce pressure on the biomass resources including forests; increase land productivity by reducing crop residue and dung usage for fuel wood and improve family health (FAO, 2003 and EPAE, 2004)

Therefore, this study may contribute to fill this gap by identifying challenges and constraints of the adoption of improved cook stoves use in the study area and propose possible solutions and recommendation.

1.2. Statement of the problems

One of the most important issues in the international agenda is about the utilization of renewable energy in order to overcome the energy poverty alongside climate change mitigation and environmental protection. Using improved cook stoves is one of the ways of improving energy efficiency. Improved cook stoves were developed primarily for their

potential to improve household health, local environmental quality, and for regional climate benefits. Compared to traditional stoves, improved cook stoves improve cooking efficiency and can reduce the amount of fuel required, time and effort spent gathering fuel, and cooking times – all of which have the potential to improve health and increase household welfare (Lewis and Pattanayak, 2012). . Inefficient open fires used to cook household meals waste fuel wood and worsen health problems associated with indoor air pollution and resulted in high depletion of the forest resources (World Vision, 2011). Use of woody biomass and dung as energy sources in Ethiopia has contributed to forest degradation, deforestation, and land degradation which are among the most severe environmental problems in Ethiopia (FAO,2003). Despite the aforementioned problems associated with traditional use of wood fuels (like energy inefficiency, deforestation, increasing use of time for collection of fuel, and deleterious health and environmental effects) and the efforts being made to disseminate improved cook stoves throughout the country by the Government and NGOs, hundreds of millions of people in Ethiopia, including the people living in the study area still rely on wood fuels for most of their energy needs using inefficient cooking stoves (FAO, 2003; UNDP, 2005b). Given current trend of population growth, urbanization, economic growth, and relative price developments of other energy sources, it is likely that wood-based biomass remain an important source of energy for the coming many decades and the problems associated with using these fuels with traditional stoves will become serious if actions are not taken. This research is therefore, aimed at identifying the trends of improved cook-stove adoption, factors affecting the improved cook stove adoption and add an original contribution to the existing knowledge with regard to this technology adoption.

1.3. Objectives of the Study

1.3.1. The General Objective

The main purpose of this study is to investigate factors that affect households' adoption of improved cook stove use in Welmara Woreda.

1.3.2. Specific Objectives:

This study was conducted to achieve the following specific objectives:

- To assess the status of improved cook stoves adoption in Welmara Woreda ;
- To identify the relationship between household characteristics and improved cook stoves adoption;
- To investigate the major constraints related to adoption and expansion of improved cook stoves use in the study area.

1.4. Research Questions

The research will be conducted to answer the following questions:

- How is the status of improved cook stoves adoption in Welmara Woreda?
- Which type of improved cook stoves are mainly adopted by households in Welmara Woreda?
- How do factors such as fuel wood source price of improved cook stove, institutional and socioeconomic factors relate to adoption?

1.5. Significance of the Study

Improved cook stoves were developed primarily for their potential to improve household health, local environmental quality, and regional climate benefits. Compared to traditional

stoves, improved cook stoves improve cooking efficiency and can reduce the amount of fuel required; time and effort spent gathering fuel, and cooking times. These all together have the potential to improve health and increase household life standard. However, improved cook stove use is not adopted yet in most kebeles of Welmara Woreda. Due to this the people are using traditional stoves which results household health problems, low environmental quality, high cost for cooking materials time consuming cooking method.

The findings of this study and recommendation helps the Welmara Woreda and areas with similar situation by providing relevant suggestions in the preparation of future plan with a better information base in promoting and adopting of improved cook stoves use. The study findings also help to identify factor affecting the adoption of improved cook stoves and proposes the strategic solution that helps to solve the problem. The study findings and recommendations are hoped to generate both practical and theoretical awareness important to other researchers, policy formulators, and policy implementers.

1.6. The Scope of the study

The scope of the study is limited to Welmara Woreda in the area where improved cook stove is practically started, to analysis of the trends of improved cook stoves use adoption, interest of the people to use improved cook stoves and to identify factors affecting adoption of improved cook stoves at the household level.

1.7. Limitations of the study

This study faced limitations due to lack of adequate secondary data in well-organized form that can give clear information in identifying problems. Lack of interest of some respondent to give full information relating to the research study and lack of adequate budget were also some of the limitation of the study.

1.8. Organization of the study

This thesis has organized into five chapters. The first chapter deals with the background of the study and defines the problem of the study, basic questions and objectives of the study, the significance the study, scope of the study and limitation of study. The second chapter includes the related literature reviews that can basically support this research study. The third chapter deals with the methods of the study. Under this section, the selection and study area description, data type and source, research design and research strategy, sampling design and procedures, data collection and instruments, data collection procedure, and data processing, definition and description of variables as well as model specification are dealt. The fourth chapter presents analysis and discussion and the fifth chapter of this paper deals with conclusion and recommendation. Finally, the reference materials and appendices are also included

CHAPTER TWO

2. LITERATURE REVIEW

2.1. General Background

Energy is vital to meet our basic needs mainly for cooking, boiling water, lighting and heating. More than three billion people worldwide burn wood, dung and other traditional fuels inside their homes which results in indoor air pollution (IAP) which brings about more than 1.5 million deaths mostly of young children and their mothers. In addition, millions more suffer every day with difficulties in breathing, stinging eyes, adverse pregnancy outcomes and chronic respiratory diseases (WHO, 2006).

Traditional stoves tend to be highly inefficient and lose a large percentage of the fuel energy due to incomplete combustion (WHO, 2006). As a result, high dependency on traditional stoves deplete resources and degrades local environments, multiplies the time needed to collect fuel, and creates IAP that threatens the well-being of the most vulnerable members of households (Douglas *et al*., 1994). Improved stoves can cut back indoor smoke levels considerably (WHO, 2006). Lack of energy, in particular lack of access to modern cooking fuels and electricity, already represents a bottleneck to development.

In Ethiopia, fuel wood is the major energy source and over 90 percent of the country's total energy for household cooking is derived from biomass fuels (EPA, 2004). According to CSA (2012:18), wood is the main type of cooking fuel, used by 77 percent of households. Burning of dung and crop residues which were sources of soil humus and fertility has brought about a progressive decline in land quality and agricultural productivity (Zenebe *et al.*, 2006). According to EPAE (2004), improved charcoal stove (Lakech) and biomass closed Enjera stove (Gounzie) can save up to 25 percent and 47 percent over open fire stove respectively.

They help to reduce pressure on the biomass resources including forests; increase land productivity by reducing crop residue and dung usage for fuel wood and improve family health (FAO, 2003 and EPA, 2004).

2.2. Improved cook stoves

Improved cook stoves are cooking stoves using biomass fuel (wood, charcoal, vegetable matter or paper) designed to maximize thermal and fuel efficiency and minimize emissions harmful to human health (Urmee and Gyamfi, 2014, UNEP, 2010). Although improved biomass stove designs vary to a large extent, most attempt to reduce fuel use and/or reduce smokiness. One of the main characteristic of an ICS over the traditional stoves is the use of insulating material such as clay or mud to conserve heat thus making the stove more efficient and in turn reducing fuel consumption. The methods which have been undertaken to reduce smokiness revolve around improving the combustion efficiency of stove to reduce emissions and/or venting emissions away from the user (Burwen and Levine, 2012). To make this possible, ICSs are designed to let air draft through the biomass fuel by ensuring it's suspended above the ground with a metallic or ceramic grate (ibid). In addition some ICSs are equipped with a chimney. As such, different classification can be used to classify existing stoves on the market today, for example based on the material used in construction of the stoves and whether it's fixed or portable (Urmee and Gyamfi, 2014)

Improved cook stoves (ICS) are part of modern cook stoves particularly mud-brick improved cook stove with and without chimney and one of the most simple, inexpensive widely used technologies designed to improve combustion efficiency of biomass and reduce exposure to indoor air pollution. The improved cook stove or ICS pertains to the solid biomass fuel burning system in which heat is produced, by combustion, for immediate use in domestic

cooking. ICSs can also perform other tasks, depending on the design purpose arising from the user's needs. Such a stove may perhaps be termed an improved stove (IS) which can be used for numerous applications, namely: cooking, food preservation/drying, domestic heating and other social and cultural activities (FAO, 1993).

2.2.1. Types of Improved Cook Stoves

Improved cook stoves are classified based on their characteristics, efficiency, impacts, advanced combustion and material made from. Based on these things improved cook stoves are classified as follows;-

Table 1: Types of Improved Cook Stoves

No.	Stove Name	Description
1	Mirt classical	Mirt stove made of cement, no chimney and developed by the Ministry of Water and Energy in the mid of 90ies, for hh, price from 100 – 250 Birr. stove-tests done by GIZ, by Aprovecho, by the Ministry of Water and Energy, by ESD (company in UK commissioned by WB project
2	Mirt slim	Mirt stove made of cement, no chimney and modified by GIZ in collaboration with Aprovecho in 2006, for hh, can be found in all intervention areas of the project, Addis, Amhara, Tigray, Oromia, in urban and rural areas mainly used by hh, price from 80 – 200 Birr) stove-tests done by GIZ
3	Yekum Mirt – I	Mirt stove made of cement, cladded with metal, with pot-rest and chimney at the back, on 4 legs, can be found only in Amhara and Tigray regions in few numbers, developed by GIZ in 2011 to evacuate smoke from the kitchen and to have a higher stove for comfort for the urban users, price between 800–1000 Birr)stove-test done by GIZ in cooperation with Ministry of Water and Energy
4	Mirt with integrated chimney	Mirt stove of cement, with expansion chamber and pot rest as well as a chimney added to the expansion chamber, developed by GIZ in 2011 in order to satisfy Government request of smoke evacuation, can be found in Tigray and Amhara in very few numbers, costs from 300 – 500 Birr) stove-test done by GIZ
5	Addis/Aprovecho stove	stove made of cement, a combination of mirt and rocket stove, no expansion chamber, no pot-rests but air inlet, developed by Aprovecho in 2006 on demand of GTZ because cement price was high and costs had to bring down by increasing the performance, can be found in some places in Amhara region (10 – 20 stoves), price unknown), stove-test done by Aprovecho, acceptability test done in Addis and is currently under way by the project in Tigray, Amhara, South and Oromia

