

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FACULTY OF BUSINESS AND ECONOMICS**

*Addis Ababa
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(Since 1950)*



***DETERMINANTS OF HOUSEHOLD DECISION TO ADOPT
FUEL EFFICIENT TECHNOLOGY: EVIDENCE FROM
IMPROVED ("MIRT") STOVE TECHNOLOGY
A Case in Adea wereda, East Shoa Zone***

By
Dawit Woubishet Mulatu

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University Department of Economics in Partial Fulfillment of the Requirements for Masters of Science in Economics (Natural Resource and Environmental Economics)

**March 2007
Addis Ababa**



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“Determinants of Household Decision to Adopt Fuel Efficient
Technology: Evidence from Improved (“MIRT”) Stove Technology
A Case in Adea Woreda, East Shoa Zone.”

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Dawit Woubishet Mulatu

Approved by the Board of Examiners:



Advisor




Signature



Examiner



Signature



Examiner



Signature



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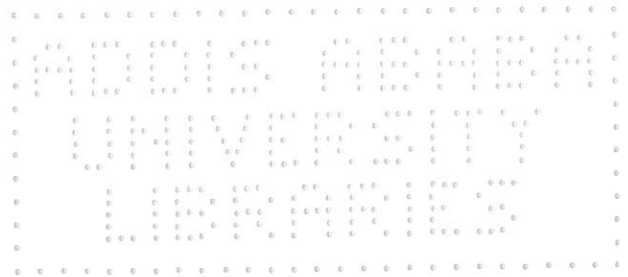
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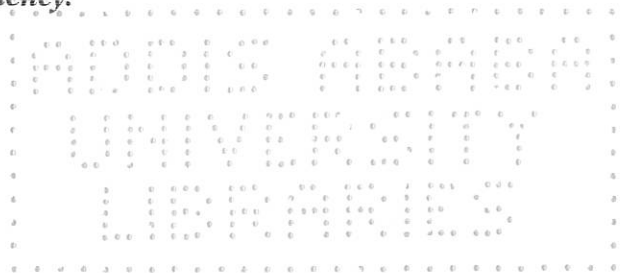
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Abbreviations

<i>Adea</i>	<i>Name of the study area</i>
<i>Birr</i>	<i>Ethiopian Currency</i>
<i>CSA</i>	<i>Central Statistic Authority</i>
<i>EEA</i>	<i>Ethiopian Energy Authority</i>
<i>EFAP</i>	<i>Ethiopian Forestry Action Plan</i>
<i>EREDPC</i>	<i>Ethiopian Rural Energy Development and Promotion Center</i>
<i>FDRE</i>	<i>Federal Democratic Republic Of Ethiopia</i>
<i>GTZ</i>	<i>Germany Technical Cooperation</i>
<i>Ha</i>	<i>Hectare</i>
<i>Injera</i>	<i>Traditional and main food item in Ethiopia</i>
<i>KW</i>	<i>Kilo Watt</i>
<i>Kebele</i>	<i>Sub-District (lower level administration of wereda).</i>
<i>LPG</i>	<i>Liquefied Petroleum Gas</i>
<i>OECD</i>	<i>Organization for Economic Cooperation and Development</i>
<i>Mirt</i>	<i>Improved stove technology in Ethiopia</i>
<i>MW</i>	<i>Mega Watt</i>
<i>MDG</i>	<i>Millennium Development Goal</i>
<i>TFC</i>	<i>Total Fuel Consumption</i>
<i>TJ</i>	<i>Tera Joule</i>
<i>Woreda</i>	<i>Sub-District (lowest level administration unit)</i>
<i>WB</i>	<i>World Bank</i>

Abstract

Energy is vital for economic development for both developed and developing countries. The need for energy in developed nations is a question of comfort but for developing nations it is a question of survival and poverty. The needs for energy in developing countries meet from biomass resource, these resources are heavily utilized and it has adverse effect on the environment and natural resource. And it is directly used by inefficient stoves; this direct burning of biomass has impact on the health of the poor (especially women and children), income, household environment and resource.

Improvement was made but success of many interventions in dissemination of efficient improved stoves in both rural and urban settings are not successful due to top down and supply nature of the programs, technology centered and lack of compatibility with the beneficiary groups. Therefore, those factors indicate the need for existing research to start from the target group not on the technology. The main objective of this study is to analyze the determinant factors that affect household decision to adopt fuel efficient improved stove technology and to acquire information about the technology. Evidence taken from improved ("Mirt") stove technology in "Adea" wereda, both in rural and urban settings. The study take in to consideration the socio-economic, demographic, dwelling characteristics, information diffusion and attitudinal variables of the households in the study area.

The increasing scarcity of biomass and the increment of the number of people who use biomass, particularly fire wood, threaten the capability of the country even to maintain the already existing low income and living standard of the people. Therefore, the need for adopting improved "Mirt" stove not only enables the households to use fuel efficiently, but also enable them to curb the problems caused by using traditional and open fire stoves as well as biomass energy related problems. It can also mitigate the impacts on the users' health, and the over all environment and natural resources brought by using those traditional and open fire stoves.

With two conditional equations, that is information and adoption equation. This study result reveals that improvement in socio economic conditions of the people have positive impact in acquisition and access information in urban and rural households. Moreover, the result supports the "energy Ladder" hypothesis as theoretical and functional useful framework to explain the fuel use and improved technology adoption in the study area. The finding also reveals socio-economic improvements also have direct and significant impact on adoption decision. This finding also reinforce the role of government and non government organization to play a major role in provision and diffusion of information and enhance the adoption decision of the people to protect the country natural resource and to resolve environmental problems that arise due to excessive utilization of biomass resources.

Key words: improved stove, information, adoption and "energy ladder"

I. INTRODUCTION

1.1. Background

Poor people are both the agents and the victims of environmental damage. Fuel-wood gathering can lead to land degradation, biomass combustion to indoor air pollution, dirty fuels to outdoor air pollution and through green house gas emission, global warming. In all these cases poor people both contribute to the environmental damage through their actions and suffer from its consequences. And the energy sector has a significant part to play in reducing the environmental damage and its harmful effects by introducing renewable energy source, supplying modern cooking fuels, and substituting cleaner fuels for dirty ones and increasing energy efficiency.

Ethiopia has integrated energy policy; the energy policy objective is basically to guarantee adequate and secure energy supplies to the nation to be used efficiently and sustainable. The objective should be realized at the lowest practical cost to the nation. While In Ethiopia traditional energy source have played and will continue to play a major role in supplying energy for domestic purposes; even though biomass fuel provides a renewable form of energy, they are profoundly over utilized there by contributing to serious environmental degradation.

Ethiopia has significant energy resource, this resource endowment is said to be enough to meet the present need and long term energy requirement of the country. Overall, only some of this endowment is being presently exploited (EEA, 1994). The main endogenous source of energy are biomass, hydropower, fossil fuel (natural gas, coal), geothermal, solar and wind.

The country's energy use and/or consumption are 95.6% from traditional sources and only 4.4% from modern sources. In terms of the level of sectoral use; household accounts for about 91.3% of the total final energy consumption. And biomass fuel account 98.5 % while the modern energy only takes 1.5%. With in the household sector the rural and urban household energy consumption accounts for 92 and 8%, respectively. (Asres, 2002)

Research results indicates that improved biomass stoves have merits which include ease of smoke removal, clean cooking comfort, fuel saving, modernity ,durability and helps to increase energy efficiency and conservation, thereby reducing the environmental impacts. However, dissemination are not successful due to different factors; such as lack of close investigation of the beneficiary groups and knowledge of the locality, the response of the target groups in different aspect about the technology is not clearly known, minimal promotional activity and information provision, and socio-economic, demographic, dwelling characteristic and attitudinal factors that deterred the poor households from taking those advantages through adoption of the improved stoves.

1.2 Statement of the problem

Energy is vital for economic development. Without fuel that power cars, trains and planes, and without electricity, light and heating, life in industrialized countries would be considerably less comfortable. In developing countries, however, it is not just a question of comfort. Poverty cannot be reduced without the greater use of modern forms of energy. Even now, around two billion people have no access to electricity, relying instead on traditional fuels such as dung and fuel-wood. Those who are fortunate in developing countries enough to have electricity, on average spend 12% of their income on energy; more than five times the average for people living in OECD countries. At the same time, the provision of energy services, especially the combustion of fossil fuels and biomass can have adverse effect on the environment. (WB, 2000)

Biomass conversion technologies both at primary and end use levels are highly inefficient resulting in great resource losses. In the vast majority of rural households, biomass fuel are burnt directly in open hearths and in urban households different types of stoves are in general used (according to the purpose they are required and the type of fuel in use), their fuel efficiency is not much better than those in rural areas. It is doubtless that the high demand for fuel-wood as cooking fuel in household has contributed significantly to the depletion of forest resources in the country. In the absence of improvement in the conversation devices (stoves) that household are employing in their day to day courses adverse environmental, social and economic impacts will continue to occur.

Improvements were made, but success of many interventions in dissemination of efficient fuel saving technologies in terms of the use of biomass energy and to different parts of rural and urban settings are often limited due to:



- *The top-down and supply led nature of the programs: which did not take in to account the practice and needs of end users (usually women).*
- *Technology-centered nature of programs: an over reliance on technology sometimes resulted in failure to recognize the broad social dimensions and the cross sectoral nature of the issue.*
- *The limited nature and scope of the program in relation to information dissemination and creating of awareness.*

Therefore, the stated factors indicate the need for research that focused on the target group, not on the technology.

Recent policy measures and research works by academician in promoting sustainable development has led to efforts to facilitate communities in adopting more efficient stoves, thus mitigating the environmental impact of fuel-wood collection and reducing the concentration of indoor air pollution and the burden of health hazards. This normative chain is based largely on the belief in an “energy ladder” as a theoretically and functionally useful framework to explain the dynamics of fuel and stove adoption and use. The ladder model suggest that with increasing affluence, a progression may be expected from traditional biomass fuel to more advanced and less polluting fuels.

Advancing up the energy ladder is also associated with increasing commercialization and cost of both stoves and fuel. For a number of developing countries, including Ethiopia, issues relating to energy choice and household energy transitions are important from policy stand point. Effort at encouraging households to make substitutions that will result in more efficient energy use and less adverse environmental, social and health impacts are advocated in many of these countries. But this requires, at a first step, research and analysis of factors that affect or determine household decision to adopt fuel

efficient technology patters in rural and urban areas. Information on this is limited and studies that have tried to quantify the effects empirically are even less forthcoming.

In Ethiopia, few studies have attempted to investigate the problem, constraint and factors affecting the household decision to adopt fuel efficient technology with the context of environment and natural resource protection. Tadelech (2001), considered the problem of population pressure and rural-urban migration and their impact on energy need in urban areas and analyzed the determinants of fuel-efficient technology adoption. She only looked at demographic and socio economic variables and her study were limited to two kebeles with in Addis Ababa. Hence, this study focuses on both rural and urban households. It is obvious that the rural household takes a significant share in energy consumption and the adoption of this technology is extremely low. Along with the socio-economic and demographic factors; dwelling characteristics, information diffusion and attitudinal or perceptions of the household to the technology are considered. The paper also provides knowledge and information with regard to promoting fuel efficient technology and conserving energy, forest resource and environment.

1.3 Objective of the study

The major objective of this study is to analyze the nature, problems and main determinant factors in households' decision to adopt improved fuel efficient technology and their impact on environment, fuel scarcity, household time and income.

Specific objectives are to:

- *Analyze factors that determine to acquire information on fuel efficient technology in households:*
- *Analyze factors that determine households decision to adopt fuel efficient technology:*
- *Analyze the contribution of this technology for conserving energy, fuel-wood and other energy sources:*
- *Derive policy implications and intervention on environment, natural resources and energy.*

1.4 Significance of the study.

Energy is vital for both developing and developed nations, significant share of environmental problem emanates from human needs for energy. Among the sector, the household sector accounts to large consumption of energy. To reduce the impact of energy consumption by the households, one possible solution is adopting fuel efficient technology. But the response of the household sector for fuel efficiency and adoption of efficient technology in the day to day course of household is not satisfactory.

This study focuses on the main determinant factors in households to acquire information and for decision to adopt fuel efficient technology. Beside, focusing on the factors affecting the utilization of technologies at household level, the result of the study would help to have a good understanding about the problems and to formulate or design methods of dissemination of these technologies.

The finding also helps to rehabilitate policy regarding energy, environment, natural resource and information. And the results have been anticipated to assist development practitioners, both governmental and non governmental organizations that are interested in alleviating poverty, satisfying the energy need of poor households and protecting natural resources.

1.5 Scope of the study.

Substantial energy saving can be attained by improving the end-use efficiency of the households fuel-wood use, in particular by improving the efficiency of cooking stoves. Improved fuel saving stove can be produced at low cost and dissemination programs can provide a cost effective solution to environment protection and improved livelihood.

In Ethiopia, projects involvement in this particular activity has not been well developed. One of the projects involved in production and dissemination of improved stove is an improved (“*Mirt*”) “injera”¹ stove, which is undertaken by GTZ- Household Energy and Protection of Natural Resources Project with the participation of private sectors in production and commercialization of the stove. Since “injera” baking alone accounts for significant amount of the total primary energy consumption and the critical importance of “injera” making in Ethiopian household, the study analysis and investigation is based on the improved (“*Mirt*”) “injera” stove in the study area.

1.6. Data source and methodology

1.6.1 Data source

The data employed to prepare this thesis is based on secondary and primary data: Attempt is made to use reference books with relevant literature and the relevant survey done by different organizations. Individual researchers published and unpublished works, journals and drafts papers on energy efficiency, technology adoption and diffusion, household energy, environment and natural resource and improved stove are considered. Statistical data collected from Central Statistics Authority (CSA), Ministry of Mines and Energy and GTZ- Household Energy and Protection of Natural Resource Project and currently known as GTZ-SUN energy.

¹ “Injera” is the traditional food of Ethiopian households.

Regarding primary data, the quantitative and qualitative data were collected from households' survey which will be undertaken in 210 households in "Adea" Woreda East Showa Zone in "Oromia" region. For the purpose of this survey, a well designed and structured questionnaire is prepared. A stratified sampling and random sampling technique are employed to select the sample household. At the first stage households classified in to urban and rural households. And with random sampling three kebeles are selected from each settlement and a random sampling technique are used to select the sample households.

1.6.2 Methodology

Descriptive statistics and econometrics methods are employed to analyze the data. Following previous studies of residential energy conservation and adoption decision of household were used in empirical analysis of household sector; economic factors, demographic variables, dwelling characteristics, information diffusion and perception of the household about the technology are considered to analyze the factors that determine the acquisition of information and adoption decision of the household. Particularly for adoption studies; when the dependent variable is dichotomous, using a random utility approach a Logit and Probit analysis are employed, through binary response model².

The most commonly used approach, notably, Logit and Probit models, assumes that the functional form of the dependence on the explanatory variables is known. The Logit and Probit models are typically estimated using maximum likelihood estimation procedure, for this study we use a Probit model from STATA 9.