6	Yekum Injera Mitad	Brick stove cladded with metal, with chimney and on 4 legs, can be found in major cities, price from 600 – 1.200 Birr, sometimes called "Lakech", developed by Ministry of Water and Energy for institutional application, nowadays also used in hh and restaurants), pre-test done by GIZ in cooperation with Ministry of Water and Energy . Promoted by government, other NGO, Community or individual stove producers.
7	Yekum Mirt – II	Mirt stove of made cement, cladded with metal, no pot-rest, no expansion chamber, one chimney, height was reduced from 24cm to 18, can be found around in Adama in Oromia Region in few numbers, stove was adapted by a trained stove producer, Meseret, price about 1.000 Birr) pre-test done by GIZ in cooperation with Ministry of Water and Energy and promoted by government, other NGO, Community or individual stove producers.
8	Awramba fixed stove	It is made of mud, stones, ash and placed on a wood base above the ground, with expansion chamber and chimney, developed in the 80ies by the Awramba communist community in Amhara Region near Bahirda, was taken over by Amhara Mines and Energy Bureau for wider dissemination, can be found in Amhara Region), stove-test done by GIZ in cooperation with the Ministry of Water and Energy.
9	Gonzye	it is made of burned clay, similar to Mirt, 3 to 4 cylindrical enclosures, no pot-rests, developed by the Government in 2002, can be found in Amhara, Oromia, Tigray and Southern area, price from 35 – 100 Birr, cheapest Injera baking ICS stove in Ethiopia), stove-test by the Ministry of Water and Energy
10	Electrical Injera Mirtad	It is locally made, developed by the Ethiopian Electrical Power Corporation; can be found all over Ethiopia, wherever electricity is available, price about 4.000 Birr

Source: List of stoves in Ethiopia-energypedia.info2018

2.2.2. Benefits of Improved Cook Stoves

According to the International Energy Agency, 2.7 billion people lack access to clean cooking facilities, of which 1.9 billion are based in Asia, 657 million in Africa, and 85 million in Latin America. These people still depend on biomass as their main source of energy, and are forced to burn charcoal or wood for cooking, despite its known downsides.

First, the inefficient burning of solid fuels on an open 'three stone fire' or by the use of traditional cook stoves has severe negative health effects. Studies by the World Health Organization (WHO) show that indoor air pollution from cooking contributes to more than 1.6 million deaths globally every year. The daily inhalation of smoke containing carbon monoxide, nitrogen oxides, benzene, sulphur and arsenic amongst others, can be compared to smoking two packets of cigarettes every day, significantly increasing the risk for respiratory diseases.

Second, the inefficient use of solid fuels in households increases deforestation. Deforestation is a large contributor to climate change as it decreases the ability of local forests to absorb greenhouse gases (GHGs). Whilst cleaner fuels exist, they are still unavailable to the world's poor due to high costs. For many the choice is to use firewood or charcoal for cooking, or not have a cooked meal at all. New and improved cooking technology could potentially reduce firewood used for cooking by more than 50% compared to 'three stone fires', and provide savings up to 20% of black carbon emissions.

Third, scarcity of readily available biomass also increases the time spent collecting firewood. In Angola, women and children spend up to 7 hours per day collecting firewood, time that could have been spent on more productive activities. Additionally, women and girls also face increased personal security risk when gathering wood in conflict areas or outside refugee

camps (DIFFERGROUP.COM, 2012).These claim on potential benefits of adopting improved cook stoves have been and are supported by many empirical case studies and experiments in developing part of the world. Case studies in developing regions such as Asia, Africa, and Latin America assert the positive impact of adopting improved cook stoves on health, economy, the environment and others.

Asia: In China Dewan *et al.*, (2013) found that the adoption of improved cook stoves can reduce fuel wood for cooking, time to collect fuel wood, and the newly felled trees by 40.1 %, 38.2 % and 23.7% respectively. Ewards *et al*., (2004) also found that in China ICS have both short-term and long term impacts. In the short run ICS reduces the emission of health risky pollutants and in the long term, these stoves play significant role in reducing greenhouse gases emission and mitigate global warming. Boy *et al*., (2000) found that in Guatemala a wood-burning improved stove, called Plancha (the modified), can save wood by about 39%, thus, saves time spent for wood collection and reduces the level of indoor air pollution. They argue that these roles of improved cook stoves have important implication for the interrelated aspects of development like health promotion, protection of the environment and the households' economy.

South America: A study by Garcia-Frapolli *et al.*, (2010) in Mexico also revealed that the adoption improved biomass cook stove, patsari, has a significant contribution for the improvement of living condition mainly because of wood savings (about 53%) and reduction indoor air pollution related health problems(by about 28%). Romieu *et al.,* (2009) investigated that patsari wood-burning stove in Mexico has positive impact on improving and reducing women's respiratory system and provides other cofounded benefits such as eye comfort. Armendariz *et al*., (2008) also asserted that improved cook stoves in Mexico can

reduce particulate matter and Carbon monoxide (CO) concentrations by 74 % and 78% respectively. They found also improved wood-burning stoves reduce personal exposure, for example Carbon monoxide (CO) personal exposure can be reduced by up to 78%. Berrueta *et al.,* (2008) revealed that patsari wood-burning stove in Mexico can save wood ranging from 44-65%.

Africa: A study in Gambia by Jacob (2013) also found that improved wood-burning stoves can save fuel wood consumption up to 40% and reduce indoor air pollution up to 90%. A study by Bwenge (2011) in Tanzania also came with evidence that in Tanzania the adoption of ICSs saved fuel wood consumption by about 70%; reduced women's workload, reduced the time spent to collect food from 4 hrs to 2 hrs per day; created self-employment and source of income for the producers; and reduces smoke emission. In Eritrea Ergereman (2003), also, found that the adoption of improved biomass stoves reduces indoor air pollution, reduce concentration of smoke, fuel saving, money and time saving for acquiring fuel and less pressure on forest and energy resources, reduces greenhouse gases, skill development and job creation in the community.

Ethiopia: Assefa (2007) experimentally found that in Ethiopia improved cook stoves; particularly Mirt stove can reduce carbon monoxide (CO) concentration and particulate materials by about 88% and 17 % respectively. A study by Gebreeziabher *et al.,* (2006) in Ethiopia found that assuming an average of 79 t of biomass per ha, the potential reduction in deforestation amounts 1,794 ha per year. They also argue improved stoves are able to reduce land gradation in such a way that if the stoves are adopted (1) less dung will be used as fuel so more manure is available, thus, fertile soil; (2) less wood consumption, thus reducing

deforestation so more wood is available, in turn less dung and crop residues for fuel and; (3) less time spent for fuel wood and dung, thus, less time spent for cooking.

In Ethiopia Asres (2002) found that the adoption of improved cook stoves (Lakech and Mirt stoves), can save about 475.44 kt wood, about USD 47million and 122, 619 ha of forest per annum; reduce indoor air pollution and improve health conditions as well as mitigate greenhouse gases emission. The study also asserted that Mirt stove saves fuel wood by about 45% as compared to open- fire (TigabuAlamir, 2014).

2.3. Household energy use in developing countries

In developing countries, especially in rural areas, 2.5 billion people rely on biomass, such as fuel wood, charcoal, agricultural waste and animal dung, to meet their energy needs for cooking. In many countries, these resources account for over 90% of household energy consumption. In the absence of new policies, the number of people relying on biomass will increase to over 2.6 billion by 2015 and to 2.7 billion by 2030 because of population growth. That is, one-third of the world's population will still be relying on these fuels. There is evidence that, in areas where local prices have adjusted to recent high international energy prices, the shift to cleaner, more efficient use of energy for cooking has actually slowed and even reversed. Use of biomass is not in itself a cause for concern. However, when resources are harvested unsustainably and energy conversion technologies are inefficient, there are serious adverse consequences for health, the environment and economic development. About 1.3 million people – mostly women and children – die prematurely every year because of exposure to indoor air pollution from biomass. Valuable time and effort is devoted to fuel collection instead of education or income generation. Environmental damage can also result, such as land degradation and regional air pollution. Two complementary approaches can

improve this situation: promoting more efficient and sustainable use of traditional biomass; and encouraging people to switch to modern cooking fuels and technologies. The appropriate mix depends on local circumstances such as per-capita incomes and the availability of a sustainable biomass supply. Halving the number of households using traditional biomass for cooking by 2015 – a recommendation of the United Nations Millennium Project – would involve 1.3 billion people switching to other fuels. Alternative fuels and technologies are already available at reasonable cost. Providing LPG stoves and cylinders, for example, would cost at most $1.5 billion per year to 2015. Switching to oil-based fuels would not have a significant impact on world oil demand. Even when fuel costs and emissions are considered, the household energy choices of developing countries need not be limited by economic, climate-change or energy-security concerns. Vigorous and concerted government action is needed to achieve this target, together with increased funding from both public and private sources. Policies to promote cleaner, more efficient fuels and technologies for cooking need to address barriers to access, affordability and supply, and to form a central component of broader development strategies (World Energy Outlook, 2006).

2.4. Factors determining Adoption of Improved Cook Stoves in Developing Countries

Development of improved stoves is not a recent phenomenon. Over the past one hundred years, middle and upper-income families have adopted different type of stoves, especially when access to petroleum-based fuels was a problem. Among the industrialized countries, enclosed wood or charcoal stoves were used both to cut down on indoor air pollution and to facilitate cooking. Several designs were developed largely by trial and error. Efficiency was not an important factor of stoves models due to the relative abundance of wood fuels.

However, the increase of urban population, difficulties in wood fuel supply, and increase in market prices induced efforts to design more fuel-efficient models (Barnes *et al.,* 1994).The recent spate of improved stove programs focusing on energy efficiency began in the 1970s after the huge rise in oil prices. In addition to a desire to rationalize the continuing reliance on biomass fuels, a desire to prevent or mitigate deforestation contributed to the growth of stove programs. With higher oil prices, increasing deforestation, and talk of an impending "fuel wood crisis," governments, donors, and nongovernmental organizations (NGOs) started to finance and develop stove programs (Barnes *et al.,* 1994). In general, women and middle and lower-income families are the main beneficiaries of ICSs programs (Eckholm, 1982). Commonly, in rural areas, people collect rather than purchase fuel wood, and using more efficient stoves has the potential to reduce the time allocated to collection, which is especially significant for women. Furthermore, estimated economic and environmental impacts of adopting improved stoves can be quite significant for communities.

A large number of empirical studies identify different benefits as well as costs associated with a household's decision to use improved cook stoves and fuels. From the users' perspective, benefits include reduced air pollution, time saved from collecting fuels, and fuel cost savings, as well as aesthetic gains and improved social standing (Malla and Timilsina, 2014).

The literature on cook stove adoption reveals that initially, households respond most – with a high rate of adoption – to fuel savings (when fuel is very scarce or monetized), to the speed of cooking, convenience, compatibility with local cooking practices, and level of advancement/modernity of the technology, and relatively less so to indoor-air-pollution related issues (Ruiz-Mercado, Masera, Zamora, and Smith, 2011). According to TigabuAlamir (2014), reviewed many literatures in his research, there are factors that found to be

determinant in determining households improved cook stoves adoption decision Such as: Age, Marital status, income of households, gender, family size, education level, separate kitchen, source of fuel wood, price of improved cook stove, institutional factors and social factors.

2.5. Improved Cook-stoves Development in Ethiopia

As research indicate Ethiopia's energy supply is heavily dependent on biomass, which accounts for above 95% and in terms of sect oral consumption, household accounts for about 91.3% of the total energy consumption, of which biomass fuel accounts 98.5 % and also within the household sector the rural and urban household energy consumption accounts for 92 and 8%, respectively (Asres, 2002). This heavy dependency on biomass fuel, coupled with open three-stone fire cooking, is one of the significant causes of deforestation and forest degradation, resulting in growing fuel scarcity and higher firewood prices, loss of agricultural productivity, creates indoor air pollution (MoWE, 2012; Gebreegziabher *et al.,* 2010). According to César and Ekbom (2013), between 2010 and 2030 annual fuel wood consumption will rise by 65% with large effects on forest degradation. Thus, for developing countries like Ethiopia whose energy supply is heavily dependent on biomass fuels such as wood, charcoal and agricultural residues, technical advances in energy efficiency are critical (NCCSPE, 2011; GACC, 2011).

By taking in to consideration the consequences of excessive and inefficient use, the Ethiopian government and other over sea organizations (mainly GIZ) have embarked on a two-pronged policy tree planting or Afforestation and dissemination of more efficient stove technologies (Gebreegziabher *et al.,* 2006). In the case of energy efficiency, mainly the Ethiopian Energy Studies and Research Center (EESRC), currently, Ethiopian Rural Energy Development and Promotion Center, exerted immense efforts since 1989 to develop improved stoves and three

types of improved stoves have been developed, Lakech charcoal stove, Electric Injera stove and Mirt improved biomass Injera stove (Asefa, 2007; Gebreegziabher *et al.*, 2006).

The National Clean Cook Stove Program Ethiopia (NCCSPE) is also one of the efforts for this purpose and improved cook stoves play a great role in reducing deforestation due to their fuel wood saving feature; reduce GHG emission due to less smoke, reduce indoor air pollution and have other social and economic benefits (NCCSPE, 2011).

Under the implementation of World Food Program-Ethiopia, there is also a new initiative which is called Ethiopia Improved Cook stoves Initiative (CPA 1) to disseminate Mirt stove for injera baking that lasts for 21 years (WFP-Ethiopia, 2013).

The National Program for Improved Household Biomass Cook Stoves Development and Promotion is an ambitious program for the deployment of more than 9 million Improved Cook stoves (ICS) in Ethiopia by January 2018. This deployment is expected to lead to a range of benefits including a reduction in emissions of up to 14 Mt of CO2e over three years, a reduction of 1,000 – 2,000 deaths per year from indoor air pollution and the creation of more than 5,000 private sector jobs. The value of these benefits is expected to be significantly greater than the resources that the Ethiopian government estimates it needs from international development partners to deliver the program.

RBA refers to the provision of financial support to national or regional governments only upon successful delivery, independently verified, of pre-agreed results. The accompanying conceptual paper discusses in more detail how RBA can be distinguished both from conventional aid modalities, which provide financial support in relation to development objectives prior to the delivery of any results, as well as from results-based financing (RBF), which provides financial support to individual service providers undertaking specific projects.

Four key preconditions needed for RBA to be successful are likely to be passed in any partnership between Energy+ and the Ethiopian government in relation to the cook stove program. There is credible capacity and willingness on behalf of the development partner (Energy+) to implement a results-based approach in this context. There is willingness on behalf of the Ethiopian government to respond to the stronger incentives that an RBA scheme would impose, as indicated by the results-based philosophy underpinning the country's sector reduction mechanism (SRM). The Ethiopian government has demonstrated the relevant capacities in cook stove program design and implementation, both through the current ICS program and through previous cook stove program. Although further discussions are needed, it would appear that the Ethiopian government could pre-finance the portion of the costs of the program that would subsequently be remunerated upon successful delivery of results (World Bank Group, 2014).

2.6. Challenges, and Constraints of Cook-stove Adoption

People rarely adopt innovations without good reason (Barnes *et al.,* 1994). While energy services are directly associated with the quality of life and level of development, the amount and quality of energy consumption has a co-relation with poverty, deprivation, social seclusion, access to knowledge and achievements, health, livelihood and security. Modi *et al*., (2006) also stressed that progress toward providing greater access to modern energy services has been slow, due to a combination of interrelated circumstances. These include low income levels among the unsaved population; lack of financial resources for service providers to build the necessary infrastructure and reduce first-cost barriers to access; weak institutional, financial, and legal structures that could otherwise encourage private investment; and lack of long-term vision and political commitment to scale up services (Modi *et al.,* 2006). The most

important factor worth mentioned by different scholars is poverty and lack of access. Households at lower levels of income and development tend to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient.

According to the WHO for example, over three billion people worldwide are at these lower rungs, depending on biomass fuels-crop waste, dung, wood, leaves and coal to meet their energy needs (Duflo and Greenstone, 2008). Economic determinants of fuel choice, as stressed by Barnes *et al.,* (2012) is by large the most widely covered driver of fuel choice. There are several components to (1) economic factors which include household income, cost of equipment and fuel, and (2) noneconomic costs such as time and access to fuels. Barnes *et al.,* (2012) emphasized that the price of stoves can be a significant barrier to their adoption. Improved wood fuel stoves are typically about twice as expensive as the local traditional stoves.

Engineman (2003) also underlined that the incidence of rural poverty is an important determinant for the adoption of improved cook stoves. He added that "it is hard to imagine a rural household which is barely meeting its subsistence needs being able to afford the whole cost of an improved cook stove." Bruce *et al.,* (2000), on their part, stressed the impact of poverty on fuel stove adoption as "the types of fuel used become cleaner and more convenient, efficient and costly as people move up the energy ladder." Improved stoves are more attractive to those households that experience (3) scarcity in biomass resources since they will benefit significantly (be it in terms of time saved from collecting firewood or money saved from the purchase of firewood) from the increased efficiency of the stoves.

As far as fuel saving stove adoption is concerned, (4) social capital (diffusion of information) has its own impact of the adoption of fuel efficient stoves. A study in northern Peruvian Andes

by Adrianzén (2011), confirmed that information diffusion during the adoption of new cooking technologies is essential, and highlights the importance of having an appropriate understanding of the village social structure, as this structure influences the degree in which local generated information will be shared and diffused. It also pointed out the relevance of high quality monitoring and extension services in stove adoption because bad news about the performance of the new technology can have adverse effects in terms of the adoption processes. Information about a new technology is more intensively diffused in villages which are likely to have strong levels of bonding social capital.

If the initial success in improved stove usage at the village level is relatively low, it negatively influences the individual decision to effectively use the improved stoves. This implies that bonding social capital played a crucial role facilitating social learning during the adoption process of improved stoves. Another factor which determines the adoption of fuel efficient stoves according to Bruce *et al.,* (2000) and World Vision (2011) is alternative purposes of an open fire. Indoor fires that cook food often also serve other purposes, such as heating indoor areas, preserving food through smoking, keeping thatched roofs dry, repelling mosquitoes and lighting. A study in Ghana pointed out that open firewood is required to smoke fish (Manyo-Plange, 2011). Failure to effectively address these issues almost guarantees that the improved stove will not be adopted.

CHAPTER THREE

3. RESARCH METHODOLGY

Under this section the selection and study area description, data type and source, research design and research strategy, sampling design and procedures, data collection and instruments, data collection procedure, data processing and analyzing procedures, definition and description of variables as well as model specification are presented.