² A binary response model is a regression model in which the dependant variable is binary random variable that takes only the values 0 and 1. In many economic applications of this model an agent makes a choice between two alternatives. The econometric problem is to estimate the conditional probability that the dependant variable takes the value one considered as a function of explanatory variables.

1.7 Limitations of the Study

The scope of the study is limited to generating information on household energy pattern and improved (“*Mirt*”) stove technology from households in “*Adea*” woreda. The major focus of the study was information acquisition and adoption decision on improved stove technology. Like other studies, absence of well organized and documented information about all households live in the area, is the major problem of this study. Shortage of financial resource and time has also limited the sample size to be only 210 households.

1.8 Organization of the paper

The remaining part of the paper is structured as follows: Chapter two focus on overview of Ethiopian energy situation and Chapter three deals with the review of theoretical and empirical literatures. Chapter four is concerned with the methodological review and model specification is discussed. Under this chapter: survey design and administration and the definition of variables and their hypothesized sign are included. Chapter five is results and discussions. The last Chapter is devoted to conclusions, and recommendation with policy implications of the study, followed by references and appendices.

CHAPTER II

Energy Situation in Ethiopia

2.1. Over view of Ethiopian energy

Energy is one of the most important basic commodities which determines the progress, status, and the well being of any society and deserve a considerable attention by both government and the public in general. In Ethiopia, fast and continuous development of energy will be required to improve the standard of living of the highly increasing population. The growth of energy demand in Ethiopia is expected to occur partly in response to population growth and partly as a result of the economic growth process.

Economic growth initiates various processes including industrialization, the shift of population to urban centers and the subsequent rise in demand in motorized transportation. An increase in energy consumption will also be necessary to sustain increase in the welfare and living standards of the population. While traditional energy sources such as fuel-wood, charcoal and agricultural residues provide a significant share for Ethiopian energy consumption. However, the availability of these traditional sources decreasing. This will imply that non-traditional energy resources including different renewable energy resources will meet the increasing share of energy demand.

Energy problems in Ethiopia have complex characteristics, which include: institutional, policy related, demographic, technological, promotional, financial, settlement related and others. No single entity can afford to tackle those problems except devising system approach where every member in the system (energy sector system) plays his role actively. Commitment and purpose oriented approach should be valued significantly backed by sustainable financial and technological input to bring into reality the vision of stakeholders in energy sector.

2.2. Energy demand and supply

Energy demand has similar meaning with energy consumption and energy supply is directly related to the resource potential readily available for exploitation, which is known as dependable reserve.

A. Energy demand composition by sector

In principle, energy development is demand driven. Due to different factors and traditional or backward nature of resources use in the socio-economic condition of the country, the demand for energy is very low as compared with resources potential we have. This is simply reflected in the low per-capita consumption of the different energy sources and also small value of sectoral energy consumption. (Table-2-1)

Table 2.1: Sectoral energy consumption by fuel type as of 1991 E.C (TJ)

Fuel Type	Woody Biomass	Crop Residues	Dung	Charcoal	Electricity	Petroleum	Total	%
Final consumption	581,352	54,450	56,330	8,785	4,841	40,476	746,238	100
Household	542,141	52,010	53891	8,565	1,832	7,332	665771	89.2
Urban	34,969	2,824	3,263	5,856	1,832	4,161	52,905	7.1
Rural	507,172	49,186	50629	2,709	-	3,171	612867	82.1
Agriculture	0	0	0	0	0	1,497	1,497	0.2
Transport	0	0	0	0	0	26,743	26,743	3.6
Industry	17,101	1,409	1,396	112	1,864	4,573	26,455	3.5
Services	22,110	1,031	1,046	109	1,145	331	25,772	3.5
Total	77.5	7.0	8.0	1.2	0.7	5.4	100.0	

Source: Rural Energy Development and Promotion Center, Ministry of Mines and Energy.

Energy consumption in agriculture, industry, and transport and services sector is very low. The lion share goes to the rural households sector. According to CSA welfare survey (2004), with in the households sector major source of cooking fuel is collection of fire wood for rural households contribute 80.7% and 70.5% for the country level. About 49.3% of the urban households use commercial sources of fire wood. This indicates that majority of the Ethiopian households depend on biomass energy sources for their day to day activities, particularly in fuel-wood (Table 2-2).

Table 2-2 Distribution of households by type of cooking fuel currently using (2004)

	Country level	Urban households	Rural households
Collect fire wood	70.50%	15.98%	80.72%
Purchased fire wood	10.93%	49.35%	3.73%
Charcoal	1.34%	7.65%	0.16%
Kerosene	2.36%	13.84%	0.21%
Butane gas	0.48%	2.69%	0.07%
Electricity	0.41%	2.36%	0.05%
Crop residue	11.49%	5.29%	12.65%
Don't use cooking fuel	0.35%	1.91%	0.05%
Others	2.10%	0.81%	2.34%
Not Stated	0.03%	0.11%	0.01%
	100%	100%	100%

Source CSA, Welfare Monitoring Survey .2004.

B. Energy supply composition by source type

Recent studies indicate that the greater proportion of renewable energy development and utilization in the country is biomass, especially fuel-wood. On the contrary, the supply of other renewable energy such as solar, wind, micro-hydro-power, biogas, and geothermal is very discouraging compared with their resource potential (Table-2-3.) However, no doubt that the country is highly endowed with large amount of these diverse renewable energy sources.

Table-2.3 Major renewable energy sources (exploitable versus exploited potential in Ethiopia)

Type of energy source	Units	Exploitable potential	Exploited potential	Percentage share (%)
Woody biomass	Million tons	37/yr	40/yr	8.0+
* Animal & crop waste	Million m ³ of gas	10.6	0.1776	0.02
Solar	Kwh/m ²	5-6	1200KWpeak	
Wind	M/s	3.5-5.5	100pumps	
Geothermal	MW	700	7.3	1.0
Hydro-power	MW	30,000	670	2.2

*- the data is only for biogas from cattle dung.

Source: Rural Energy Development and Promotion Center, Ministry of Mines and Energy.

Most of the resources in the country are renewable, except natural gas (2.7 TFC) and the coal (70 million tons) reserves. Energy supply in the form of directly burned wood biomass has offset demand by 8%. Firewood and charcoal take the significant share of this consumption (Table 2-3). This trend is still there since the population is growing with no considerable effort to reverse the situation. However, no exhaustive data could be obtained to estimate the use of other renewable energy technologies, where as nationwide it is very insignificant. Small hydropower plants with a capacity of 100MW, solar with 35 to 100MW, wind, biogas, and geothermal all together did not exceed 2000 units which means that they are at very infant stage of development.

The main problems related to energy demand in Ethiopia are poor efficiency, less diversification and limited research activities. Problems related to energy supply are poor exploitation, traditional or inefficient sources and technologies, poor level of technological adoption, lack of focus on renewable energy sources, limited diversification in technological innovations or adoption/adaptation and others.

2.3. Nature of fuel-wood demand and supply in Ethiopia

Fuel-wood, which is highly consumed by the households, it is the preferred renewable and dominant source of energy in Ethiopian economy. The practice of excessive deforestation, intensive cultivation of steep slopes and overgrazing, which resulted in environmental degradation in the country, together with other factors has created heavy shortage of fuel-wood resources or energy crisis.

In Ethiopia the household sub-sector is the major consumer of energy and almost the entire energy demand of this sub-sector is met from biomass sources. Poverty, the state in which about half of the population of Ethiopia is existed, is instigating among the others, by the fast degradation of the natural vegetation of the country. The ever increasing need for existing biomass energy is among the factors that constitute major causes of this degradation. All regions of the country are in short of biomass energy supply to meet their current level of demand. In year 2014, the supply of fuel-wood for the country is estimated to be only about 10% of the demand. Therefore , the fact that scarcity of the biomass energy on one hand and the continuously increasing fuel prices on the other are suggesting that , timely and continuing intervention are required to halt the household energy problem in this country.(Getachew 2002)

The demand, especially for fuel-wood, which is driven by high population growth, has led to mass deforestation and soil erosion, which now threatens agricultural production and productivity and also food security. In many parts of the country, unsustainable exploitation of biomass resources has resulted in adverse economic and environmental impacts.

According to EFAP³, about 150000-200000 ha of forest land per annum would be affected by deforestation. The production and consumption of fuel-wood estimate indicated that wood provided 78%, while dung and crop-residue supplied 16% of energy required. The gap between sustainable fuel-wood supply and demand is continuously widening. The demand of the household for forest product also exceeded by far than the annual incremental yield. The household sector is the major consumer of the energy accounts for about 89% of the over all energy consumption. Therefore, some possible interventions are proposed to narrow the gap, the main interventions are:

- *The introduction and intensification of the use of improve stove (Closed stove) over open fire stove to improve end-use efficiency, it is one of the main demand side intervention.*
- *The implementation of large scale re-forestation and a forestation program in all areas of forest resource production, through participatory programs and approaches. (See on Annex 5, the projections with and with out interventions)*

2.4. GTZ-SUN Energy project

The Ministry of Agriculture and GTZ, The German Development Cooperation, in 1998 have launched an improved stove dissemination program to promote biomass energy efficiency in households. The main objective of the project is defined as “The efficient use of biomass resources has been improved by integrating household energy measures into development plan”. And the overall goal of the project is to contribute to environmental protection and sustainable environmental development. The project focuses on the dissemination of improved (“Mirt”) stove fuel saving for “ingera” baking. The

³ EFAP Ethiopian Forestry Action Program

technology choice has been taken on the ground that baking “injera” alone takes a significant share of the primary energy consumption.

The improved (“*Mirt*”) stove has been under extensive research and testing by the Ethiopian Rural Energy Development and Promotion Center (EREDPC) in the beginning of 1990s, when the stove was introduced in Addis Ababa market. The improved (“*Mirt*”) stove has certain features that make it particularly suitable for commercial dissemination approach, among them:

- *It has double the efficient of an open fire and saves up to 50% of biomass fuel at household level.*
- *It reduce smoke emission and fire hazard*
- *It has a modern design and clean and convenient to use*
- *It accommodates different type of fuel.*
- *It can be produced from locally available materials.*
- *It is marketable product which allows production and marketing by small and micro enterprises.*

The project strategy is based on the following key elements:

- *Focus on commercial stove dissemination*
- *Encouraging private sector participation in production and marketing.*
- *Promoting decentralized production*
- *Enhancing the capacity of public institutions and organizations to promote energy efficiency*
- *Promoting public awareness on energy and environment issue.*

According to GTZ-SUN⁴ energy project, the impact of improved stove dissemination program become effective, the proper installation and usage of the “Mirt” stove in 10,000 households is expected to result in the following benefit.

- *Fuel-wood saving amount to 5.7 tons per year*
- *Household energy expenditure saving amount to about 2 million per year.*
- *Annual fuel-wood saving are equivalent to 750-1000 ha of eucalyptus plantation*
- *Avoid re-forestation cost (based on eucalyptus plantation) amount to 4,750,000 Birr per year*
- *Reduce indoor air pollution, improved health condition and kitchen hygiene (environment).*
- *Reduce net carbon emissions responsible for global warming*

Table 2-3 Efficiencies of cooking devices

Type of appliance	Efficiency
Three stone fire stove	5---10%
Improved “Mirt” injera stove	18---25%
Improved “Lakech” charcoal stove	20---30%
Kerosene stove	30---40%
LPG stove	60---70%
Electric stove	70---80%

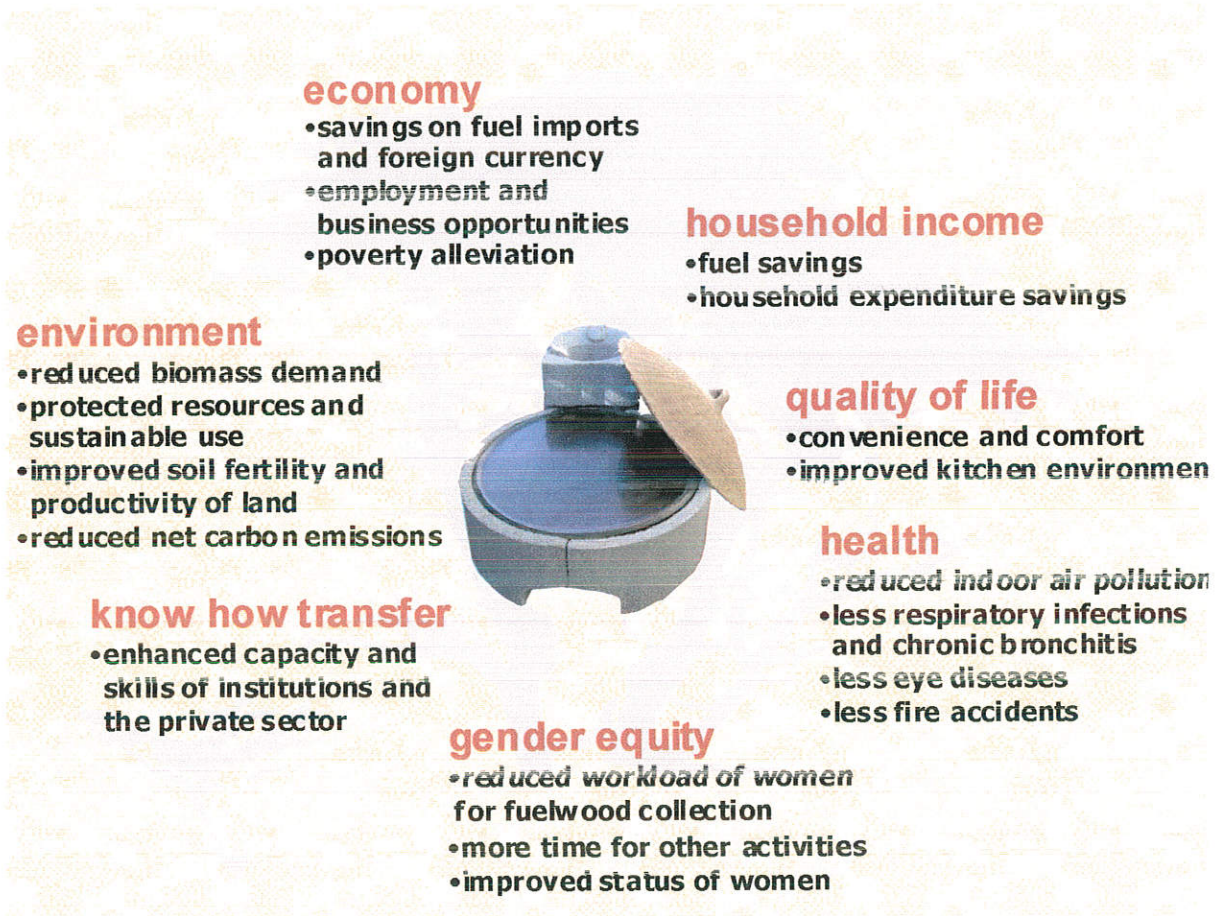
SOURCE: Renewable energy and development, GTZ-SUN energy, April 2004

A ten percent efficiency of the three stone stove means that 90% of the fuel is vain and its energy does not reach to the cooking pot.

⁴ GTZ-SUN Energy: A project financed by The German Development Cooperation for sustainable energy and protection of natural resource and environment, and food security.

In general, impacts of improved energy efficiency:

Figure 2-1 Impact of improved energy efficiency.



Source GTZ-SUN Energy

CHAPTER III

3. 1 Theoretical Background

3.1.1 Energy-Environment Interaction

From the mid 1970's on wards, the rapidly increasing cost of all forms of energy, led by the world oil price, stimulated the development of new analytical tools and policies. (Munasinghe,1980). First, the need became apparent for greater coordination between energy supply and demand options. Second, energy-Marco-economic link-began to be explored more systematically. Third, the more disaggregate analysis of both supply and demands with in energy sector offered greater opportunities for inter fuel substitution (especially away from oil). Fourth, the analytical and modeling tools for energy sub sector planning became more sophisticated. Fifth, in the developing countries, greater reliance was placed on economic principles, including the techniques of shadow pricing. Finally, heightened environmental concerns have led to a better understanding of energy – environmental interactions.

The environmental and health consequences associated with various cycles of energy production and consumption is, for a large part, very similar among energy sources. Differences may exist mainly in terms of the magnitude of those effects. Major disruptions in the environment and health impacts are linked to biomass energy from gathering and combustion.

Gathering of fuel-wood and removal of crop residues or animal manures in the course of using biomass as fuel have; for instance, been argued to contribute to serious deforestation in the long run, increased incidence of floods, stream sedimentation, and decreased water yields from watersheds. Excessive removal of agricultural residues or animal dung affects soil fertility, and exposes soil to increase wind and water erosion. Biomass combustion has the potential to create indoor air pollution, if wood stoves are improperly installed. It has been reported that increased background ozone levels in

rural areas due hydrocarbon emissions. Among the emission control method, improved stove technology is one of the alternative choice for most developing countries because biomass is the most important source of energy and its wide spread nature of use by the poor people.

3.1.2 The Energy Ladder Hypothesis

The most comprehensive hypothesis regarding energy use pattern of households focuses on the concept of “energy ladder”. The energy ladder depicts various combinations of fuels used by a household at its different stage of development. With movements up the ladder, fuel mixes are generally considered as clean and efficient. This is also directly correlated with income growth, bringing about an increased use of modern fuels and less use of biomass (Israel, 2002). The basic assumption of energy ladder is that a household is faced with a range of different energy supply choices, which can be classified in order of increasing technological sophistication.

Households use fuel for variety of activities, including cooking, water heating, lighting, and space heating. The order of different fuel types on the energy ladder can vary according to this end use. For cooking Munasinghe and Meier (1993), for example arranged the range of different energy leader as follows: first, dung and crop residues (which are inferior quality biomass fuels, and grouped at the bottom of the ladder); second, fuel-wood and charcoal (relatively higher quality biomass fuels and placed in the next step); third, kerosene; forth, Liquefied Petroleum Gas (LPG); and finally, natural gas and electricity.

As the economic status of a household rises, reduced use of lower quality fuel type and switch to consumption of relatively higher quality ones occurs. As a result, the household is said to move up in the energy ladder. If, on the other hand, the economic status of a household declines, then it is

expected to consume a relative inferior quality fuel. In this regard, Hosier and Dowd (1988) point out that energy ladder acts as a stylized extension of the economic theory of a consumer. That is, as household increases its income, it makes a decision not only to consume more of the same good, but switches towards consuming other goods of higher quality.

3.1.3 Theoretical background on energy conservation determinants

Economic theory suggests that, in order to gain comfort and time households are becoming excessive energy users, neglecting the environmental impact of their choices. According to household production theory, households are treated as productive units organized to provide services for the occupants; energy is treated as input in the provision of a range of household services. Consumers' choices define the utility they can derive (Becker, 1965; Muth, 1966). The extent of service that we can derive from a given amount of energy depends not only on the efficiency of the technology but also the consumers' lifestyle. Several theoretical and empirical studies focused on households' energy conserving behavior and its links with socio-economic parameters, which hint at lifestyle changes.

In the context of residential energy use, lifestyle should reflect the understanding that environmental responsibility and concern for energy sources go part and parcel with our daily energy based actions (Held, 1983). This demand-conscious lifestyle does not necessarily imply curtailment or sacrifices as far as the level of comfort or the quality of living are concerned. On the contrary, this approach is centered on an altered awareness of energy consumption in our daily lives.

As coomer (1977) claimed a significant decrease in energy consumption may mean a perceived lifestyle change and should not be identified by means of reduced quality of life or social status, and as Leonard-Barton (1981) defined in a discretionary change of lifestyle, a low energy lifestyle is

characterized by ecological awareness and attempts to become more self-sufficient users, known as voluntary simplicity lifestyle.

Van Raaij and Verhallen (1983) and Weber and Perrels (2000) specified that lifestyle approach should take into consideration a broader socio-cultural concept. In this concept, lifestyle patterns are shaped as a consequence or enduring activities with regards to time, housing, family and income conditions that households face and partly as a way or self-expression and self-realization.

3.1.4 Energy, Technology and “Market Reform” Policies

To understand the potential for public policy to affect energy efficiency, we also need to understand the process through which technology evolves: invention, innovations, diffusion and product use. Policies can affect each stage in specific and different ways. Invention involves the development of new idea, process, or piece of equipment. This activity takes place in laboratory or in research activity. The second stage is the process of technology innovation, in which new process or products are brought to the market. Another way of describing this stage is commercialization. The third step is diffusion, the gradual adoption of new processes or products by firms and individuals, who then also decide how intensively to use new products or processes.

Market failures in the choice of energy efficient technologies could arise from a variety of sources. Some of these are relatively uncontroversial, at least in principle, such as in adequate private sector incentives for research and development and information shortages for purchasers regarding the benefits and costs of adopting technologies. Other potential market failures are more controversial. For example, to what extent is small scale investment in energy efficiency limited because of financial constraints is the best example.

Aside from market influences, public policies also can affect the diffusion of more energy-efficient technologies. Policies that raise the cost of energy will induce the diffusion extant of energy-efficient technology as well as the development of new-technologies. This opens the question of whether additional non-price policies are needed to promote energy-efficient, “climate-Friendly” technology advancement and investment. Proponents of such policies argue that economic incentives are not adequate to change behavior. They advocate public education and demonstration programs; subsidies for the development and introduction of new technologies; institutional reforms, and technology standards, such as the use of renewable energy sources for energy need.

No one doubts that such approaches might eventually increase energy efficiency. Most economic analysis recognizes that energy use suffers from inefficiencies, but remains skeptical that large no-regret gains exist. Economic analysis also acknowledges a role of government when consumers have inadequate access to information or if existing regulatory institutions are poorly designed. This can include subsidies to basic research and developments, reform energy sector regulations and reduction of subsidies that encourage uneconomic use; and provision of information about new technological opportunities.

3.1.5. Theoretical Foundations for Adoption

The basic concepts of adoption and diffusion of innovations have received considerable attention over the years. The individual processes of adoption and diffusion can be integrated as component parts of the larger process of social change. Zaltman and Lin (1971) have developed a summary paradigm of the social process that provides an interesting perspective on this relationship. The basic components are (1) the innovation itself, that is, some “new” product, method, or idea; (2) an individual who decides to adopt the innovation, thus exhibiting innovative behavior, and (3) the diffusion of the innovation through a social system. As more individuals make an adoption decision.

The concept of innovativeness can be considered at several levels. Traditionally, it has been defined as “the degree to which an individual is relatively earlier in adopting an innovation than other members of his system” (Rogers and Shoemaker 1971, p. 27). This is an operational and behaviorally observable measure of the hypothetical trait, innate innovativeness.

Additionally, discussion has focused on the attributes of innovations and the measurement of adopters’ perceptions of these attributes. The attributes most commonly considered include:

- *Relative advantage, or the degree to which the innovation is perceived as being superior to the idea or product it replaces;*
- *Perceived risk, the expected probability of economic or social loss resulting from innovation;*
- *Complexity, the extent to which the innovation appears difficult to use and understand;*
- *Compatibility, the degree to which the innovation is seen as consistent with the innovator’s existing values, past experiences, and needs;*
- *Trial-ability, the extent to which one can experiment on a limited basis with the innovation;*
and
- *Observability, the degree to which the results of innovating are visible to others.*

The Rogers and Shoemaker (1971) work indicates that individual perceptions of these attributes affect the rate of adoption of an innovation, or the relative speed with which an innovation diffuses through a social system (typically expressed as the length of time elapsing before some percentage of the system had adopted the innovation). Ostlund (1974) extended this research to predict innovativeness (adoption versus non adoption) by individuals on the basis of their perceptions of the innovation attributes. The relationships between attribute perceptions and innovative behavior were generally positive, with the exception of perceived risk and complexity. That is, adopters of an innovation rated

it higher in relative advantage, compatibility, trial-ability, and observability, and lower in perceived risk and complexity.

3.1.5.1 Adaptation strategies

Hardesty (1986) defines adaptation as; (1) a mechanism for coping with a host of problems such as limits on energy, hazards, and a variety of other constraints, and; (2) a way in which humans take advantage of new resources or environmental conditions and create new ecological niches. Consequently, the adaptation can be defensive where the households cope within different constraints and structures, or offensive where they, through new options, overcome constraints that are imposed by their physical-technical environments (Tognoli 1987).

The possibility of developing adaptation strategies is dependent on the household's environmental structure. Buildings and technical systems can, to a varying degree, extend or limit the possibilities for taking actions. As long as the physical technical system does not fulfill the individual's demands of comfort, control, costs and security, a latent readiness in the individual to act will exist.

Based on this theoretical review, three a priori themes focusing on the relationships between households and their environment are formulated:

- At an increased pressure to change, households will not respond directly. But, if the pressure continues to grow, as a result of increased prices or other events, households will change their behavior, or they will take actions to change their physical-technical environments, in order to take off the pressure. When households consider the situation as satisfactory, they will, however, gradually routine their new behavior. Accordingly, after a period of change a phase of normalization will occur, and the households will adhere to their new patterns of action.



- If the pressure to change is extended for a longer period, the households will endeavor to maximize their options to secure their energy services.
- Depending on the pressure to change, the physical-technical environments and their lifestyles, households will develop different adaptation strategies. Some of these are defensive, i.e. households adapt within the framework that is imposed by the physical structure. Other strategies are offensive and the households try actively to broaden their possibilities of taking actions.

3.2 Empirical Evidence

There are some empirical studies that focused on the determinants of household decision to adopt fuel efficient technology, energy conserving and the link between improved stove technology and health, income, environment, fuel use and its implication for development in different countries. Findings of these set of empirical work are organized here.

Barbara D. et. al. (2000), this study tests the applicability of energy ladder model in environmentally homogeneous but socio-economically stratified villages in Mexico. By taking in to consideration the improved Lorena stove and traditional three stone stove in Jaracurarch village. The result presents an important and interesting alternative to energy ladder socio-economic advancement model. Lorena stove present several advantages; their proper use can save 30-40% of the average fuel-wood requirement of traditional stoves. In addition, the average total suspended and carbon oxide concentration associated with the “Lorena” stove can be half that of the traditional models. The study also reveals increase in socio economic status resulted in better kitchen and cooking environment in household. However, it is dependant on careful training, installation, management and education. In communities with active improved cook stove promotion and construction programs, the Lorena’s have been quite successful and in considerable demand among the wealthy and the poor alike.

Douglas et.al (1994), the study result stated that with increasing income people generally move up the energy ladder from fire wood to charcoal or kerosene and then liquefied petroleum gas, natural gas or electricity for cooking. This upward shift occurs usually in urban areas because in rural areas scarce cash income combined with freely available resources leads people to continue to rely on biomass in many parts of Africa. The increase in national income has barely kept pace with the increase of population over the last decades; so some household have had to switch back from modern fuels to

biomass. Besides, poor distribution systems for modern fuels have prevented many families from switching to it.

Hosier and Dowd (1987), the study test the energy ladder hypothesis empirically for household fuel choice in Zimbabwe using a Multinomial Logit model which shows that although economic factors do affect household fuel choice, a large number of other factors are also important in determining household fuel choice. In addition, fuel switching is often not complete and it is a gradual process with many households often using multiple fuels. The reasons for multiple fuel use are varied and not dependent on economic factors alone, although the affordability or cost of the energy service has an important bearing on the household's choice. In some cases, households choose to use more than one fuel because they want to increase security of supply. In other cases the choice might be dependent on cultural, social and taste or preferences.

Reddy (1995), the paper looks at household energy carrier choices, for a sample households residing in the city of Bangalore, India. He employs a series of binomial Logit models to determine the choice between each pair of energy carriers, to explain the shift in and the pattern of consumption of different fuels used for cooking and water heating. The study result confirms the hypothesis that households ascend an energy ladder and the choice is largely determined by income. However, factors such as family size and occupation of the head of the household are also seen to play a significant role in fuel selection amongst households in Bangalore.

Erick Boy et. al. (2000), this study reports on the fuel efficiency of a popular wood burning stove (The “Plancha”) in western Guatemala, in comparison with the traditional open fire stove. In five days test of routine cooking, the improved “Plancha” is found to use 39% less fuel-wood than the open fire. The fuel efficiency and pollution emitted from bio-fuel stoves have important implication for a number of interrelated aspects of development, including health promotion, protection of environment and the household economy. The study also emphasized that the dissemination of improved stoves like “Plancha” have implication for the majority of poor people living in developing countries.

Vigay Laxmi et. al. (2003), this paper indicates that the use of unprocessed bio-fuels for cooking is interlinked with many other factors such as socio-economic conditions, availability of alternative fuels, cooking practices, health impacts, gender equality and housing characteristics. The analysis of the data collected from the rural areas of Rajasthan, Covering 6403 females and 5552 males from 1989 households in 13 villages. The result reveals that women undergo a lot of burden due the use of bio-fuel. The economic burden of bio fuel use generally women and female children are involved in collection and transportation of fuel-wood in rural areas of Rajasthan. The total time required for gathering and transporting the fuel is about 3 billion person-hours per year. This time, if utilized for some productive work, would improve the economic status of these women. The total loss to the economy due to this at nominal wage rate of Rupees 60 per day for 10 hour of work, then the society loses approximately Rupees 19 billion per annum. It is clear that not all of this time allocate for income earning activity, for many reason such as child labor, low efficiency, low skill and scarce opportunity for employment. But if 25% of the time can be utilized for productive purposes, it might be able to generate funds for the rural economy to transform some of the villages.

According to Arnold as cited Hosier (1995), discussed that fuel consumption depend on the availability of wood. Wood –poor areas show lower consumption rate than wood-rich area. And the problem of income elasticity of demand for fuel-wood by saying that for rural area fuel use is relatively insensitive to changes in income, while in urban areas income elasticity is slightly positive due to the dependency on commercial fuels. This shows the role of each energy source varies with the type of settlement. In rural areas fuel-wood, other biomass and animate energy are the major source of energy while the mix is diverse and the choice is wide in urban settings. The main reason for not utilizing non- fuel-wood energy source both in rural and urban area is the high cost of acquiring the required stoves and appliances. For example it was mentioned that in urban Upper Volta, the three stone stove for burning wood costs nothing, while a butane stove and a bottle can cost more that USD 50.00. This shows that for many households appliance cost are unaffordable.