3.1. Description of the Study Area

3 .1 .1 Location and physical condition

This study was conducted in Welmera woreda located in Special Zone of Oromia Regional State in the central highlands of Ethiopia. It is bordered on the south by the Sebeta Hawas, on the west by West Shewa Zone, on the North by Mulo, on the Northeast by the Sululta, and on the east by the city of Addis Ababa. Holeta Genet town is the seat of the district. Wolmera district is about 29 km away from the capital city of Addis Ababa along the Ambo road. (Tadele *et al.,* 2014).The area ranges in elevation from 2,000 to 3,000 masl (World Potato Atlas, 2009) at 8^0 12’29’’N latitude and $34^0$8’20’’E. The highest point in this district is Mount Wechecha, located in the southern part of the district. The Menagesha National Forest covers the southern and western slopes of this mountain; it is 2500 hectares in size. Other notable peaks include Mount Menagesha between 2800 and 2900 meters (Tadele *et al.,* 2014).

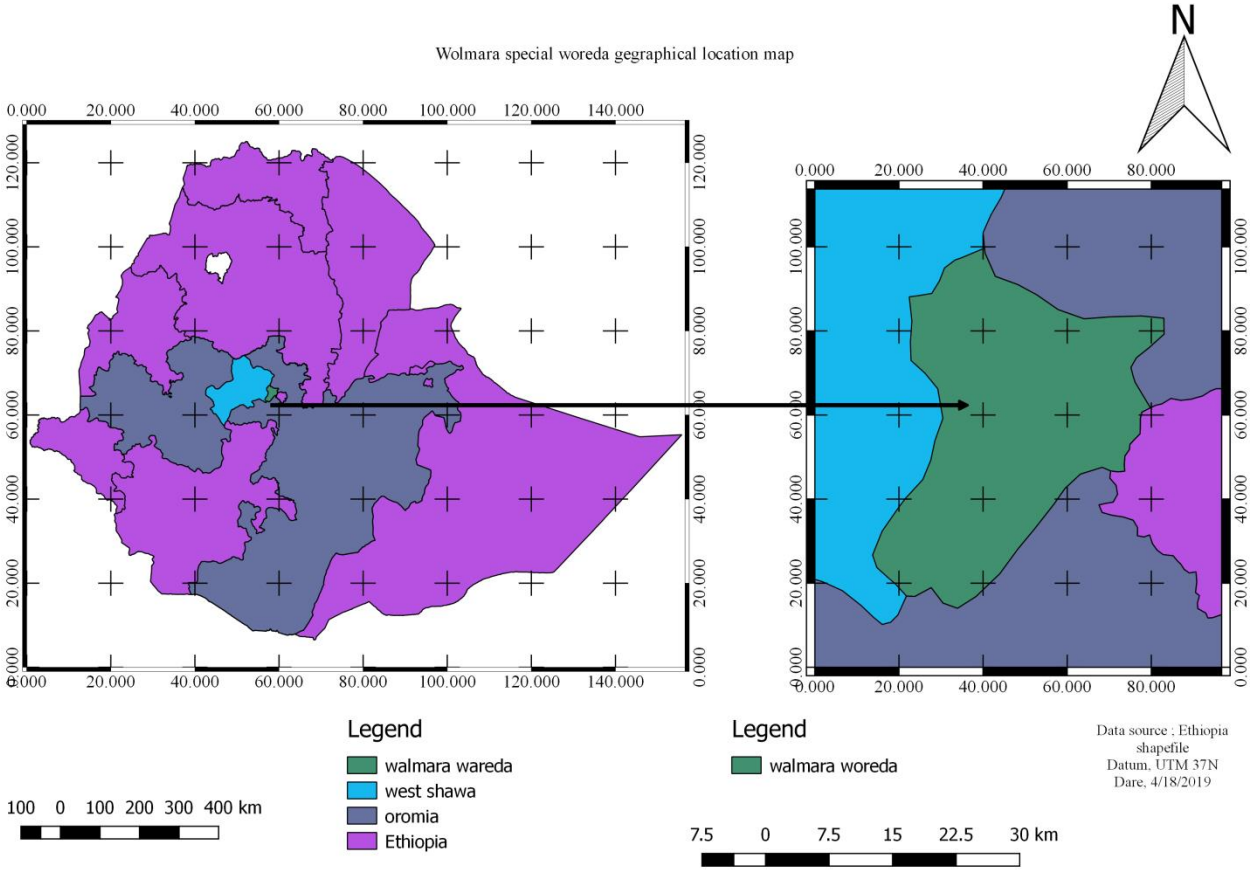

Figure 1: Map of the Study Area

3.1.2 Population

The Welmara has a total population of 146,227 of which 72,301 (49.4%) are males and 73,926 (50.6%) are females. In terms of area residence 100,857 (69%) population are living in the rural areas while 45,370 (31%) are living in the urban centers (BoA, 2013).

3.1.3. Climate and Soils

The Welmara is classified into two agro climatic zones namely Dega (61%) and Wayne dega (39%) (BoA, 2013). Shallow alfisols, clay loam in texture, occupy many of the steep slopes. Lower, gentler slopes are often characterized by deeper clay in ceptsols which are well drained and easy to work, but poor in organic matter and nitrogen. Deep, fertile, clay vertisols occur in the lowlands. These are subject to water logging and are generally difficult to work.

Mean monthly temperatures range from 10.8º C in November to 15.4º C in April with considerable diurnal range. Frost at night in the winter is common. Average annual rainfall is 1,054mm.Most of these falls from June to September, with moderate rainfall (60-75 mm/month) from March to May, and little precipitation from October to March (World Potato Atlas, 2009).

3.1.4. Economic Activities

The major economic activities of Welmera Woreda are dominantly agriculture and service sectors such as Trade, Hospital, Hotel and others. From agriculture sector production of potato and selected potato seed multiplication is the main source of income of the local farmers. From crop production wheat and teff are dominant cereal crop. Apiculture, horticulture and dairy farmer are the major economic sources and economic potentials from agriculture sectors. Small trades and hotel services are also from the economic activities of the service sectors which are practical in Holeta and Menagesha town. Wolmera Woreda has the potential of industry sector but not expanded more as one branch and source of economy. Even though Welmera Woreda is a district which has proximity to Addis Ababa there is no industry expansion. Until know only two cement industries are established and working (**Source;** Oromia Special Zone Administration office).

3.2. Research Design

This study used cross-sectional data collection with descriptive statistical research analysis to describe and summarize features of information quantitatively as well as descriptive research method such as observational and survey method in order to identify, determine and describe the characteristics of a population or phenomenon being studied. Analytical method also used to analyses facts or information already available to make critical evaluation.

3.3. Types and Sources of data

For this study, the researcher employed both quantitative and qualitative data. The quantitative data were employed in order to address research questions and objectives that could be better addressed quantitatively. Therefore, socioeconomic data about respondents were gathered numerically. The qualitative data were used to address research objectives which could be better addressed qualitatively as well as explain the results of quantitative analysis.

With regard to the data sources, the researcher used both primary and secondary sources. The primary sources of this study were obtained from the sample households and the key informant interviewees of improved cook stoves producers, kebele administrators, and Woreda water resource and energy office experts. The secondary sources were obtained from reports and written documents of Oromia regional state Water Resource and Energy Bureau and wolmera Woreda's water resource and energy office.

3.4 Sampling Design and Procedures

To make generalization about the whole population different sampling designs and procedures are used to get the truly representative sample (Israel, 1992). Thus, this section presents the sampling designs and procedures that were employed for this study.

This study selected two kebeles of walmara worada (GoroKeransa and Kolobo) from the total of 31 kebeles, 23 are rural kebeles and 8 are urban kebeles. The study selected the two kebeles with purposive sampling technique. It is in these two kebeles that improved cook stoves were introduced and distributed when the research was being conducted. The two selected kebeles have total populations of 13,351(7,582 in Goro Keransa and 5,769 in Kolobo kebele).Finally, a total sample of households was selected by using simple random sampling. The total number of sample households was allocated among the two Kebeles in proportion to

their population size. Based on general formula developed by Yemane (1967), at 92% confidence interval the number of house hold included in survey was determined.

$$n = \frac{N}{1 + N(e)^2}$$

Where, n = Sample size, N= Total population, e= level of precision (0.08)

Accordingly, from total population of 13,351; **154** households were selected.

Table 2. Sample distribution in sample's kebele

Kebele	Kebele population	How to get sample size in each kebele	Sample households
Goro-keransa	7,582	7582*TS/Tp=7582*154/**13351**	= 87
Kolobo	5,769	5769*TS/Tp=5769*154/**13351**	= 67
Total	**13,351**		**154**

Source: Own source, 2019

3.5 Data Collection and Instruments

Different instruments and procedures were used to collect data. These instruments and procedures of this thesis are discussed below.

1. Questionnaire: A structured questionnaire was administered. The researcher developed the questionnaire in English and translated into Afan Oromo. The questionnaires used to gather information about rural households' improved cook stove use the respondent's characteristics, the presence of separate kitchen, source of fuel wood, the price of improved cook stove, institutional and social factors as well as improved cook stove adoption constraints.

2. Key Informant Interview: informants selected for interview are individuals who are knowledgeable, open minded, articulate, and cooperative for research interview purpose (Neergaard 2007). Interviews were used to explore variables under investigation in greater

detail and conducted by six (6) persons from improved cook stove producers in each kebele, Woreda water resource and energy office experts and kebele administration leaders.

3. Focus Group Discussion: was conducted by 9 persons and held with the presence of key informants. The key informants' responses were considered and checked to design and guide the group discussions and ensure that the relevant information obtained.

3.6. Method of data analysis

This study used descriptive statistical research method to describe and summarize features of data quantitatively as well as descriptive research method such as observational and survey method in order to identify, determine and describe the characteristics of a population or phenomenon being studied. Analytical method also used to analyses facts or information already available to make critical evaluation

3.7. Description of variable

3.7.1. Dependent variable

In this study adoption is the dependent variable that shows the improved cook stove technology use. The qualitative dependent variable is adoption which takes **(1)** is code for adopter of improved cook stove and (0**)** is code for non-adopter of improved cook stove technology.