Elleni Sardanou (2005), this paper develops an empirical model to investigate the main determinants of household energy conservation patterns in Greece employing cross section data. In empirical analysis household energy conserving choices models are employed, using a discrete and latent trait variable respectively as dependent variable. The result shows that socio economic variables such as consumers' income and family size are suitable to explain differences towards energy conservation preferences. In addition, the result suggest that electricity expenditures and age of the respondent are negatively associated with the number of energy conservation actions that consumer is willing to adopt. Other variables such as environmental information feedback and consciousness of energy problems are characteristics of the energy conservation measures.

Held (1983), the study raised a critical question for researchers of energy conservation and energy efficiency determinants. Why does households decision towards energy use diverge not only from what it seems effective for an economic point of view but also from environmental one? Information

seeking was another path of investigation, which was assessed. Information diffusion tends to be a voluntary and communicative strategy for activating energy conserving behavior. As Scott (1997) stressed, on survey of 1200 households in Ireland, the households' sense of small potential economic savings from adoption of energy saving and conserving actions is attributed to lack of information. Whereas Schipper and Hawk (1991) reported that consumers not only may lack the information about costs and benefits of energy efficiency improvements but also may not understand how to use the available information.

Stern and Gardner as cited in Elleni Sardanou (2005), the paper argued home ownership prescribes the type of energy conservation behavior that residents would adopt. More precisely, efficiency measures are more available to consumers and to homeowners, whereas curtailment may be the only option for renters. In addition, Black et.al (1995), based on answers of 478 residents of Massachusetts during summer of 1980, and argued that homeownership had strongest direct effect on investment in energy efficiency. They observed that homeowners gain the personal benefits of investment, either in comfort energy saving, property values, or whatever, whereas renters are not likely to invest their money to improve the energy efficiency. Brandon and Lewis (1999) substantiated the above mentioned conclusion and added that people living in rented accommodation might not have the right, as tenants, to invest in energy efficiency improvements of their homes.

Duncan G. et. al., (1981), this study examines residential solar energy systems with in an adoption and diffusion of innovations framework. The finding indicates considerable difference between adopters and non-adopters on many measures. Comparing the adopters with the general population, the adopters are younger, more highly educated, higher income, earlier in the family cycle and higher in occupational status. Comparing the perception of adopters with the perception of the general population sample, adopters find that solar energy system offer advantages over other energy sources.

Additionally they evaluate solar systems to be less financially risky, less socially risky less complex, more compatible with their personal values, and less observable by others.

Albert N. (2004), the paper present an adoption model of resource management technology derived from a three step decision process (information, adoption and intensity of adoption). The Probit estimation of the information and adoption models at farmer's level gives results that are globally statistically significant. The result reveals that the demand and supply of information in relating fallow system technology adoption are statistically significant by the farmers' age, the active participation of the farmers in the acquisition of informal information, the effort of official extension services and the agricultural wage rate. The influence of the farmer's age is negative; revealing that younger farmers are more active in gathering information related to the natural resource management technologies. The influence of access by farmers to official services and non-official means of information are positive, revealing the synergistic effect of both variables in acquisition of information. The wage rate has a positive impact on information acquisition.

Berhanu (1998) conducted a study on the pattern and determinants of urban household energy consumption in Nazareth and the prospects of the Nazareth fuel-wood Project. Attempt is made to analyses using multiple correlation or regression model. Total energy consumption is identified to be positively affected by household income, family size and number, potential functional index and efficiency of household appliances. But the situation is different when one looks at traditional and modern fuels separately. Income negatively explains consumption of traditional fuels. This emanates from the shift of households to modern fuels with rising income. Family size also explains consumption of traditional fuels negatively and less significant.

Unlike traditional fuels consumption, a modern fuel is positively affected by income and family size. Assessment of pattern of end uses of household energy is other areas of the study. It is identified that, fuel-wood is largely used for baking among the majority of the people while it is also used for cooking among some of the lower income group. Cow dung used for cooking and baking in poor households. Crop residue and charcoal almost exclusively used for baking and cooking among the majority of the households, respectively. Charcoal is the major cooking energy source for medium income group. On the contrary, electricity is used for diversified functions with increasing income though it is commonly used for lighting among all household that use electricity and for cooking and baking by the rich households. This study assessment confirms the energy ladder hypothesis in Ethiopia while the main focus of the study is on the consumption of fuel-wood in urban settings of Nazareth.

Tadelech (2001), under her study held by considering the population pressure and rural-urban migration have impact on the energy need of the people. The study analyze factors affecting the use of fuel saving technology at household level by taking the case of two weredas' in Addis Ababa. The finding of the study reveals that the probability of owning the technology is higher in male-headed households than female headed. Family sizes, education level of the respondent have a positive impact on the decision to adopt the technology. Household income is highly significant factor for decision to adopt the technology. This shows that with higher income, a higher probability of adopting the technology than those who are found in the lower group. However, the study focused on urban households in Addis Ababa.

CHAPTER IV

METHODOLOGY

4.1 Methodological Review

One of the most important developments in econometrics in the past years has occurred in the area of qualitative response models. Qualitative response model also known as quintile, categorical or discrete models. In these statistical models the endogenous random variables takes only discrete values. Qualitative response model have been extensively used in biometric application for a much longer time than they have been used in economic applications. The kind of Qualitative Response model used by biometricians is usually the simplest kind-a univariate dichotomous dependent variable (survival or death) and a single independent variable (dosage) (Amemiya, 1981).

There are numerous different types of qualitative response models in different situations. What they have in common is that, they are models in which the dependent variable is an indicator of a discrete choice, such as "Yes or No" decision. In general, conventional regression methods are inappropriate in these cases. Details of proof for most of these models can be found in surveys done by Amemiya, (1981), G.Maddala, (1983), Dominich and Mc Fadden (1975).

Inmost of the cases we shall study, the values taken by the dependent variables are merely coding for some qualitative outcomes. None of these situations lends themselves readily to our familiar type of regression analysis. Nonetheless, in each case, we can construct models that link the decision or outcome to a set of factors, at least in the spirit of regression. Our approach will be to analyze each of them in general frame work of probability models:

$$\text{prob (event } j \text{ occurs)} = \text{prob } (Y=j) = (\text{relevant effect, parameters}) \dots\dots\dots 1$$

The study of qualitative choice focused on appropriate specification, estimation and use of models for the probabilities of events, where in most cases, the “event” is an individual’s choice among set of alternatives. (Green-2003)

A binary response model is a regression model in which the dependant variable is a binary random variable that takes on only the value zero and one. In many economic applications of this model, an agent makes a choice between two alternatives. The econometric problem is to estimate the conditional probability the dependant variable equal to one or zero considered as a function of the explanatory variables.

One possibility is to retain the familiar linear regression,

$$F(X, \beta) = X' \beta \text{-----}2$$

Since $E(Y/X) = F(X, \beta)$ we can construct the regression model,

$$Y = E[Y/X] + (Y - E[Y/X]) = X' \beta + \epsilon \text{-----}3$$

Equation (4.1.3) is a linear probability model, it is estimated by fitting a straight line to the observation on X and Y by ordinary least square. The linear probability has a number of shortcomings. A minor complication arises because ϵ is hetroscedastic in a way that depends on β . Since $X' \beta + \epsilon$ must equal 0 or 1, ϵ equals either $-X' \beta$ or $1 - X' \beta$, with probabilities $1 - F$ and F , respectively. Thus,

$$Var[E/X] = X' \beta (1 - X' \beta) \text{-----}4$$

We cannot constrain $X'\beta$ to the 0-1 interval. Such a model produces both nonsense probabilities and negative variances. For these reasons, the linear model is becoming less frequently used except as a basis for comparison to some other more appropriate models.

The defect can be corrected by replacing the linear function with one a lower kink that keeps the conditional probability from being less than zero and an upper kink that keeps it from being greater than one; it is a cumulative distribution function. The cumulative distribution function of a probability distribution is an S-shaped curve that has a lower bound of zero and an upper bound of one. If F is a cumulative distribution function, the conditional probability is automatically constrained to lie between zero and one.

In principle, any proper, continuous probability distribution defined over the real will suffice. The normal distribution has been used in many analyses giving rise to the Probit model,

$$Prob (Y= 1/X) = \int_{-\infty}^{X'\beta} \phi (t) dt = \Phi (X' \beta) \text{-----}5$$

In equation (4.1.5), the function $\Phi (.)$ is a commonly used notation for the standard normal distribution. Partly because of its mathematical convenience, the logistic distribution: (ibid)

$$Prob (Y=1/X) = \frac{e^{X'\beta}}{1 + \exp^{X'\beta}} = \Lambda (X' \beta) \text{-----}6$$

Equation (4.1.6) has also been used in many applications; we use the notion $\Lambda (.)$ to indicate the logistic cumulative distribution function. This model is called Logit model.

The logistic and normal distributions are both symmetrical around zero and have similar shapes except that the logistic distribution has flatter tails. As a result, the conditional probability functions are very similar for both models, except in the extreme tails.

The probability model is a regression:

$$E(Y/ X) = 0 \{1 - F(X' \beta)\} + 1 [F(X' \beta)] = F(X' \beta) \text{ -----7}$$

What ever distribution is used, it is important to note that the parameters of the model, like those of any nonlinear regression model, are not necessarily the marginal effects we are accustomed to analyzing.

It is obvious that these values will vary with the values of **X**. In interpreting the estimated model, it will be useful to calculate this values at, say the means of the regressors and where necessary, other pertinent values. For convenience, it is worth noting that the same scale factor applies to all the slopes in the model.

For computing marginal effects, one can evaluate the expressions at the sample means of the data or evaluate the marginal effects at every observation and use the sample average of the individual marginal effects. Another complication for computing marginal effects in binary choice model arises because **x** will often include dummy – variables. Since the derivative is with respect to a small change, it is not appropriate to apply for the effect of a change in a dummy variable or change of state. The appropriate marginal effect for a binary independent variable, say, **d**, would be:

$$\text{Marginal effect} = \text{prob}(Y=1/x(d), d=1) - \text{prob}(Y=1/x(d), d=0) \text{ -----8}$$

Where $x(d)$, denotes the means of all the other variables in the model simply taking the derivative with respect to the binary variable as if it were continuous provides an approximation that is often surprisingly accurate. (Ibid)

4.2 Model specification

The model begins with the information held by the household, the potential adopters. It would be misleading to categorize the population of household in to adopters and non-adopters; if not all members of the potential adoption community are informed. The adopting households are therefore those that are informed about the existence of the technology and find it efficient. Thus the adoption decision is conditional on the other decision such as the need for information.

4.2.1. Information Equation

A common practice in adoption studies is to divide the adoption population in to adopters and non-adopters with out worrying about whether all members of household of the potential adoption population are informed about the existence and utilization the technology under the study. This usually results in inefficient and biased estimator. Then, if in any community, some potential adopters are not informed about the existence and how to use the technology, the information equation should be the first equation of adoption model (Seha. et al 1994)

Let us take a household with a level of information equal i^* and let i^0 be the threshold of level of information that a household should have in order to be classified as informed. Then the household is informed if $i^* > i^0$

By defining the latent variable Y^{H*} as $Y^{H*} = i^* - i^0$ the condition to classify a household as informed becomes

$$Y^{H*} = i(X^H) - i^0 > 0 \text{ -----} 9$$

Where subscript H stands for “Household has heard that the technology exists and knows how to use it”

X^H = vector of household characteristics and attributes that could influence i^* , say the supply and demand of information

Then the theoretical equation to be estimated is then.

$$Y^{H*} = X^H \cdot \beta^{H*} + \epsilon^{H*} \text{} 10$$

Where β^{H*} = Vector of parameter to be estimated

ϵ^{H*} = error term

i^*, i^0 and consequently Y^{H*} are not observable. To estimate the information equation, we need to construct a variable that account for whether the household is aware of the technology and how to use it. Let denote that variable by Y^H . Which takes the value 1 for a positive answer ($Y^{H*} > 0$) and 0 for a negative or null answer ($Y^{H*} \leq 0$).

The theoretical Probit equation to be estimated is therefore:

$$Y^H = \Phi(X^H \cdot \beta^H) \text{} 11$$

Where β^H = vector of parameter to be estimated

4.2.2. Adoption equation

After the information equation formulate, the adoption equation is conditional on the information, if the household is not informed; in such cases, it is not possible to consider adoption. Household may well inform about the existence and use of the technology but there are different factors that affect the decision of the household whether to adopt or not. Therefore, adoption equation formulates to analyze only for informed households.

The Probit Model is used to identify factors that affect the probability of adopting the improved (“Mirt”) stove technology. In this study, households are informed about the existence and how to use the technology, which they may adopt or not. Hence, it is a single bounded dichotomous choice model to be framed under the random utility method (approach). The random utility model also provide convenient approach and the point of departure is a utility model that is composed of two parts, one observed by the analyst, the other treated as random.

Dominich and Mc Fadden (1975) used a random utility approach, permit a more systematic look at the primary determinants of adoption behaviour and make possible a systematic sensitivity analysis of the predicted probabilities of adoption decision to changes in key explanatory variables. The model uses the random utility approach; the household chooses the technology because it provides a maximum expected utility among the choice. And Khanna (2001) also use a random utility approach under the study of sequential adoption of site specific technology and its implication for Nitrogen productivity.

Haab and McConnell (2002) quoted Hanemann (1984) also developed the basic model to analyse dichotomous responses based on the random utility theory. The central theme of this theory is that

although an individual knows his/her utility certainly, it has some components which are unobservable from the view point of the researcher. As a result, the researcher can only make probability statement about respondent's 'YES' or 'NO' responses or decisions.

Let us consider the decision of a household regarding whether he/she adopt the improved ("Mirt") stove or he/she adopt the traditional or open-earthed stove for the household baking appliance. Let assume that the utility associated with each mode of appliance is a function of the mode of characteristics (compatibility and complexity) of the stove to the user (Z_j), the individual socio-economic and demographic attributes and characteristics (H_j), dwelling status of the individual house (D_j) and fuel cost (expense), and members of household participate for collection of fuel-wood and other energy source for the household energy need (C_j) plus a random component of the given indirect utility.

Let's define that indirect utility function for the j^{th} household can be specified as follows:

$$U_{ij} = U_i(Z_j, H_j, C_j, D_j, \epsilon_{ij}) \text{-----12}$$

Where $D_j = j^{\text{th}}$ respondent's dwelling status.

$H_j =$ vector of household socio economic and demographic characteristics and attributes.

$Z_j = j^{\text{th}}$ household response about the compatibility and complexity of the technology.

$C_j = j^{\text{th}}$ household cost (expense) for fuel, and members of household participate for collection of fuel-wood and other energy sources for the household energy need

ε_{ij} = random component of the given indirect utility

$$U_{1j}(Z_j, H_j, C_j, D_j, \varepsilon_{1j}) \text{-----} 13$$

Equation (2) represents the household utility function with the baking appliance (stove) in the house is the improved ("Mirt") stove technology.

$$U_{0j}(Z_j, H_j, C_j, D_j, \varepsilon_{0j}) \text{-----} 14$$

Equation (3) represents the household utility level with the baking appliance (stove) in the house is the traditional or open hearth stove technology.

The household is introduced about the improved ("Mirt") stove technology and knows improvement in household energy efficiency and environment; the household adopt the improved ("Mirt") stove technology if and only if:

$$U_{1j}(Z_j, H_j, C_j, D_j, \varepsilon_{1j}) > U_{0j}(Z_j, H_j, C_j, D_j, \varepsilon_{0j}) \text{-----} 15$$

For the researcher, however, the random components of preferences cannot be known and he/she can only make probability statement of "YES"/ "Adopter" or "NO"/"Non-adopter" of the technology. Thus, the probability that the respondent says "YES"/ "adopter" is the probability that he/she decided that he/she is better off in adopting the technology.

For individual j, the probability statement is:

$$P(Yes) = [U_{1j}(Z_j, H_j, C_j, D_j, \varepsilon_{1j}) > U_{0j}(Z_j, H_j, C_j, D_j, \varepsilon_{0j})] \text{-----} 16$$

This probability statement provides an intuitive basis to analyse binary responses. Assuming that the utility function is additively separable in deterministic and stochastic preferences:

$$U_{ij}(Z_j, H_j, C_j, D_j) + \varepsilon_{ij} \text{-----} 17$$

Given the additive specification of the utility function the probability statement for respondent j becomes:

$$P(Y_{es}) = [U_{1j}(Z_j, H_j, C_j, D_j) + \varepsilon_{1j} > U_{0j}(Z_j, H_j, C_j, D_j) + \varepsilon_{0j}] \text{-----} 18$$

This probability statement is the point of departure for the linear utility function in a set of covariates, which is assumed by our empirical model.

The household adopt the technology if the utility they get from improved (“Mirt”) stove is greater than the traditional or open fire stove. However, the adoption decision of individual household is conditional on the acquisition of information. This procedure needs to be sequential and let denote the vector of explanatory variables that explain adoption decision by X^A . Then, we obtain the following theoretical model:

$$Y^{A*} = X^A \cdot \beta^{A*} + \epsilon^{A*} \text{-----} 19$$

Where: β^{A*} , vector of parameters to be estimated,
 ϵ^{A*} , error term

The latent variable Y^{A*} is not observable and we defined by its proxy Y^A taking a value **One (1)** for adopters and **Zero (0)** for non-adopters for the sub-sample of informed households ($Y^H=1$). Thus, the conditional Probit model to be estimate is then:

$$Y^A = \Phi(X^A \cdot \beta^A) \text{-----} 20$$

Equation (11) and (20) are model of sequential, adoption of one technology based on information acquisition. As in Khanna (2001), under the study of sequential adoption components of technological packages and just making the substitution of technological component for decision. It is possible to say: since decisions (information and adoption) are interrelated, single equation are inefficient because they ignore the correlation of error terms of equations that explain each decision. This correlation arises because the same unobserved characteristics may influence all inter-related decisions.

For the empirical estimation, Let us assume that $(\varepsilon^H, \varepsilon^A)$ has a bi-normal distribution. That is:

$$(\varepsilon^H, \varepsilon^A) \text{BVN}(0,0;1,1, \rho) \text{-----} 21$$

Where: ρ is the correlation coefficient between ε^A and ε^H .

Under the above assumption, the conditional probability of the adoption decision given by equation (22) (see Seha et al., 1994; G.S Maddala, 1983)

$$\begin{aligned} & \text{Prob}(Y^A = 1/Y^H = 1) \\ & = E[Y^A / (i^* - i^0) > 0] = \Phi(X^A \cdot \beta^A) + \rho \cdot \frac{\phi(-X^H \cdot \beta^H)}{1 - \Phi(-X^H \cdot \beta^H)} \text{-----} 22 \end{aligned}$$

Note $\alpha = -X^H \cdot \beta^H$ and $\lambda(\alpha) = \frac{\phi(\alpha)}{1 - \Phi(\alpha)}$; $\lambda(\alpha)$ is the inverse of Mills' ratio. Then, we have

$$\text{Prob}(Y_A = 1/Y_H = 1) = \Phi(X_A \cdot \beta_A) + \rho \cdot \lambda(\alpha) \text{-----} 23$$

Φ and ϕ are the functions of cumulative distribution and normal probability density, respectively.

For traditional Probit and Logit estimations, only element $\Phi(X^A \cdot \beta^A)$ is considered in equation (23), resulting in inconsistent estimators β^A . More importantly, application of traditional Probit and Logit estimations that ignore self-section would result in biased estimates of marginal effect on probability of adoption of a variable X_j that is common to vectors X^H and X^A .

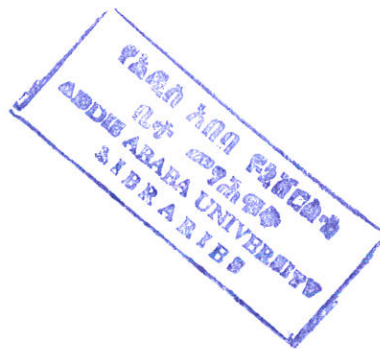
From (23), we have:

$$\frac{\partial \text{Prob}(Y^A = 1/Y^H = 1)}{\partial \chi_i} = \Phi(X^A \cdot \beta^A) \beta_j^A + \rho \cdot \beta_j^H \cdot (\lambda\alpha - \lambda^2) \text{-----} 24$$

If the possibility of self-section is ignored, the second element of the right side of equation (24) will be omitted. For all parameters to be identified, X^H and X^A should differ at least in one independent variable.

Therefore, the maximum likelihood estimates of parameters β^A , β^H , ρ can be obtained from maximizing the following log-likelihood function, which rests on the definition of conditional probability:

$$\ln L = \sum_{Y^A=1, Y^H=1} \ln \Phi_2[X^H \beta, X^A \beta^A, \rho] + \sum_{Y^H=1, Y^A=0} \ln \Phi_2[X^H \beta^H, -X^A \beta^A, -\rho] \\ + \sum_{Y^H=0} \ln \Phi[-x^H \beta^H] \text{-----} -25$$



4.3 Survey Design and Administration

Adea is selected for this study as it is one of the major urban and rural centers of the country with severe forest degradation and fuel-wood and other energy source problems. The data type used in the study mainly includes primary and cross-sectional for the time period of 2006. Data sources were mainly on survey conducted for this purpose and relevant documents from *Adea* Municipality and Rural Administration Office. The primary data were collected by making a household survey with questionnaire having five parts: household information; household energy pattern; fuel use; cooking pattern, kitchen environment and improved stove and household perception, and attitude towards the improved stove technology.

After designing the draft questionnaire, pre-testing of the questionnaire was conducted through a focused group discussion with municipality officials, producers of the improved stove, and fifteen randomly selected households. The purposes of the pre-test were to make some possible modifications in the design of the questionnaire for the main survey, so that objectives of the survey can be met.

Based on the pre-test the order of the questionnaire was restructured, making questions on household characteristics (particularly questions with economic characteristics, income, for which households were reluctant to give true responses).

First, the *Adea* wereda divide into rural and urban households. To identify the well informed households⁷; for urban households GTZ-SUN energy Project organized a demonstration activity about the improved (“*Mirt*”) stove technology in different places and time. It is estimated that about 30000 household attend the demonstration activity in *Adea* wereda. For rural households the rural development agent’s in collaboration with GTZ-SUN Energy Project provided training and

demonstration about the stove in church, local people associations meeting and in extension training programs. According to GTZ-SUN energy in *Adea* wereda approximately 6,856 stoves are distributed of which 1,596 and 5,260 in rural and urban households, respectively.

For consistency of data analysis, for urban households those who attend the demonstration activity effectively had been considered as well informed and know very well about the improved ("*Mirt*") stove technology and those who did not attend the demonstration activity effectively are considered as not well informed about the technology. And for rural households, who are not actively participate in demonstration activity by development agents and weak in extension participation and training programs are considered as not well informed about the technology.

A Stratified and random sampling technique was used for the study. Due to lack of well documented information on number of households and their location for the newly established 9 urban and 27 rural kebeles from each settlement; three kebeles were randomly selected. The rural kebeles' were selected from the surrounding eleven kebeles which is near to the town of "Debrezeit". Then from each selected urban and rural kebeles 30 and 40 households are randomly selected, respectively. Time and financial limitations were taken into account and random sampling technique employed to select a sample population of 210 households for this study.

Seven enumerators, four of them diploma holders in rural development and three college students and two supervisors including the researcher, participated in the main survey. For this purpose, a two-day long training was given to the enumerators on nature of the survey and how to administer it. The survey was conducted from September 10 up to November 3, 2006. Finally, the data collected was coded and prepared for analysis using Excel and STATA 9 for econometric analysis.

4.4. Description of variables and their hypothesized sign

1. **Age:** Number of years the household heads live, Age has a negative relation with acquiring of information and adoption decision. The younger households are more active in gathering and acquiring information and they are active in decision making.
2. **Dummy for Sex of household head (DHEADH):** It takes a value **one (1)** for male headed households and **zero (0)** otherwise. The probability of acquiring information is high in female-headed than male-headed. It is also hypothesized that the head of household has a direct relationship with adoption of improve stove technology; male-headed household could possess modern and improved technology than female headed household.
3. **Income⁵:** The monthly gross income of the household. Energy ladder hypothesis reveals that as the socio-economic and income of the household increase (improve), the household move from one energy ladder to better. It is from dirty fuels to more clean one and also adopt modern appliance in their house. Therefore, household income has a positive impact on both information acquiring and adoption decision.

⁵ The log of monthly income is considered in this study.

4. **Dummy or Availability of modern energy source (electricity) for household lightning (DELECTRIC):** It takes **one (1)** if the households have access to modern energy source (electricity) and **zero (0)** otherwise. If households have access to modern energy would able to acquire formal sources of information. And it is positively related to the demand and supply of information or acquiring of information about the stove. The probability of acquiring information is higher in households which has electricity than those households without electricity.
5. **Dummy for access to credit (DACREDIT):** takes a value **one (1)** if the households obtain credit facility during the last six month and **zero (0)** otherwise. Having access to credit enhances the household capital shortage and household can attain to hold fixed assets. Therefore, having access to credit has positive impact on adoption decision and information acquiring.
6. **Family size (FAMILYSI):** The number of household or members of household live in the house. As the family size increase, the probability of adoption and access to acquire information also increase and it has a positive relation with both variables.
7. **Dummy for households participation in local associations (DACTIVEPAR):** **one (1)** if the household actively participate in local association and **zero (0)** otherwise. Participation in association has a positive contribution to have ac access to informal sources of information. The probability of acquiring information is high in households that are actively participating than the households who are not active in participation.
8. **Dummy for location of household access to the market for improved (“Mirt”) stove (DMARKET):** which is the presence of producers of the improved (“Mirt”) stove is the area. It takes value **one (1)** if there is a produce in the area or existence of market and **zero (0)** otherwise.

Household near to the market (producers) have higher access to information and access to market have also positive impact on information acquisitions.

9. **Dummy for dwelling status of the household (DDWELLSTA):** The “ownership of dwelling” is also a standard of living indicator. It takes **one (1)** if the household is the owner of his house and **zero (0)** otherwise. A head of household who is the owner of his house, to certain extent master of the management of his dwellings’ space (mainly space for storing fuel and to decide on free places and space). Therefore, the probability of adoption decision is higher in owners than tenants or household who live in rent and kebeles’ house.

10. **Dummy for existence of external and separate kitchen (DSEPKITCH):** take a value **one (1)** if the household has a separate kitchen to baking and cooking activities and **zero (0)** otherwise. The existence of external and separate kitchen is an indicator of household’s dwelling standing and its standard of living. The probability of decision to adopt this technology is higher in a household who has a separate kitchen than those who use in their living room, shared kitchen or open air place. Because having separate kitchen mean the household is independent in utilization of the stove.

11. **Dummy for household response on technology which has a relative advantage, compatible and lower complexity (DCOMPATIB):** It takes **one (1)** for positive or **Yes** response and **zero (0)** otherwise. The probability of household adoption decision is higher in household with positive or yes response than no or no idea response.

12. **Dummy for marital status (DMARSTAT): one (1)** if the household is married and **zero (0)** otherwise. The probability of decision to adopt and to acquire information about improved stove is higher in married household than non-married households.

13. **Members of a family participate to collect fuel for the household (MEMFORCO):** The capacity of the rural household to participate in fuel-wood and other sources of energy collection. If the household can participate more of its member for collection, the less the decision to adopt the technology, while if the household members are less to participate for collection, the higher the probability for decision to adopt the technology.

14. **Dummy for spouse education (DSPOUSEDU):** takes **one (1)** If the spouse of the household wife able to write and read and above and **zero (0)** otherwise. The probability of adoption decision and information acquisition is higher in educated spouse (wife) than illiterate spouse. Spouse education has a positive relation with information acquisition and adoption decision.

15. **Fuel expense (fuelexp):** Household monthly expenditure for fuel need and this variable consider for adoption decision in urban household, and as expense for fuel increase, household tend to decide to adopt efficient appliance in their house. There is a positive relation between expense for fuel and adoption decision.

16. **Dummy for the household head education (DEDUCATIO): one (1)** If the head of the household educational level is primary and above and **zero (0)** if the head is illiterate. It is widely accepted fact that there is a direct link between openness towards innovations and information with improvement in educational level.

CHAPTER IV

EMPIRICAL FINDINGS: RESULTS AND DESCUSSION

“*Adea*” wereda, which is 45 km far from Addis Ababa, is found in Oromia region. “Bishoftu”, the capital city of *Adea*, was also established after Ethiopian-Djibouti railway had been operational, in 1917 E.C. *Adea* has been serving as an administrative center for different levels of administrations since the incumbent government controlled the country. Following the range of reform program by the current government, *Adea* wereda administration is divided into two administrations: “Bisheftu” Urban Local Government (BULG) and the *Adea* Wereda Rural Administration (AWRA). Having administered fifteen kebeles for a long period of time, the administration has recently reduced the number of urban kebeles to 9 and also introduced 27 rural kebeles to put good governance in to effect.

The total area of the town is about 4320 hectares. According to the strategic planning team of the town, the population of “Bishoftu” city is estimated at 136,072 of which 49 and 51% were males and females, respectively. According to the *Adea* Rural Wereda Administration, the rural population is estimated at 141,436 of which 52% are males and 48% females.

Apart from having suitable weather, very hospitable people and diversified culture and tradition, the city has also beautiful and breathtaking creator lakes: “Babogaya”, “Hora”, “Arsedi”, “Bishoftu” and “Kuriftu”. It is no doubt that these creator lakes will generate a considerable tourism income if they are to use properly. There are also two other shallow lakes called “Chlleleka” and “Chefe”.

5.1 Descriptive results

The household level data were collected to get comprehensive picture of socioeconomic conditions, Characteristics of the dwellings, pattern of using energy , contribution of improved stove for household kitchen environments and its advantage for fuel saving, clear picture of problems related to traditional and open fire stoves, and further information on cooking and baking activities.