Logistic regression is a probability estimation model applied when the dependent variable is binary and the independent variable is in any form of measurement scale (Cramer, 2003; Leech et al., 2005).

y = a+bx…… (1)

$$p = \frac{1}{1+e^{-(a+bx)}} = \frac{e^{a+bx}}{1+e^{a+bx}} \text{ ……..(2)}$$

Where P is the probability of the event occurring, X are the independent variables, e is the base of the natural logarithm and a and b are the parameters to be estimated by the model. As p is the probability of adopting an improved cook stove, 1- p is the probability of not adopting the improved cook stove. Therefore

1-p $=\frac{1}{1+e^{a+bx}}$ ……. (3)

To obtain the odds ratio of adopting the improved cook stove will be

$\ln(\frac{p}{1-p}) = 1 + e^{-(a+bx)} = a + bx$ ……. (4)

The logistic prediction equation or multiple variables the equation will be as follows

$$\ln(\frac{p}{1-p}) = \beta o + \beta 1X1 + \beta 2X2 + \cdots + \beta iXi + \varepsilon i \text{ .... (5)}$$

Where Y= adoption of improved cook stove technology (dependent variable)

β0= constant (coefficient of intercept)

β1, β2, βi = parameters to be estimated

X1, X2 …. Xi = the explanatory variables to fitted into the model

3.7.2 Independent variable

Table 3: Description of explanatory variables for ICS technology adoption model

Variable	Type	Description	Expected sign (positively related/+) (negatively related/-)
Age	Continuous	Age of household head in years	positive/+
Sex	Dummy	Sex of household head (**0= female 1= male**)	positive/+
Education level	Dummy	Household head's educational level in year of schooling (0=**illiterate, 1=literate**	Positive/+
Family size	Continuous	Total number of people in the house hold	Positive/+
Marital status	Dummy	In this study marital statusis a dummy which refers to the respondent's state of being single or married. **(1=married,0=single**)	Negatively/-
Income level	Dummy	Total annual income of household in ETB(**1=high,0=low**)	Positive/+
Separate kitchen	Dummy	Presence or absence of separate kitchen(1= **presence, 0= absence)**	Positive/+
Fuel wood	Dummy	It is about a household's main source of fuel-wood.**1=withcharge,0=without charge**	Positive/+ or Negative/-
Price	category	refers the end users cost to buy Mirt stove	Negative/-

Source; Own source (from definition of variable)

Explanatory variables and their justification are discussed below

Age: household head's age was indicated to be significant negative factor that determines the adoption of improved cook stoves across studies reviewed Lewis and Pattanayak (2012). In contrary, results from Gebreegziabher *et al.,* (2010) show that household head's age to be positive and statistically significant determinant factor of cook stove adoption and utilization decision..

Sex: (Adrianzén, 2009; Damte and Koch, 2011) reported that, women headed households are more likely to adopt fuel efficient new technologies as compared to male headed households.

Education level: A review by Lewis and Pattanayak (2012) found that household head's education is positively and statistically significant factors that determine the adoption of improved cook stoves across studies reviewed. It is argued that educated potential customers are more likely to be aware of the benefits of improved cook stoves as compared to uneducated or less educated customers (Inayat, 2011; Menon &, Thandapani, 2011; Adrianzen, 2009). Menon and Thandapani (2011) again claim that the consumers education about the different financial instruments they can avail to purchase the cook stove so that the perceived expensiveness can be minimized. Damte and Koch, Gebreegziabher *et al.,* (2010), Dawit (2008) and Makame (2007) found household head's education as a positive factor in influencing Mirt stove adoption decision in Ethiopia. It was found positive association between the household head's level of education and Mirt stove adoption. Thus, positive and significant correlation is expected between women's literacy level and improved cook stoves adoption decision.

Family size: Report from (Gebreegziabher *et al.,* 2010; Pine *et al.,* 2012) revealed that an increase in family size has a positive and significant influence on the adoption of ICS.

Level of income: The systematic review of Puzzolo *et al.,* (2013) found constituency among research results that higher socio-economic status is positive and significant factor in determining a household's improved cook stoves adoption decision. A review by Lewis and Pattanayak (2012) found that income is positively and significant factor that determine the adoption of improved cook stoves across studies reviewed. Pine *et al.,* (2011) and Inayat (2011) found that household income is determinant factor of households improved cook stoves adoption decision.. The works of Damte and Koch (2011), Gebreegziabher *et al.,* (2010) and Dawit (2008) reveal that household income is statistically significant positive determinant factor in determining households' Mirt stove adoption decision. Thus, this study consider, the positive significant of income on mirt stove adoption decision

Separate kitchen: Puzzolo *et al.,* (2013) found constituency among research results that having separate kitchen is positive and statistically significant factor in determining a household's improved cook stoves adoption decision. Previous studies found separate kitchen house as one significant factor that has positive effect on a household's improved cook stoves adoption decision (Axen, 2012; Damte& Koch, 2011; Adrianzen, 2009). These works investigated the positive correlation between separate kitchen and improved cook stoves adoption. Based on the existing literature, having separate kitchen is expected to have a positive effect on households' Mirt stove adoption decision in the study area. Households with kitchen are expected to be found more likely Mirt stove adopters with the assumption that since Mirt stove is larger in size and technically fixed in nature, additional space is needed.

Marital status: Single women (female headed households) were found more likely to adopt improved cook stoves as compared to married women male headed counter parts (Damte and

Koch, 2011; Inayat, 2011; Adrianzen, 2009). Consumption is very less than that of married women and they get fuel wood with less charge or without charge.

Source of fuel-wood: Geary *et al.,* (2012) found that the free availability of fuel-wood one of the factors that lead to the decision not to adopt improved cook stoves. Source of fuel-wood is determinant factor of improved cook stoves adoption decision (Inayat, 2011). The investigation found that households not collecting wood for free were found more likely to adopt improved cook stoves. A study by Pine *et al.,* (2011) also found that the access to open forest is found to be negatively correlated and statistically significant with the probability of improved cook stoves adoption decision. Axen (2012) and Troncoso *et al.,* (2007) also investigated a positive correlation between lack of access to open forest and improved cook stoves adoption and the vice versa. Based on this previous study, availability of fuel wood without charge expected to have negative significant on improved cook stove adoption decision

Price: price variables include the price of improved cook stoves, the price of fuel-wood, the price of kerosene and others. But for this study purpose, the influence of improved cook stoves' price on households' adoption decision is reviewed. A recent study by Levine *et al* (2013) found that inability of the poor to pay the cost of improved cook stoves is one of important barriers of adoption decision. Axen (2012) argues that the price of improved stoves and households' perception on the price have effect on the probability of the households adoption decision. Slaski and Thurber (2009) identified that improved cook stoves' cost affordability by the poor is a positive determinant factor of adoption.

Institutional factors: Institutional factors in this study included providing trainings on improved cook stove use, promotion activities for awareness creation, system establishment

on quality and price control and technical, material and financial supports and provision of improved cook stove production sites to the potential producers.

Social factors: Social factors in this study included information diffusion about improved cook stove technology, participation in social activities, the influence of early improved stove adopters and the influence of neighbors.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

This chapter presents the findings of the research study identified through the applied research methodology and discussion as well as interpretation of the result gathered through the structured questionnaire, semi-structured interviews and focus group discussion. The result and discussion of this part of the study specifically focused on the Mirt stove as the study it was the only introduced improved cook stove in Welmera Woreda. The Mirt stove is mainly used for baking Injera. On the other hand, data obtained from water resource and energy Bureau of Oromia showed that, from distributed improved cook stoves, Lackech and mirt stoves were first and second rank in use, respectively. Other data obtained from water resource and energy office Welmara woreda showed that mirt stove started in Welmara worada in year 2008 in two selected kebeles and distributed to 900 households. Generally, in this section findings of the research study are explained and summarized based on the research objectives.

4.1. Status of Mirt Stove Adoption

To identify the current status of Mirt stove adoption by households in Welmera Woreda household respondents were asked whether they used Mirt stove or not in the form of 'Yes' or 'no' response question. Similar studies, for instance, (Inayat, 2011; Dawit, 2008) used such type of objective response. The result found by this study was showed in table follow.

Table 4: Status of Mirt Stove Adoption

Adoption	Number of households	Percent (%)
Adopters	60	39
Non-adopters	94	61
Total	154	100

Source: Own survey data; 2019

As it is observed in Table.4 from the total of 154, 60 respondents (39 %) were found to be adopters of Mirt stove while 94 respondents (61%) were non-adopters. This implies the majority of the households surveyed were found to be non-adopters. According to the result the rate of adoption is less than half of the sample (39%). This finding is similar with study by Tigabu Alamir (2014) that revealed majority of the respondents were non-adopters and the rate of adoption is 36.7 %.As this study's findings show, the reason of adoption that the researcher obtained from the adopter why they have adapted this technology were benefit of Mirt stove technology, role of this technology in environmental protection, in time saving, and its health benefits.

4.2 Reasons to adopt Mirt stove technology

To identify the reasons for adapted to Mirt stove in study area, 60 adopters found on table.5 were asked. The distribution or importance of reasons for adoption of Mirt stove in terms of proportion of respondents is shown in table 5.

Table 5 show reason for adopters of Mirt stove technology

Reason	Response	%
Improved households' health status	57	95
Fuel wood collecting time saving	55	91.6
reduce deforestation	40	66.6
Reduce environmental pollution	35	58.3

Source: Own survey data (2019)

Table 5 presents, health benefits from using improved stove and time saving from less collected firewood are the most important reasons for adoption of Mirt stove. The role of the technology in reducing environmental pollution and deforestation are the next mentioned reasons for adoption. This finding is similar to the previous studies (Bubendorfer, 2011; Shanko, 2001) that found cleaner cooking, safer to use, wood saving and quicker to cook to be the main reasons to purchase improved cook stove technologies and the study by Dewan *et al.*, (2013) that found that the adoption of improved cook stoves can reduce fuel wood for cooking, time to collect fuel wood, and the newly felled trees by 40.1 %, 38.2 % and 23.7% respectively.

4.3. Relation between Households' Characteristics and Improved Mirt Stove Adoption

Household characteristics are those variables that explain information about the household such as respondent's gender, age, and marital status, level of education and occupation. But,

for this study, household characteristics include only variables of the respondent's age, marital status, literacy level and family size. These factors are explained below.

Table 6. Socioeconomic and demographic characteristics of respondents (categorical variables)

Variable	Category	Respondents		Adoption			
			%	Adopter	%	Non-adopter	%
Sex	Female(0)	140	91	58	96.7	82	87.2
	Male(1)	14	9	2	3.3	12	12.8
	Total	154	100	60	100	94	100
marital status	Married(1)	149	97	59	98.3	90	95.7
	Single(0)	5	3	1	1.7	4	4.3
Education Level	Illiterate(0)	71	46.1	4	6.7	67	71.3
	Literate(1)	83	53.9	56	93.3	27	28.7
Separate kitchen	Yes(1)	86	56	60	100	26	27.7
	No(0)	68	44	0	0	68	72.3
Income	High(1)	51	33	48	80	3	3.2
	Low(0)	103	67	12	20	91	96.8
Perception on Price	Expensive(1)	53	34.4	5	8.3	48	51.1
	Cheap(0)	33	21.4	22	36.7	11	11.7
	Fair(2)	68	44.2	33	55	35	37.3
Source of fuel wood	With charge(1)	63	41	44	73.3	19	20.2
	Without charge(0)	91	59	16	26.7	75	79.8

Source: Own survey data (2019)

4.3.1. Mirt Stove Adoption, Age and family size

Table 7 Demographic characteristics of respondents (continuous variables)

Variable	Adoption	Minimum	Maximum	Mean	Std Deviation	t-value	P-value
Age		18	67	37.058	13.76993		
	Adopter	19	67	41.183	12.5028	3.036	0.003
	Non-adopter	18	67	34.436	13.94888		
Family size	Adopter	2	10	4.75	1.8468	3.912	0.000
	Non-adopter	1	10	3.595	1.7059		

Source : Own survey data(2019)

As this study identified the minimum and maximum years of the respondents are 18 and 67 while the mean and standard deviation are 37.0584 and 13.76993 respectively. The minimum and maximum years of the adopters are 19 and 67while 19 and 67 years are for the adopters respectively. And also, the means and standard deviation for adopters is 41.1833 and 12.502887 respectively. While the minimum and maximum year's age of non-adopters is 18 and 67, the means and standard deviations for non-adopters is 34.4362 and 13.9488, respectively. These findings show that there is mean variation between the Mirt stove adopters' and the non-adopters' age. This mean variation was found to be statistically significant with t-value of 3.036. This t-value suggests that there is significant difference between the mean of Mirt stove adopters and the mean of non-adopters at p-value is 0.003. The average age of adopters is greater than the average age of non-adopters. This implies that the older the ages are the more likely adapted to Mirt stove. The researcher formed that, the older the ages were the more likely adapted to mirt stove because of family size of the older ages are larger than family size of the younger ages. Contrary of this study, the study by

Tigabu Alamir (2014) that shows, the younger the ages are more likely to adapted to Mirt stove.

4.3.2. Mirt stove Adoption and Family Size

As this study showed the minimum and maximum family size is 1 and 10, respectively while the mean and standard deviation are 4.0519 and 1.84990, respectively. And also, the minimum and maximum family size for Mirt stove adopters were 2 and 10, respectively and the means and standard deviation is 4.7500 and 1.84689 respectively. While the minimum and maximum family size for non-adopters were 1 and 10 respectively and the mean and standard deviation is3.5957 and 1.70590 respectively. The finding implies mean variation that shows the large family size is more likely to Mirt stove adoption. In addition, this mean variation was found to be statistically significant with t-value of 3.912. This t-value suggests that there is significant difference between the mean of Mirt stove adopters and the mean of non-adopters at p-value 0.000. This study was similar with the previous study by (Gebreegziabher *et al.*, 2010; Pine *et al.*, 2012) which revealed that an increase in family size has a positive and significant influence on the adoption of ICS

4.3.3. Mirt stove Adoption and marital status

Marital status is one the variable of households' character and the result findings of this study shown in the following table.

Table 8: Table show marital status and Mirt stove adoption

Variable	Category	Mirt stove adoption				Chi-square	p-value
		Adopters		Non- adopters			
Marital		Frequency	%	frequency	%		
status	Married	59*	98.3	90	95.7	0.781*	0.377
	Single	1*	1.7	4	4.3		
	Total	60	100	94	100		

Source: Own survey data (2019)

Table.8.shows that out of 154 surveyed households, 149 are married in which 59 of them are Mirt stove adopters and 90 of them are non-adopters. From the total respondents 5 were single in which 1 is Mirt stove adopters and 4 of them are Mirt stove non-adopters. The majority (61 %) of married were found to be Mirt stove non- adopter while the 39 % of married were found to be adopter. This study showed that, marital status is statically insignificant since p-value is 0.377. From surveyed households 154, the majority 149 (96.7%) were married while 5 (3.3%) were single. Similar study by TigabuAlamir (2014) shows from surveyed households the majority of married respondents were non-adopters of Mirt stove technology.

4.3.4. Sex and Mirt stove Adoption

In this study from 154 surveyed households 140 were female and 14 were male. This is shown by table 9

Table 9 Gender and Mirt Stove Adoption

Variable	Category	Adoption				Chi-square	P-value
		Adopter		Non-adopter			
Sex		frequency	%	frequency	%		
	Female	58*	96.7	82	87.2	3.943*	0.047
	Male	2*	3.3	12	12.8		
	Total	60	100	94	100		

Source: Own survey data (2019)

Table.9.Shows the majority of the respondents 140 (91%) are female and 14 (9%) are male. When adopters and non-adopters compared from total females 140 in which 58(41.4%) of

them are adopters and the majority of them 82 (58.6%) are non-adopters. When compared adoption based on gender from total 60 adopters 58(96.7%) are females and 2 of them (3.3%) are male. From this what researcher understood was females are responsive to Mirt stove technology adoption than male. This study indicated that, gender is statically significant with p-value 0,047. This study was similar with previous study by (Adrianzén, 2009; Damte and Koch, 2011) which showed that, women headed households are more likely to adopt fuel efficient new technologies as compared to male headed households.

4.3.5. Literacy Level and Mirt Stove Adoption

Table 10 shows, from the total of 154 respondents, 83 (53.9 %) were found literate and 71 (46.1%) were illiterate. When compared adopter and non-adopter with literacy level from 83 literate households, 56(93.3%) of them are adopter and 27(28.7%) of them are non- adopters. On the other side from71 illiterate household surveyed, 4(6.7%) of them are adopters and 67(71.3%) of them are non- adopters.

Table 10. Literacy Level and Mirt Stove Adoption

Variable	Category	Adoption				Chi-square	P-value
		Adopter		Non-adopter			
Education		Frequency	%	frequency	%		
level	Literate	56*	93.3	27	28.7	61.526*	0.000
	Illiterate	4*	6.7	67	71.3		
	Total	60	39	94	100		

Source: Own survey data (2019)

From this finding one can understand that, literate households are found to be more likely Mirt stove adopters as compared to those illiterate households. This may be because literate

households are more likely to be aware of the benefits of improved cook stoves as compared to uneducated. This study revealed that, education is statically significant with p-value0.000 to mirt stove adoption decision. This finding is similar to the previous empirical works of (Puzzolo *et al.*, 2013; Damte and Koch, 2011; Inayat, 2011; Tsangari, 2010) 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.

4.3.6. Income of households and adoption of Mirt stove

Table 11.Income and adoption of Mirt stove

Variable	Category	Adoption				Chi-square	p-value
		Adopter		Non-adopter			
		frequency	%	frequency	%		
Income	High	48*	80	3	3.2	94.311*	0.000
	Low	12*	20	91	96.8		
	Total	60	100	94	100		

Source: Own survey data (2019)

As Shown in table 11, from the total households surveyed, 154 respondents 51 (33%) of them were high income earnings relatively from the local life standard of the study area and 103 (67%) of them were low income households. From the total 60 Mirt stove adopters 48(80%) were high income households, while the rest 12 (20%) households were low income households. According to this finding, high income households are more likely to adop Mirt stove than low income households. This implies that income is significant to mirt stove adoption decision with p-value 0.000.This study is similar with the study by (Duflo and Greenstone, 2008), Households at lower levels of income to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient

4.3.7. Separate Kitchen and Mirt Stove Adoption

Table 12 shows, out of surveyed 154 household respondents, 86(55.8 %) have separate kitchen house in which 60 of them are Mirt stove adopters and 26 of them are non-adopters. On the other side, 68 (44.2%) have no separate kitchen house in which all of them are non-adopters. From the total households the majority of the households 94(61%) are non-adopters. According to this research findings the reason of non-adopter for those who have separate kitchen but non-adopter of Mirt stove is lack of purchasing power due to budget constraint, lack of technical skill (technical support) and due to quality problem of the Mirt Stove produced.

Table. 12. Show: separate Kitchen and Mirt Stove Adoption

Variable	Category	Adoption				Chi-square	p-value
		Adopter		No-adopter			
Separate		frequency	%	frequency	%		
kitchen	Yes	60*	100	26	27.7	75.701*	0.000
	No	0*	0	68	72.3		
	Total	60	100	94	100		

Source: Own survey data (2019)

These study findings show that households who have separate kitchen are found to be Mirt stove adopters as compared to households that have no separate kitchen. This is because of its fixed nature and larger in size which requires larger space. As the result of this it requires having own house and it is difficult for those who live in rental house. This finding indicated that, separate kitchen is statically significant to mirt stove adoption decision with p-value 0.000.This result has similarity with the previous works of (Puzzolo *et al.,* 2013; Axen, 2012; Damte and Koch, 2011) that found households who have separate kitchen are more likely to

adopt improved cook stove technologies as compared to households that have no separate kitchen.