Energy use pattern includes information on consumption of fuel-wood and other energy sources, measures taken during fuel shortage, time and effort exerted in gathering and collection of fuel, and source of fuel for the households. Dwelling characteristics also include information on dwelling status, number of rooms, and presence of separate kitchen for cooking and baking activities.

5.1.1 Socio-Economic Characteristics of the households

On average 11% of the rural households were female-headed and 89 % were male-headed while the proportions in urban areas were 64 and 34%, respectively. Household age ranges from 20 to 83 years and the sample average equals 47 and 50 years for rural and urban households, respectively. About 78 and 64% of the rural and urban households, respectively, were married. However, the average household consisted of seven individuals for rural areas, ranging from one to eighteen members and five individual for urban areas (Table 5-1-A and B).

TABLE 5-1-A FAMILY SIZE, AGE, MARTIAL STATUS AND HEAD OF THE RURAL HOUSEHOLD

Family size	Freq	%	Age	Freq	%	Martial status	Freq	%
1-3	10	8%	20-30	15	12.5%	Married		
4-7	58	48%	31-40	16	13%	Yes	93	78%
8-11	44	37%	41-50	31	25.5%	NO	27	22%
>11	8	7%	51-60	41	34%	Head of the household		
			>60	17	15%	Male	106	88%
						Female	14	12%
Total	120	100%	Total	120	100%	Total	120	100%

TABLE 5-1-B FAMILY SIZE, AGE, MARTIAL STATUS AND HEAD OF THE URBAN HOUSEHOLDS

Family size	Freq	%	Age	Freq	%	Martial status	Freq	%
1-3	25	28%	20-30	17	19%	Married		
4-7	47	52%	31-40	21	23%	Yes	58	64%
8-11	16	18%	41-50	32	37%	NO	32	36%
>11	2	2%	51-60	13	17%	Head of the household		
			>60	7	7%	Male	59	65%
						Female	31	35%
Total	90	100%	Total	90	100%	Total	90	100%

SOURCE: OWN COMPUTATION

The education of the household head was categorized into four levels. Those who cannot read and write are categorized under illiterate group and constituted 37% of the rural households' heads. Nonetheless, those with a formal education of 1-6 grades are grouped under primary level education since they can read and write and constituted about 40%. Those with a formal education of between 7 and 12 grades accounted for 21% of the rural respondents and grouped as under secondary level. About 2% of the rural respondents have completed high school, and thus they are grouped under tertiary level (Table 5-2-A). In rural areas female literacy level is very low; only 38% of the household wives are literate (Annex 4-4-7).

TABLE 5-2-A EDUCATIONAL LEVEL, INCOME AND CREDIT ACCESS IN RURAL HOUSEHOLDS

Education	Freq	%	Income	Freq	%	Credit	Freq	%
Primary level	48	40%	85-500	63	53%	No access to credit	50	42%
Secondary level	25	21%	501-1000	40	33%	100-500	2	2%
Third Level	2	2%	1001-2000	14	12%	501-1000	11	9%
Illiterate	45	37%	>2000	3	2%	1001-1500	23	19%
						1501-2000	11	9%
						2001-2500	10	8%
						>2500	13	11%
Total	120	100%	Total	120	100%	Total	120	100%

TABLE 5-2-B EDUCATIONAL LEVEL, INCOME AND CREDIT ACCESS IN URBAN HOUSEHOLDS

Education	Freq	%	Income	Freq	%	Credit	Freq	%
Primary level	31	34%	85-500	66	74%	No access to credit	43	48%
Secondary level	27	30%	501-1000	17	19%	100-500	9	10%
Third Level	6	7%	1001-2000	4	4%	501-1000	14	16%
Illiterate	26	29%	>2000	3	3%	1001-1500	10	11%
						1501-2000	3	3%
						2001-2500	5	5%
						>2500	6	7%
Total	90	100%	Total	90	100%	Total	90	100%

SOURCE: OWN COMPUTATION

In urban households' heads, about 34% attended primary level education while 30 and 7% attended secondary and tertiary level, respectively. The remaining 29% are disappointedly illiterate. However, female literacy in urban areas takes 56% (Table 5-2-B).

The average monthly rural households' income is found to be 656.12 birr and 53% of the respondent rural households earn monthly income of less than five hundred Birr whereas in urban households the average is only 506.72 birr and the majorities (74%) earn monthly income of less than five hundred Birr. Thus, the study indicates that the average income of the rural households is surprisingly greater than urban households.

The respondents stated that their income is not enough to cover their basic needs. Since the households were not interested to disclose their monthly income, expenditure on major items has been taken as a proxy of monthly income. Currently, there are a number of microfinance institutions and other credit organizations that facilitate credits for dwellers, but only 52% and 58% of the urban and rural household have access to credit facilities, respectively.

Dwelling status is used to indicate the standard of living of the people. As per the survey result, 78% of the rural households live in their own house while the rest 22% live either with their relatives or in rental house. But, in urban households, only half of the sample households live in their own house while the rest reside in kebeles' house, temporary shelter or private rental house. The study found that housing problem is more severe in urban households than in rural households.

The average dwelling size and the kitchen environment are almost similar in both settlements, urban and rural. The great numbers of houses are built with mud, wood and corrugated iron, and they consist of three rooms on average. About 60% percent of the rural households bake and cook in separate kitchen; however, the remaining 40% bake and cook in open air and in their living rooms. Nonetheless, about 42% of urban households bake and cook in shared kitchen, open air and with in their living rooms. Those households, who do not have separate kitchen, are faced problems related to cooking and baking activities such as accident to burning, heat and smoke problem (Annex A-4-7).

About 44 and 51% of the rural and urban households who are interviewed are actively participating in local associations, such as “Idir”, “Iqub” and “Mahiber”, respectively. Participation in those associations is believed to enable households to get informal source of information (Annex A-4-7).

5.1.2 Fuel Consumption and related issues

Most of the interviewed households (92%) mentioned that they are using fuel-wood and cow dung as a major source of energy. About 37 and 44% of the households always use fuel-wood and cow dung as a substitute while facing shortage of any kinds of fuel sources, respectively. This result thus indicates that there is excessive utilization of biomass resources in rural and urban areas, which might cause a negative impact on the natural resources and environment.

Households collect fuel-wood and other energy sources from different areas. In rural areas, 31% collect energy sources from their back yards while 36 and 22 % collect from their own farm (field) and open field, respectively. The remaining 11%, however, purchase from their nearest fuel market. In urban areas 21% of the households collect from their back yard where as 20 and 15% collect from their own field and open field areas, respectively. The remaining 44% are using commercial means to meet their energy need (Annex A-4-2).

The study has identified that households adopt different coping strategy to overcome fuel shortages: Storing of fuel and substituting one fuel source by other are some of the coping strategies to alleviate the problems. About 40 and 32 % of urban households and 54 and 31 % of rural households use Storing of fuel and substituting strategies, respectively.

Concerning getting information about the new and improved stove technology, around 49% of the urban households obtain their information from demonstration activities undertaken by GTZ-SUN energy whereas 62 % rural households obtain from development agents demonstration. Thus, provision of information is important through informal channels to address all the population. (Annex A-4-6).

Mirt is one of the improved stove technologies, which was introduced by GTZ- SUN energy. Those who adopt the improved *Mirt* stove in their house were asked to rank the advantages they get from the improved stove. Majority of the households who have adopted the stove claimed that it has enabled them to be free from suffering by the heat and smoke and obtain a clean kitchen environment. About 51% of the respondents who rank first said that the stove produces less smoke when it compared with the previous appliance they were using for baking. In their second ranking, 36% of them respond that the stove is convenient to use. It also enables them to bake quickly and provides them enough space to use two pots simultaneously. A significant proportion of them, about 31%, also said that it conserves fuel consumption properly (Annex A-4-4).

Households who are using traditional and open fire stoves complained that these stoves cause difficulty in breathing because of extreme heats and smokes emitted from them. Thus, about 42% of the households who adopt traditional and open fire stoves respond that they are faced to bear a flame of heat as the stoves give the fire out freely in their vicinities. Moreover, 32% of the households respond that the stoves consume too much fuel. However, among those who have given the above and other reasons in their first complaint, about 38 % of the households said that the stoves generate unbearable heats and smokes while 37% of the respondents believe that the stoves consume much fuel on their second complaint (Annex A-4-4).

The above results reveal that biomass proved itself to be the main current source of households' energy. Urban interviewed households who have access to electricity also said that they are forced to shift back to use biomass fuel due to the radical increments of electricity tariff and the hike of liquid petroleum gas price. Hence, the increasing scarcity of biomass and the increment of the number of people who use biomass, particularly fire wood, threaten the capability of the country even to maintain the already existing low income and living standard of the people.

Therefore, the need for adopting improved *Mirt* stove not only enables the households to use fuel efficiently, but it will enable them to curb the problems caused by using traditional and open fire stoves as well as biomass energy related problems. It can also mitigate the impacts on the users' health, the over all environment and natural resources brought by using those traditional and open fire stoves.

5.1.3. Time and effort involved in gathering and expense for fuel.

The responsibility of gathering fuel-wood and other energy sources lay on women and children in most developing countries. It is also known that collection and transportation of fuel involve tedious and tough work such as walking long distance with carrying loads and others that might cause health disorders on individuals. Similarly, the study tries to indicate that those who collect fuel-wood and other energy sources have to cover long and tiresome distances at least two times per week and about sixteen hours per month to fulfill their energy consumption (Table 5-3-A).

About 78% of the rural households meet their energy need from collection. On average from two to three members of the family participate in fuel gathering activities and 73% of the households at least they travel two times per week and two of family member participate in fuel collection.

Among the rural respondents who adopt improved stove and collection is their main source of energy, about 77% of households collect fuel from their own farm to meet their needs and took less than half an hour. But 45 and 62 % of non adopters and non informed households spent more than one hour for fuel collection, respectively. This indicates that the rural households spent a lot of their time for collection and the advantage of end-use efficiency and less requirement of fuel result time saving. (Annex A-4-4).

However, 42% of urban respondents have to travel two times per week to collect fuel sources and 48% of the households, at least two member of the family, participate in fuel collection. Accordingly, the study has identified that the effort exerted and the time spent to collect fuel sources in urban areas are relatively less from that of rural areas. It might be because of the prevalent use of commercial energy sources in urban areas (Table 5-3-A and B).

TABLE 5-3-A MEMBERS PARTICIPATE IN FUEL COLLECTION, NUMBER OF TRAVEL AND TIME TAKEN PER TRAVEL IN RURAL HOUSEHOLDS

Members for collection	Freq	%	Number of travel per week to collect fuel	Freq	%	Time taken for collection per travel	Freq	%
Non collectors	14	12%	0-1	22	18%	Less than Half hour	30	25%
1 up to 2 members	88	73%	2-3	88	73%	1/2- 1 hour	17	14%
3 and 4	16	13%	4-5	6	5%	1hr-2hr	40	33%
>4	2	2%	>5	4	4%	>2hr	19	16%
						Non-collector	14	12%
Total	120	100%	Total	120	100%	Total	120	100%

TABLE 5-3-B MEMBERS PARTICIPATE IN FUEL COLLECTION, NUMBER OF TRAVEL AND TIME TAKEN PER TRAVEL IN URBAN HOUSEHOLDS

Members for collection	Freq	%	Number of travel per week to collect fuel	Freq	%	Time taken for collection per travel	Freq	%
Non collectors	40	44%	0-1	51	57%	Less than Half hour	17	19%
1 up to 2 members	43	48%	2-3	38	42%	1/2- 1 hour	13	15%
3 and 4	7	8%	4-5	1	1%	1hr-2hr	4	4%
>4	-		>5	-		>2hr	16	18%
						Non-collector	40	44%
Total	90	100%	Total	90	100%	Total	90	100%

SOURCE: OWN COMPUTATION

Purchase of fuel as a source is very common in urban areas as 61% of households who adopt the improved stove use commercial source where as only 30% and 42% of urban non-informed and non-adopter households use commercial sources. Only 1% of the households who adopt improved stove spent on average from half to one hour for gathering energy sources while the remaining 38% spent less than half an hour. The result has revealed that the economic viability of improved stove technology has benefited households to save considerable time in their households' activities tremendously (Annex A-4-3).

Since traditional and open fire stoves consume too much fuel and households are not able to meet their fuel need from their surrounding areas, non-informed and non-adopters of the improved stove are forced to move longer distance to find open field and backyard places in order to collect fuel sources. In those areas, fuel-wood and other energy sources are not easily accessible. According to this survey, 57 and 45% of rural and urban households who use traditional and open fire stoves spent on average more than two hours for gathering energy sources on which at least two household members involve and they also travel twice per week, respectively. Therefore, if a household collects fuel for nine months assuming that they may use the stock or any other means

of energy need for the rest three months of a year, an individual member of the household will spend 135 working hours per year only for fuel gathering activities in those households. This indicates that children have to miss their school day and women are left less time to carry on other house chores (Annex A-4-2).

According to the survey result, the average monthly expenditure for fuel need is 41 and 17 birr in urban and rural households, respectively. Adopters of improved *Mirt* stove on average spent 29 Birr in urban households and 11 Birr in rural households. However, non adopters of the stove spent 49 Birr in urban areas and 18 Birr in rural areas. In both settlements, the non informed households mostly use collection of fuel as a source and they spent about 35 and 21 Birr for fuel in urban and rural households, respectively. Thus, if effort is made to distribute one million improved stoves in Ethiopia, it is possible to save on average 11.5 million Birr per month. This result indicates that the contribution of improved fuel saving technology towards households expenditure saving and it also directly reduce impacts on fuel-wood and other biomass resources demand.

If this extra effort and time were to be put for some other productive use, it would surely help to reduce the burden of rural women and children in household activities and environment. It might also enhance the economic status of those women who participate in fuel collection. However, it is understood that not all of this time and effort can be put into productive and income earning activities due to many reasons such as child labour, low efficiency, low skill and lack of employment opportunity. But, it will be possible for the households to generate income and reduce the burden of women should they utilize sixty percent of the extra time, which they spend

to collect fuel, for productive purposes. The children will also be able to use the time for their education.

5.1.4. Reasons for not using improved stove

Basically, as previous studies indicate, the cost of efficient stoves is one of the main limitations for non-adopters to use the technology for they (the stoves) have required higher prices while people purchasing power is very low. The non-existence of information about the improved stove is also accountable for non-adopting of the technology in majority households. Thus, a decision to adopt the technology, acquiring of information about its existence and how to use it become essential.

This study focuses on those who are well informed, but not yet adopt the technology. The result reveals that low purchasing power only evidenced by rural households, about 76% of the households responded that the meager income they get prevents them to adopt the improved stove. However, about 53% of urban households reported that their main reason that hinders them from adoption is financial constraint. About 42% of urban households responded that their housing or dwelling status was the other key reason not to adopt the improved stove, especially the absence of separate kitchen in their living compound for those resides either in kebele house, temporary shelter or private rental house (Annex A-4-4).