4.3.8. Mirt Stove Adoption and Perception on Price

This study was conducted to identify effect of price on Mirt stove adoption through asking the respondents three categorized questions, such as, Expensive, fair and cheap. From the total respondents 53 (34.4%) answered expensive, while 68 (44.2%) of the respondents answered fair and 34(21.4) of the respondents were answered cheap. From the adopters the majority answered that the price of Mirt stove is fair.

Table 13.priceand adoption of Mirt stove

Variable	Category	Adoption				Chi-square	p-value
		Adopters		Non-adopters			
		Frequency	%	Frequency	%		
	Expensive	5*	8.3	48	51.1	32.727*	0.000
	Fair	33*	55	35	37.3		
Price	Cheap	22*	36.7	11	11.7		
	Total	60	100	94	100		

Source: Own survey data (2019)

As table.13 shows, from the respondents who said the price is expensive 5 of them (8.3%) are adopters while 48 (51.1%) of them are non-adopters. From the respondents who said the price is fair 33 (55%) of them are adopters while 35(37.3%) of them are non-adopters. From the respondents who said the price is cheap 22(36.7%) of them are adopters while 11(11.7%) are non-adopters. As this study shows, the majority of the households 48(51.1%) of them who responded the price is expensive are non-adopters. This implies that price is statically significant to mirt stove adoption decision with p-value 0.000. This study is similar with study

by Levine et al (2013) found that inability of the poor to pay the cost of improved cook stoves is one of important barriers of adoption decision.

4.3.9. Mirt Stove Adoption and Source of Fuel-wood

As it is presented in Table .14, from the total of households 154 surveyed, 91 (59 %) get fuel-wood without charge in which 16(26.7%) of them are found to be Mirt stove adopters and 75(79.8%) of them are found to be non-adopters. On the other hand, 63 (41 %) get fuel-wood with charge in which 44(73.3%) of them are found to be Mirt stove adopters and 19(20.2%) of them are non- adopters.

Table 14.show: source of fuel wood and adoption of mirt stove

Variable	Category	Adoption				Chi-square	p-value
		Adopters		Non-adopters			
Source of fuel wood		Frequency	%	Frequency	%		
	With charge	44*	73.3	19	20.2	42.473*	0.000
	Without charge	16*	26.7	75	79.8		
	Total	60	100	94	100		

(Source: Own survey data 2019)

As shown in table 14, when compare those who get their fuel-wood without charge Mirt stove adopters 75 of them are non- adopters and larger than the proportion of those who get their fuel-wood with charge 44 were Mirt stove non-adopters. This analysis shows that, those who get their fuel-wood free of charge were found to be larger than those who Mirt stove adopters and those who get fuel wood with charge. This implies that the more a household's source of fuel-wood is with charge, the more likely to be found Mirt stove adopter and vice versa. This finding showed that, fuel wood is statically significant to mirt stove adoption decision since p-

value is 0.000 This finding is similar to the works of (Puzzolo *et al.,* 2013; Axen, 2012; Damte and Koch, 2011; Inayat, 2011) 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.

4.4 Determinants of Mirt Stove Adoption

In the previous section determinants of mirt stove adoption decision analyzed by using descriptive statistics/t-test and chi-square/. In addition to this analysis to identify and understand which variable is significant and which is not and the extent to which these factors affect Mirt stove adoption decision binary logistic model was employed as follow:

Table 15 variable included in logit model

Variables in the Equation

Variables	B	S.E.	Wald	Df	Sig.	Exp(B)
Marital status	-0.455	1.635	0.078	1	0.781	0.634
Fuel wood	3.281	0.789	17.307	1	0.000***	26.596
Income	4.923	0.859	3 2.874	1	0.000***	137.387
Price	-0.894	0.422	4.476	1	0.034*	0.409
Sex	2.632	1.531	2.957	1	0.086	13.908
Constant	-18.193	3.931	21.423	1	0.000	0.000

a. Variable(s) entered on step 1: marital status, fuel wood, income, price, sex.

The above result shows, from the variable included in analysis, income, fuel wood and price are significant with p-value less than 0.05 ($p<0.05$). The others variables studied in the study area were dropped in variable analyzed by logit model and analyzed by t-test and chi-square

test. The reason for dropping these variables from logit model was, there was multi-colonarity with each others. The results found from this regression were more interpreted as follow:

Fuel wood: With p-value of 0.00/at1%/ ($p<0.001$) and odd ratio of 26.6 a household's source of wood was found significant factor that affects households' Mirt stove adoption decision with marginal effect/slop/ of 3.281. The odd ratio of this variable indicate that Mirt stove adoption probability for a household that gets fuel-wood with charge is 26.6 times higher than a household that gets fuel-wood without charge. As it was expected getting fuel-wood without charge was found negative factor that affects Mirt stove adoption decision while getting fuel-wood with charge was found positive factor that affects Mirt stove adoption decision. This study is similar to previous works of (Geary *et al.,* 2012; Inayat, 2011; Pine *et al.,* 2011;Tsangari, 2010) that found access to open forest has significant negative effect on rural households' improved cook stove new technologies. This study also came up with similar findings of Axen (2012) and Troncoso *et al.,* (2007) that found lack of free access for open forest is positively correlated with the adoption of improved cook stoves in rural households.

Income: With p-value of 0.00 /at1%/ ($p<0.001$) and odd ratio of 137.387a household's income was found significant factor that affects households' Mirt stove adoption decision with marginal effect/slop/ of 4.923. This odd ratio indicate that Mirt stove adoption probability for a household that earn high income is 137.38 times higher than a household earn low income. As it was expected income of household was positively related to mirt stove adoption decision. This finding is similar with the study by (Duflo and Greenstone, 2008) that revealed households at lower levels of income to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient.

Price: With p-value of 0.034 ($p<0.05$) and odd ratio of 0.409 price of mirt stove was found to be significant factor that affects households' Mirt stove adoption decision with marginal effect/slop/ of -0.894. This odd ratio for price indicate that Mirt stove adoption probability for a household decreases by 0.409 times existing price. The marginal effect of -0.894 for price, also, indicates that the probability of Mirt stove adoption decreases by -0.894.As it was expected price of mirt stove was negatively related to mirt stove adoption decision. This finding is similar with the findings of Puzzolo *et al.,* (2013), Gebreegziabher *et al.,* (2010) and Makame (2007) that found price as one determinant factor that affects improved cook stoves adoption decision.

4.5. The major constraints related to adoption and expansion of Mirt stoves

As this study showed, the majority of households 94 (61%) in the study area were not found to be Mirt stove adopters due to different constraints and challenges. The major constraints identified by this study are; Lack of separate kitchen, price, Income, Source of fuel wood and institutional influence (Lack of awareness, technical supports, promotion and quality control) and social factors(.membership to social associations, active participation in social activities, the influence of information diffusion about the mirt stove technology ,and neighbors relation These constraints are listed in table below and discussed in detail as follows;

Table. 16. Show: constraints identified by household surveyed in the study area /response from non-adopter/

Constraints	**Response**	**Percent/%**
Income	91	96.8
Presence of fuel wood without charge	75	79.8
Lack of credit access	67	71.3
Lack of awareness	65	69
Absence of promotion on improved cook stove	51	54
Lack of technical support	23	24.5

Source: Own survey data (2019)

4.5.1. Lack of separate kitchen

Table.16 showed, out of 94 non-adopter surveyed 68 (72.3%) household responded lack of separate kitchen is the reason for we are non-user. This implies that, lack of separate kitchen is constraint for mirt stove adoption decision. This is because of its fixed nature and larger in size which requires larger space. As the result of this it requires having own house and it is difficult for those who live in rental house. The researcher argued that lack of separate kitchen is one of the major constraints of households' Mirt stove adoption decision. This result has similarity with the previous works of (Puzzolo *et al.*, 2013; Axen, 2012; Damte and Koch, 2011) that found households who have separate kitchen are more likely to adopt improved cook stove technologies as compared to households that have no separate kitchen

Figure 2.show: kitchen of Household who has her/his/own house and Mirt stove adopter in study area by observed

Figure 3.show household who live in rental house and Mirt stove adopter in study area.

4.5.2. Mirt Stove Price

As shown in from table 16. 48(51%) of non-adopter surveyed responded, increase in price of mirt stove is the reason for we are non- user of mirt stove. This result showed that unbalanced price of mirt stove is one of the constraints of mirt stove adoption decision. This study is similar with study by Levine *et al.,* (2013) found that inability of the poor to pay the cost of improved cook stoves is one of important barriers of adoption decision.

4.5.3. Income of the Households

The result of income showed in table.16.revealed that, 91(96.8%) of non-adopters surveyed responded they cannot afford due to low income and they used by three stone /open-fire/ by collecting fuel wood/dung, crop-residue/.This implies that, income is the main constraints of mirt stove adoption decision. Similar study with (Duflo and Greenstone, 2008), revealed that, Households at lower levels of income to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient.

4.5.4. Source of fuel wood

Table.16 above showed that, study showed 75(79.8%) of non-adopters surveyed responded there was enough fuel wood and get free of charge. This implies that, availability of fuel wood without charge is one of the constraints of Mirt stove adoption decision. Based on this the researcher argued that getting fuel-wood free of charge is one of the major constraints of households' Mirt stove adoption decision. This study is similar with study by Geary et.al (2012), found that the free availability of fuel-wood is one of the factors that lead to the decision not to adopt improved cook stoves. Source of fuel-wood is determinant factor of improved cook stoves adoption decision (Inayat, 2011).

4.5.5. Institutional factors/lack of awareness, lack of technical supports, absence of promotion on mirt stove and lack of credit access/

The study identified that, the institutional factors influence on households' Mirt stove adoption decision in the study area were absence of provision of services, supports and provision of Mirt stove production sites, absence of credit system for producers, absence of quality control system, lack of means of transport, the mandated governmental institution did

not set up system of promotion and awareness creation and absence of technical supports were analyzed. This information was information getting from group discussion. As showed on the table 16.above the result of the study findings from 94 Mirt stove non-adopters respondents in case of the institutional factors mainly affect the Mirt stove adoption decision of households were lack of credit access 67(71.3 %), while 65(69%) were responded lack of awareness (such as training, experience sharing, means information dissemination),51(54%) respondents answered absence of promotion on improved cook stove through media promotion, market promotion on site visit and 23(24.5%) of the households responded lack of technical supports. This study is come up with similar study by (Massawe *et al.*, 2015) the low level of knowledge and awareness about the merits of the ICS were among the reasons for non-adoption of ICS

4.5.6. Social Factors

Social factors explain social relationships and networks, membership to social associations, the influence of others, the influence of neighbors', the influence of family members and other variables. But, by this study as information obtained from key informants and group discussion the social factors identified as constraints of households' Mirt stove adoption were membership to social associations, active participation in social activities and the influence of information diffusion about the mirt stove technology .Based on this the researcher argued social factors has effect on households' Mirt stove adoption decision. Similar study by Adrianzén (2011), in northern Peruvian Andes confirmed that information diffusion during the adoption of new cooking technologies is essential, and highlights the importance of having an appropriate understanding of the village social structure, as this structure influences the degree in which local generated information will be shared and diffused.

CHAPTER FIVE

5. Conclusion and Recommendation

5.1 Conclusion

This study investigated the constraints and challenges of households' Mirt stove adoption decision in Welmara Woreda two kebeles by taking 154 household respondents systematically from the households.

The study first (1) Assessed the status of Mirt stoves adoption in Welmara Woreda, secondly(2) identified the relationship between household characteristics and Mirt stoves adoption and finally (3) investigated the major constraints related to adoption and expansion of Mirt stoves use. In assessing status of Mirt stove adoption in study area, from total surveyed households, (39 %) were found to be Mirt stove adopters. The main reasons for adopt to Mirt stove were time saving of fuel wood collecting, cleaner cooking(no indoor pollution) as the result of this improve households' health status, reduce environmental pollution and reduce deforestation. On the other hand, from the total surveyed households 94(61%) were found to be non-adopters. This implies that the (1) majority of the households were non-adopters of Mirt stove. To identify relationship between household socio economic characteristic and mirt stove adoption decision the socioeconomic characteristic data was collected and statically analyzed. The result obtained from statically analysis/t-test and chi-square test/ shows that, socioeconomic (2) characteristics of households were all significant to mirt stove adoption decision with p-value less than 0.05/$p<0.05$) except marital status which was insignificant to mirt stove adoption decision. The major constraints identified by this study were (3) Lack of separate kitchen, income of households, free availability of fuel wood, institutional factors and social factors.

5.2 Recommendations

Based on this study, literacy level or being educated or not has direct relation that means positive significance to Mirt stove adoption decision. In general, the following recommendations were given by researcher.

- Create awareness through promotion and information dissemination about this technology should be strongly continuous.
- The government should work strongly at national and Regional level by establishing institutions that supply credit for both producers and users.
- The government also encourage NGOs and association those who work on this technology in order to enhance Mirt stove technology adoption.
- In addition the local government experts such as Woreda energy office experts, agriculture office experts and kebele development agents (DAs) have to give continuous technical support to the households on improved cook stove use.
- The intervention of government required to reverse exist condition and needed to promote the technologies that enhance renewable energy use in order to realize green economy as well as environmentally friend and sustainable economic development is the recommendation of the researcher.

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Appendix

Annex –A- Household survey questionnaire

Woreda ……interviewer's Name ……..

Kebele ……Date of interview ……..

Code of sampled household ……interview starting time…… End time…….

Dear Respondents,

I am a student in Hawasa University, Wondo Genet College of forestry and natural resource management. I am starting a research study for my master of degree in renewable energy utilization and management. My study is on **adoption and constraints of improved cook stove use in Welmara Woreda Oromia region, Ethiopia** as part of research that aimed at investigating factors that affect households' adoption of improved cook stoves use in Welmara Woreda Oromia region, Ethiopia. Therefore, you are kindly requested to give your invaluable response for all the questions here in after. Your response will be highly appreciated and will be treated with confidentiality. It will only be used for academic purposes.

Please do not write your name or contact address on the questionnaire. Thank you for your invaluable response

I demographic Data

- Choose possible response and circle it.

1. Indicate your Gender: 0) female, 1).male
2. Indicate your age _____
3. Indicate your marital s 1) Married (0) single
4. Indicate your educational status: 0) illiterate,1) litrate

5. Indicate your family number _____

6. Have you separate kitchen: 1) yes, 0) No

7. What about fuel wood do you use? How do you get? 1) With charge, 0) without charge

II. Economic status

Table of appendix 1 Yearly Income of households.

No	**Source of income**	**Response**
1	Crop production	
2	Animal husbandry	
3	Monthly salary	
4	Trade	
5	Daily laborer	
6	Others, specify	

8.1 circle the following to indicate your average yearly income 1) high, 0) Low

(High= =36,000.00- 60,000.00, Low=27,000.00- 36,000.00)

III. Technology Adoption

9. Is the improved cook stove introduced in Welmara Woreda?

a) Yes b) No

10 .If your answer for question number '9', is yes' how many households are using from your local area? a).Large number b) Small number c) I hadn't information about this technology

11 11 .What type of improved cook stove introduced?

a) 'Mirt' stove c) Tikikil

b).Gonzye d) Mirchaye

e) Other specify _____

12 Are you using the improved cook stove yourself?

1).Yes 0) No

13.If your answer for question number '12 ' is yes' which type of improved cook stove you are using? A) 'Mirt' stove b) Gonzye c) Tikikil d) Mirchaye e) Others, specify _____

14.If you are using improved cook stove what benefit you gained?/reason out why did you use/ Answer can be more one make write mark in front of your choice)/for adopters.

Table of appendix 2 reason of adoption to mirt stove technology

	Reason	Response
A	Improve households' health status	
B	Save cooking time	
C	Reduce fuel wood consumption	
D	Reduce environmental pollution	
	Save time collecting fuel wood	
E	Minimize forest degradation	
F	Others benefit ,specify	

15. Who is the supplier of improved cook stove in your area? (Answer can be more than one makes write mark in front of your choice

Table of appendix 3 suppliers of improved cook stove

	Supplier	Response
A	Government	
B	NGO	
C	Private body	
D	. Others, specify	

16. If your answer for question number '12' is 'No' what is your reason? (Answer can be more than one makes write mark in front of your choice)/for only non-user/

Table of appendix 4 for non- user of improved cook stove

	Constraints	**Response**
A	Lack of awareness	
B	Lack of income	
C	Presence of enough fuel wood	
D	Lack of separate kitchen	
E	Problem of technical support	
F	Lack of credit access	
G	Due to the price increase	
H	Lack of quality control	

17. How is the attitude of the households towards the improved cook stove use?

a) Positive b) Negative

18. If your answer for question number '17' is 'positive' how you explain it?

a) It is very strongly demanded by households b) It is strongly demanded by households

c) It is demanded by households

d) Others, specify _____

IV. Questioners for key informant and Focus group discussion

A. Zonal and Regional Water and energy Bureau

1. How do you evaluate the effect of fuel-wood on improved cook stove expansion as a region?

2. How do you evaluate the role of government in improved cook stove expansion?
3. What are the major challenges or opportunities to expansion of improved cook stoves?
4. What measures are taken in order to create awareness for households on improved cook stoves use?
5. How do you measure the level of awareness of the rural households on improved cook stoves?
6. What is the rate of adoption as a region by type of improved cook stove technologies?
7. What is the future plan on improved cook stoves expansion

B. For Woreda level experts

1. When improved cook stove introduced in Welmara Woreda?
2. How do you evaluate the awareness of the households on improved cook stove use?
3. What measures are taken in order to create awareness for households on improved cook stoves use in Welmara Woreda?
4. How do you evaluate the attitude of the households towards the improved cook stove use?
5. What are the actions taken in order to change the attitude of the households towards the improved cook stove use?
6. What are the major challenges or opportunities to expansion of improved cook stoves in Welmara Woreda?
7. What are the factors affecting improved cook stove adoption?
8. Are there plans to further promote alternative sources of energy?

C. For Keble leaders and DA (kebele level expert)

1. What energy access available in your area?
2. Do you have an awareness of improved cook stove technology?
3. What types of improved cook stove technology introduced in your area?
4. Are the households adapted to improved cook stove use as you evaluate?
5. What are the major factors affecting the adopting the ICS?
6. Are there extension services related to domestic energy?

D. Questions for Focus Group Discussion

1. What are the major energy sources in your area?
2. Is there an energy source problem in your area? To what extent?
3. What are the measures being taken against the problem of wood fuel scarcity in your locality?
4. What is the acceptance status of improved cook stove technology in your area? Do you think the technology has been expanded to the expected level?
5. If you think adoption is low what are the main reasons?
6. What are the factors affecting improved cook stove technology adoption?
7. Do you think improved cook stoves use has a benefit? What are the main benefits?
8. Do the peoples have an awareness of environmental and health problems that results from using fuel wood as source of energy?

E. Stove producers

1. What initiated you to produce improved cook stove technology?
2. What types of improved cook stoves you are produce currently?
3. How do you evaluate their quality?

4. Do the price affordable for the users?
5. Do you have market access if you produce excess cook stoves?
6. What are the main challenges for large scale distributions of improved cook stoves?

What are the main problems facing you to produce the stoves