According to the survey result, the major problems of the households encounter in the kitchen of which size is too small to store fuel-wood and other energy sources. Sharing the kitchen with other neighbors exacerbates the already existed problem and prevents the households to use the stove independently. Particularly, urban households who use shared kitchen complained that their stove is easily accessible to all who live in the compound and other outsiders. Therefore,

improving the kitchen environment and dwelling status of the people may contribute a lot for the household's energy efficiency and usage of better energy appliance. By doing so, households will be able to move into the upper energy ladder.

5.2 The Econometric Result

The conditional probability functions are very similar for both Probit and Logit models, except in the extreme tails. The Probit model estimation is applied for this study. In order to check whether there is any serious multicollinearity among the explanatory variables, a correlation matrix that could help to drop some variables having higher multicollinearity is used. The presence of multicollinearity between (among) variables reduces the precision of estimating the coefficients of the strongly correlated variables.

It is worth nothing that the values of certain variable contrast greatly in size with other variables which may induce hetroscedasticity. A test for the presence of heteroscedasticity⁶ problem in the model was also done. The test result shows that the null hypothesis of homoscedasticity is rejected implying that there is heteroscedasticity problem in the model as it is expected and common problem in cross-sectional data. To minimize this problem, the natural log of the monthly income of the household is considered in the model (Maddala, 1983) and heteroscedasticity-consistent Probit models from STATA 9 program were applied (See Annex Table A-3-3 - A-3-10). And Table 5-4-A and 5-4-B summarize the empirical results of information and adoption equations of rural and urban households, respectively.

⁶ The LR test is 88.17 and 84.27 for rural and urban estimates, respectively. The critical value of the chi-square at each estimation degree of freedom is at 95% level. Comparison of the results (test statistics) with critical table value shows that all of the test statistics (computed values) are found to be larger than the critical table value. This implies that the null hypothesis of homoscedasticity is rejected, i.e. hetroscedasticity is the problem for the model.

5.2.1. The information results.

Many empirical evidences show that acquisition of information and adoption decision is determined by the socio-economic status, demographic characteristics, modern source of energy, educational attainment, income, and others have a crucial influence on information and adoption. Hence, the study tries to analyze the factors that determine information acquiring and adoption decision on improved *Mirt* stove technology in both rural and urban households in the study area.

In rural areas, the probability of information acquisition is higher in female-headed households than in male-headed and significant (at 5%). This support the common tradition practiced in Ethiopian rural households, which is women are responsible to prepare food and collect fuel. As a result, rural women are concerned about the improved stove technology information.

Surprisingly, family size has a positive and significant impact on information acquiring in rural households while in urban households it has positive impact even if it is not a significant variable. At the margin, the increase of rural household member by one may raise the probability of information acquiring by 7.9%. This indicates that particular rural family household members may disseminate and pass information to their family.

As expected, household age has negative impact on information acquiring in both urban and rural households, yet it is not significant. An increase in household age causes a reduction on the probability of information acquiring. The result suggests that information acquiring about improved *Mirt* stove is higher in young-headed households than older-headed ones.

Table 5-4-A Probit estimation of sample selection for rural households

Number of obs	=	120	LR chi2(11)	=	88.17
Censored obs	=	62	Pseudo R2	=	0.5304
Uncensored obs	=	58	Wald chi2(11)	=	33.38
Log pseudolikelihood	=	-53.3968	Prob > chi2	=	0.0005

<i>Adoption</i>	Coefficient	Marginal Effect	Standard Error	P> z	Mean
<i>Members participate for collection**</i>	-0.6808	-0.1689	0.2536	0.007	1.93333
<i>Family size</i>	0.1073	0.0266	0.0872	0.219	7.03333
<i>D⁷ Dwelling status</i>	0.5499	0.1161	0.8081	0.496	.783333
<i>D separate kitchen</i>	-0.7334	-0.1909	0.6057	0.226	0.575
<i>D compatibility**</i>	1.3820	0.3788	0.6815	0.043	0.4
<i>D spouse education***</i>	1.3884	0.3991	0.8413	0.099	0.35
<i>Age*</i>	-0.0734	-0.0182	0.0230	0.001	47.325
<i>D head of the household</i>	1.1136	0.1928	0.9436	0.238	0.80833
<i>D access to credit</i>	0.7870	0.1913	0.5150	0.126	0.525
<i>D education**</i>	1.7467	0.4864	0.8403	0.038	0.60833
<i>L income*</i>	2.2085	0.5479	0.6098	0.000	6.2065
<i>constant*</i>	-12.3860	-	3.1867	0.000	-
<i>D active participation</i>	(offset)				
<i>Information</i>					
<i>D marital status</i>	0.2955	0.0342	0.7271	0.684	0.89166
<i>Family size**</i>	0.1920	0.0796	0.0753	0.011	7.03333
<i>D spouse education</i>	0.5304	0.2077	0.3647	0.146	0.35
<i>Age</i>	-0.0092	-0.0039	0.0135	0.494	47.325
<i>D head of the household**</i>	-1.0584	-0.3803	0.4276	0.013	0.80833
<i>D active participation*</i>	2.1819	0.7144	0.4050	0.000	0.441667
<i>D access to credit</i>	0.4047	0.1730	0.3509	0.249	0.525
<i>D electricity access **</i>	1.2242	0.4469	0.4451	0.006	0.60833
<i>D market</i>	0.0815	0.0730	0.5496	0.882	0.21666
<i>D education</i>	0.2426	0.0948	0.4593	0.597	0.597
<i>L income</i>	0.4331	0.1626	0.3012	0.150	6.2065
<i>constant **</i>	-4.9715	-	2.1584	0.021	-
Athrho	0.6198		1.2219	0.612	0.612
Rho	0.5510		0.8509		

*** Significant at 10% ** Significant at 5% *Significant at 1%

⁷ D indicates for those variables that are Dummy.

On the supply side of the information, the source of information is either formal or informal sources. Access to modern source of energy or electricity, active participation in local associations, and presence of producers of improved *Mirt* stove in the living areas are considered in this study. Access to electricity means that households can attend television and radio programs; as a result the households may get access to formal sources of information. This variable is highly significant and has positive impact in rural households than in urban areas. The probability of information acquisition is higher in rural households that have access to electricity than those of with out electricity access. Therefore, provision of electric service to rural areas plays a pivotal role to disseminate information through formal means.

Producers of the improved *Mirt* stove have been exercising different commercialization strategies and promotional activities to introduce *Mirt* stove. The activities of producers indirectly enable the society to access information about the technology. Thus, the study has revealed that the presence of *Mirt* stove producers in the urban households' living area or market has a positive and highly significant impact on information acquisition. In this manner, the probability of information acquiring is higher in urban households who are close to *Mirt* stove producers than those of far from the producers. Being the urban households near to market the probability of information acquisition will increase by 45.1%. It has also positive impact on rural household information acquiring despite its insignificant. The insignificance of this variable in rural households may be due to the inaccessibility of market for *Mirt* stove in the vicinity of the people. This study has also identified that the rural households mainly obtain information about *Mirt* stove from development agents.

Finally, Active participation in local associations such as “Idir”, “Iqub” and “Mahiber” bring positive influence and highly significant for information acquiring in both settlements (at 1%). Both in rural and urban households who are actively participating in local associations have higher probability to acquire information than households who are not active in participation. Being active in local associations’ participation will increase the probability of information acquiring by 71.4 and 71.8% in rural and urban households, respectively. Indeed, informal channels of information dissemination are more effective for those households who are active in local association participation.

We can conclude, then, among other variables the probability of rural households’ information acquiring relating to the improved *Mirt* stove technology are statistically explained by family size, sex of household heads, active participation of households in local associations, and availability of modern source of energy (electricity). Regarding to urban households, the study result has indicated that active participation in local associations, and market or presence of producer of *Mirt* stove technology are the main significant factors to acquire information. Therefore, the study results reveal that improvement in the socio economic status and facilitation of information provision in rural and urban households would bring positive impact on information acquisition.

Table 5-4-B Probit estimation of sample selection for urban households

Number of obs = 90 LR chi (12) = 84.27
 Censored obs = 33 Pseudo R2 = 0.7183
 Uncensored obs = 57 Wald chi2(12) = 28.04
 Log pseudolikelihood = -33.63697 Prob > chi2 = 0.0055

<i>Adoption</i>	Coefficient	Marginal effect	Standard. Error	P> z 	Mean
Age	-0.0593	-0.00759	0.0379	0.118	50.4333
D marital status ***	2.2639	0.29652	1.2361	0.067	.566667
Family size **	0.3366	0.04308	0.1729	0.052	5.31111
D dwelling status	0.2791	0.03603	0.8090	0.730	.488889
D separate kitchen **	1.1748	0.14142	0.8018	0.043	.577778
D compatibility	0.6088	0.07864	1.1171	0.586	.511111
D spouse education	0.5289	0.06928	0.8129	0.515	.488889
D head of the household *	-4.3273	-0.92108	1.4616	0.003	.677778
Fuel expense	0.0131	0.00168	0.0166	0.429	41.0444
D access to credit	1.1795	0.20348	0.7585	0.120	.344444
D education*	3.4843	0.43912	1.2413	0.005	.611111
L income	0.2721	0.03482	0.6331	0.667	5.88359
constant***	-5.2242	-0.00759	3.1936	0.102	
D active participation	(offset)				
Information					
D marital status	-.4286643	0.07418	.8178782	0.600	0.5666
Family size	.1765413	0.03083	.136889	0.197	5.3111
D spouse education	1.048235	0.18711	.9874462	0.288	0.4888
Age	-.0221105	-0.00386	.0235583	0.348	50.433
D head of the household	-.9716964	-0.14128	1.147533	0.397	0.6777
D active participation *	3.65241	0.71873	.7598789	0.000	0.5111
D access to credit	-.8260403	-0.16356	1.114081	0.458	0.3444
D market ***	2.617077	0.45128	1.41075	0.064	0.4444
D electricity access	.8047146	0.18816	1.190112	0.499	0.7666
D education	.0949537	0.01405	.8640634	0.912	0.6111
L income	.8235751	0.14724	1.122381	0.463	5.8835
constant	-6.424711	-	6.698139	0.337	-
Athrho	.0848789	-	3.270068	0.979	-
Rho	.0846757	-	3.246622	-	-

*** Significant at 10% ** Significant at 5% *Significant at 1%

5.2.2 The adoption equation results

The “energy ladder” hypothesis relate improvement in socio-economic status of the household with transition to more energy efficient stoves and higher quality and less polluting fuel appliance is often invoked as theoretical model for analyzing household energy demand practice. The finding of this study is consistent with *Barbara D.et.al (2000)* and *Hosier and Dowd (1987)*, *Reddy (1995)* study result in Mexico, Zimbabwe and India, respectively. The energy ladder hypothesis was also discussed in Ethiopia, by *Tadelech (2001)* in Addis Ababa households and *Berhamu (1998)* in Nazareth town. Those studies test the hypothesis, as socio economic status of the household increase, the household move up to the upper energy ladder.

Income is found to be one of the major variable which has a positive and highly significant (at 1%) impact in rural households. A 10% increase in income will increase the probability of adoption decision for improved *Mirt* stove technology by 0.05% in rural households. But, this variable has positive impact but it is not significant in urban households.

Contrary to the expectation of the study, the probability of adoption decision is higher in female-headed urban households than male-headed and it is highly significant. The finding is inconsistent with the result by *Tadelech (2001)*. The plausible reasons in urban households’ female are becoming decision makers, where as in rural households the probability of adoption decision is higher in male-headed household than female-headed and it is insignificant. The result indicates in rural households’ men are still decision makers on resources than female but for urban households female may have an influence on resource decisions for households’ activities.

The coefficient of the household head age is negative, and it is significant in rural households. An increase in household head age causes a reduction in the probability of adopting improved stove. At the margin, an additional year of age reduces the probability of adoption decision by 1.8% and it has also negative relation with urban households even if it is insignificant. Thus, the result reveals that the probability of adoption decision for improved *Mirt* stove is higher in younger rural households than older ones.

Similarly, marital status is positively related to household's adoption decision for improved ("Mirt") stove in urban household but due to collinearity problem this variable dropped from the rural households regression. The probability of adoption decision is higher in married urban households than unmarried and significant (at 10%). This may be due to the fact that married people are likely to have a responsibility for family members and mostly in urban areas unmarried households may outsource their food consumption. Accordingly, family size also has a significant and positive influence on adoption decision of urban households. As the member increase by one, the probability of adoption of the technology will increase by 4.3 %.

Household's schooling has a positive and highly significant effect (at 1%) on adoption decision of the urban households. The marginal contribution of completion of an additional schooling of the households head on the probability of adoption decision is 43.9%. Education also has significant effect in rural household too, with marginal effect, additional schooling on rural household result increase in the probability of adoption decision by 48.6%. Therefore, household's schooling or the educational level is one of the most important variable explaining the adoption decision of improved *Mirt* stove technology.

Another vital result from this study in relation to education is the literacy level of the rural household wives. This variable has a significant and positive influence on the adoption decision. This finding suggests that provision of education to female would result higher benefit for the rural areas and possible to get economic and environmental benefits that could derive from stove adoption.

The main source of fuel for rural households is through collection. If the rural households have a capacity to participate more of its members for fuel-wood and other energy source collection, the probability of adoption decision will decreased. This variable has a negative sign as expected and it is highly significant. In fact, as members of the family participate for fuel collection increased by one member, the probability of adoption decision for improved *Mirt* stove decreased by more than ten percent. The result indicates adoption decision influenced by the availability of labour force in rural areas.

Households are the users of the technology product and it is important to note that their subjective preferences for the characteristics of new technologies affect adoption decision. Some of the desirable characteristics considered in this case: convenience of the stove, compatibility and a relative advantage. The households' perceptions about those characteristics may have impact on adoption decision. The result is expected because adopters and non-adopters of the technology differ on the basis of their perception about the technology. The probability of adoption decision is higher in rural households that have considered the stove has relative advantage, convenient and compatible than those who do not have this perception, and it is significant (at 5%).

Existence of separate kitchen in households is the indicators of the household dwelling standing and their living standard. At the marginal, the variable indicates that the passage from households whose habitat is with out a kitchen room to those whose habitat is provided with separate external kitchen involves a rise of 14.1% in urban households' adoption probability and it is highly significant. The result indicates that the presence of separate kitchen enables the urban households' independent utilization of their stoves and increase in their socio economic status result a better kitchen and housing environment.

Since the majority of rural households may get advantage mainly for fuel storage, to decide on free space and others in their living compound, as a result the existence of separate kitchen may provide weak support for adoption decision in rural households. And surprisingly the probability of adoption decision is lower in households having external kitchen than households who do not have separate kitchen but it is insignificant variable for rural areas.

The study concludes that above all factors that determine the adoption decision of improved *Mirt* stove in rural households are household head educational level, income, age of the household head, members of the family participate in fuel collection, educational level of the spouse (wives) and the perception of the households towards the technology are more compatible (compatibility) are found to be significant. However, for urban households the significant variables are sex of the household head, family size, educational level of the household head and existence of separate kitchen and marital status are the main ones.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study provides important evidence for the pattern of household decision to acquire information and decide to adopt energy efficient technology. Utilizing cross sectional data, we conclude that households' characteristics do specify the information acquisition and adoption decision behavior. Our empirical findings, as far as socio-economic and demographic characteristics and household unit are concerned, are in line with other reported studies.

A number of studies identified many of the population in developing countries are still primarily dependent on biomass energy for domestic use. Fuel efficient and convenient stoves therefore have important implication for a number of interrelated accepts of development including health, protection of natural resource and environment, and household economy. Indeed, various empirical studies reported that "energy ladder" relating improvements in socio economic status with transition to more efficient appliance and to higher quality fuels is often invoked as a theoretical model for analyzing household's energy management practice. Thus, the findings of this study are also support the energy ladder hypothesis.

Our study also reveals, biomass energy saving technologies have a significant role and one of the major demand side intervention to protect natural resource depletion. Biomass conversion and end use efficiency have positive and significant impact on environment, know how transfer, economy (both micro and macro), improvement in income and health, and time. The effort, therefore, should be made to areas of information provision and dissemination of the technology in order to address the target group.



To this end, most empirical studies in the literature have considered technology adoption decisions with assumption that all potential adopters are very well informed and know about the technology. But, in such cases the result seems to be sensitive to the methodology used. If all potential adopters were not well informed about the technology; then the technology adoption decision is conditional on information acquisition. Therefore, the information acquisition is considered before adoption decision in this study. In addition, the study tries to analyze both urban and rural households independently.

The study result reveals that household sector use significant share of energy consumption. This sector was highly dependent on biomass resources .Especially, in rural areas the major source of fuel is through collection and it has adverse impact on natural resource and environment. Such as deforestation and soil erosion due to fuel-wood collection, loss of soil fertility due to animal dung used as a source of energy. Although in urban households due to an ever increasing price of electricity and LPG, household back to use biomass sources. This indicates the need for efficient biomass stoves through promotion of technically simple and economically feasible that could be adopted by the majority of the people.

In particular, in the empirical analysis household's information acquiring model is employed, using a discrete variable as dependant variable. The result shows that acquiring of information relating to the improved *Mirt* stove technology are significantly explained by the socio economic variables that are family size, sex of household heads, active participation of households in local associations, and availability of modern source of energy (electricity). Regarding to the urban households, the study result has indicated that active participation in local associations, and market or presence of producer of *Mirt* stove technology are the main significant factors to

acquire information. Therefore, the study results reveal that improvement in the socio economic status and facilitation of information provision in urban and rural households would bring positive impact on information acquisition.

The study also concludes that above all factors that determine the adoption decision of improved *Mirt* stove in rural and urban households: educational level of the household head is the common significant variables. In addition to this variable, particularly for urban households' existence of separate kitchen, sex of the household head, family size and marital status are the main ones. Although for rural households the other main variables are members of the family participate in fuel collection, age, compatibility and educational level of the household spouse (wives) are found to be significant. Similarly, improving the dwelling status and cooking and baking environment for urban and rural households has positive impact for energy efficiency.

6.2 Recommendations

Given the increased need for sustainability and quality of life, Ethiopian household should alter their energy behavior to an environmental friendly one. With those major findings of the study, the following policy issues and implications are suggested for considerations:

- The household energy demand (consumption) has significant adverse impact on natural resource and environment. Therefore, energy policy, programs and measures should give due attention and consideration to the households' rationale. In addition, a conducive environment should be created to encourage rural households' energy efficiency in the view of their role in improving natural resource conservation. Especially, in fuel-wood and other biomass resources gathering and combustion.
- From energy and environmental policy point of view, the result shows that in order to support households' adoption decision for energy efficient technology and less adverse environment, social and natural resource impacts. Encourage the provision and disseminating information about the environmental and economic benefit of energy efficiency derived from improved stove technology would be an effective instrument for economic development. In particular, intervention through provision of information in local associations and demonstration programs are more important.
- Research, innovations and dissemination strategies of technologies should start from the existing socio-economic circumstances, their competence, knowledge and experience of the target group.

- Accordingly, it is recommended that the government should have to look energy policy impact and effect at each stage of technology adoption (invention, innovation and diffusion). It should also be ready to take appropriate policy measures immediately.
- Finally, adoption of efficient and improved stove technology has an important implication for natural resource conservation and environmental protection. To this end, policy makers and other stake holders in energy sector should seriously consider the fact that provision of information and enhancement of the adoption decision for improved stove technology as a means and ways to create viable economic benefit for the country. Particularly, improve the income of the rural people and dwelling status of the urban households.

The importance of information diffusion and adoption decision in household's decision for energy efficient improved stove technology is established from this study. It would be interesting to empirically investigate, the following questions for further research of Ethiopian's preferences towards household energy efficiency measures:

- The power of information compared to other energy and environmental policies.
- Improved stove technology and its contribution for MDG environment protection strategy.
- Improved stove technology and indoor environmental quality or air pollution.
- Improved stove technology and gender inequality.

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APPENDIX I

ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDY DEPARTMENT OF ECONOMICS

This questionnaire is designed and prepared to collect data from households by the student of Addis Ababa University, for the partial fulfillment of the Master of Science in Economics. The data collected is kept under confidential and only for academic purpose and result.

The main objective of this questionnaire is to assess the main determinants of household to acquire information about fuel efficient stove and also what determinant factors affect household decision to adopt this technology. By taking evidence from improved (“Mirt”) stove technology in Ada wereda. To this end, your direct participation has been found essential and determinant.

Therefore, to show your direct contribution, provide the information honestly and responsibly. I sincerely express my at most thanks for your unreserved cooperation.

Notice

1. Please follow the directions carefully to tick answer(s) for each question.
2. Please use the code for each question.

PART I
HOUSEHOLD INFORMATION

1.1. Identification of household

A. Type of settlement _____ 1. Urban 2. Rural

B. Wereda _____

C. Kebele _____

D. Name of the household head _____

Age of the house hold head _____

Head of the household _____

1. Male

2. Female

Education level _____

1. Illiterate 2. Primary 3. Secondary 4. Third level

Educational level of the household spouse (wife) (use the code above) _____

1.2. Family information

A. Family size _____ B. Male _____ C. Female _____

1.3. Number of children's in the family less than 13 years of age _____

1. Male _____

2. Female _____

1.4. Marital status of the household _____

1. Married

2. Unmarried

3. Widow

4. Divorced

1.5. Household income (Birr)

1.5.1. Urban household

1. Monthly household head gross income (Birr) _____

2. Monthly gross income of other family member's _____

3. What are your sources of income? (Note! **Each household may have more than one source of income**)

- 3.1 Civil service _____ 1. Yes 2. No
3.2 Pension, _____ 1. Yes 2. No
3.3 House rent _____ 1. Yes 2. No
3.4 Sale of food and beverage _____ 1. Yes 2. No
3.5. Agriculture (crop and/or livestock) _____ 1. Yes 2. No
3.6 Trade _____ 1. Yes 2. No
3.7 Daily laborer _____ 1. Yes 2. No
3.8. Other (specify) _____ 1. Yes 2. No

1.5.2. Rural household

1. Give us your annual family income obtained from

- 1.1 Crops _____
1.2 Livestock _____
1.3 Non-farm _____
1.4 Other (specify) _____

1.6. Number of livestock in the house _____

- A. Cattle _____ D. Sheep and Goat _____
B. Horses _____ E. Chicken _____
C. Donkey _____

1.7 Main Expenditures of the Household (in Birr):

- A. Housing: _____
B. Food: _____
C. Energy consumption _____
D. Phone: _____
E. Education: _____
F. Health: _____
G. Other Expenses ('Eder', 'Ekube', etc.): _____

1.8. Do you obtain credit? (Yes/No) _____ 1. Yes 2. No

1.9. If your answer is "Yes" to Question number 1.8.

1. How much money did you get? _____

2. From which source do you get credit (loan)?

1. Government credit association _____ 1. Yes 2. No
2. Bank _____ 1. Yes 2. No
3. Relatives or friends _____ 1. Yes 2. No
4. Non-Governmental credit Associations _____ 1. Yes 2. No
5. Other (specify) _____ 1. Yes 2. No

1.10. If your answer is "No", what is the reason for not obtaining credit? _____

Reason for not obtain credit

1. Not want (need) to take credit _____ 1. Yes 2. No
2. Non-availability of credit institutions and bank in your area _____ 1. Yes 2. No
3. People are not willing to provide loan to you _____ 1. Yes 2. No
4. Fear of credit to repay back _____ 1. Yes 2. No
5. Other (Specify) _____ 1. Yes 2. No

1.11. Owner ship of the house in which you live _____

Ownership of house

1. Privately owned _____ 1. Yes 2. No
2. Kebele house _____ 1. Yes 2. No
3. Temporary shelter _____ 1. Yes 2. No
4. Other (specify) _____ 1. Yes 2. No

1.12. Status of the house _____

1. Number of rooms _____

2. Wall made of _____

1. Bricks/ stone 2. Wood and "Chika" 3. Others (specify) _____

3. Roof made of _____

1. Corrugated iron 2. Grass 3. Other (specify) _____

PART II
STATUS OF HOUSEHOLD ENERGY

2.1. Do you use electricity for household purpose(s)? (Yes/No) _____ 1. Yes 2. No

2.2. If your answer is "yes" what about the electric meter? (Choose from below) _____

Electric meter

1. Private (serving only our household)
2. Common (we share it with other)
3. The line is from other household's electric meter
4. Other (specify)

2.3. Other energy sources used (if any) others than electricity for household purpose(s)

1. Fuel wood _____ 1. Yes 2. No
2. Cow-dung _____ 1. Yes 2. No
3. LPG _____ 1. Yes 2. No
4. Oil seed cakes _____ 1. Yes 2. No
5. Leaves _____ 1. Yes 2. No
6. Saw dust _____ 1. Yes 2. No
7. Charcoal _____ 1. Yes 2. No
8. Other (specify) _____ 1. Yes 2. No

2.4. Is there shortage in any of energy resource you use for household purpose(s)?

(Yes/No) _____ 1. Yes 2. No

2.5. If your answer is "yes" for question number 2.4, indicate the type of energy source

You mostly observe shortage. _____

1. Fuel wood _____ 1. Yes 2. No
2. Cow-dung _____ 1. Yes 2. No
3. LPG _____ 1. Yes 2. No
4. Oil seed cakes _____ 1. Yes 2. No
5. Leaves _____ 1. Yes 2. No
6. Saw dust _____ 1. Yes 2. No
7. Charcoal _____ 1. Yes 2. No
8. Other (specify) _____ 1. Yes 2. No

2.6. Which energy source(s) that you mostly use as a substitute when you face a shortage in any of your common energy sources?

- 1. Fuel wood _____ 1. Yes 2. No
- 2. Cow-dung _____ 1. Yes 2. No
- 3. LPG _____ 1. Yes 2. No
- 4. Oil seed cakes _____ 1. Yes 2. No
- 5. Leaves _____ 1. Yes 2. No
- 6. Saw dust _____ 1. Yes 2. No
- 7. Charcoal _____ 1. Yes 2. No
- 8. Other (specify) _____ 1. Yes 2. No

2.7 What kind of problem you face due to the type of fuel you use in the house?

Part III
FUEL USE

3.1. What type of food do you prepare and what type of fuel do you use for it?

	Mostly	Sometimes	Rarely
1. Ingera			
2. Bread/Kitta			
3. Wot			
4. Coffee			
5. Tea/milk			
6. Boiling (all type)			
7. Grain roasting (Kolo)			
8. Lighting			
9. Space heating			
10. Other (all)			

- Code
1. Wood
 2. BLT
 3. Dung
 4. Agri-residue
 5. Electricity
 6. Oil seed
 7. Charcoal
 8. Kerosene
 9. LPG
 10. Other
 - 11.

3.2 Type of appliances to use fuel wood?

1. Traditional "Mitad" _____ 1. Yes 2. No
2. Open-earthed stove _____ 1. Yes 2. No
3. Modern ("Mirt") stove _____ 1. Yes 2. No
4. Other (specify) _____ 1. Yes 2. No

3.3. Is there a specific season, when you experience fuel wood shortage?

- (Yes / No) _____ 1. Yes 2. No

3.4. If your answer is "yes" for question number 3.2. When did you face? _____

1. Main crop season _____ 1. Yes 2. No
2. Both main crop and other seasons _____ 1. Yes 2. No
3. Other (specify) _____ 1. Yes 2. No

3.5. How do you cope with it?

1. Do nothing _____ 1. Yes 2. No
2. Substitute with other fuels _____ 1. Yes 2. No
3. Conserve fuel use _____ 1. Yes 2. No
4. Stock on fuel _____ 1. Yes 2. No
5. Other (Specify) _____ 1. Yes 2. No

3.6. What is your source of fuel wood and other energy sources; is it from?

1. Collection _____ 1. Yes 2. No
2. Purchase _____ 1. Yes 2. No
3. Both collection and purchase _____ 1. Yes 2. No
4. Other (specify) _____ 1. Yes 2. No

3.7. If you collect fuel wood, from where do you collect? _____

1. Back yard _____ 1. Yes 2. No
2. Own farm _____ 1. Yes 2. No
3. Open field _____ 1. Yes 2. No
5. Other (specify) _____ 1. Yes 2. No

3.8. In your living area, is there a communal forest area to collect fuel wood? _____

- (Yes / No) _____ 1. Yes 2. No

3.9. How long does it take you to get to the place and collect, where you normally collect fuel?

(One way in minute) _____

3.10. How many members of a family participate in collection of fuel wood and other energy sources? _____

1. Female ____
2. Male ____
3. Children less than 13years _____

3.11. How often do you travel to collect fuel wood and other energy sources per week? _____

3.12. If you use fuel wood and other energy sources, and your source is purchase, which one do you purchase mostly? .

Mode of fuel wood purchase

1. Donkey load _____ 1. Yes 2. No
2. Human load _____ 1. Yes 2. No
3. Government source _____ 1. Yes 2. No
4. Retail sale _____ 1. Yes 2. No
5. Other (specify) _____ 1. Yes 2. No

3.13. On Average how much money do you spend per month for fuel expense? _____

PART IV

COOKING PATTERN, KITCHEN ENVIRONMENT AND IMPROVED STOVE.

4. COOKING PATTERN

4.1. How many days per week do you prepare foods and beverage?

1. "Injera" (per week) _____
2. Bread/"kitta" _____
3. Tea/Milk _____
4. Boiling (all) _____
5. Grain roasting ("kolo") _____
6. Other (specify) _____

4.2. How many "Injera" did you bake per session? _____

5. Kitchen Environment

5.1. Do you have separate kitchen for preparation of food?

(Yes/ No)_____ 1. Yes 2. No

5.2. Do you have a permanent place for cooking and baking?

(Yes / No)_____ 1. Yes 2. No

5.3. If your answer is "Yes". Do you cook and bake in? _____

1. Separate Kitchen _____ 1. Yes 2. No

2. Shared kitchen _____ 1. Yes 2. No

3. in the living room _____ 1. Yes 2. No

4. Open air _____ 1. Yes 2. No

5. Other (Specify) _____ 1. Yes 2. No

5.4. If you are using for baking, what are the main problems?

1. It is hot while baking _____
2. Exposure to accident burns _____
3. The smoke _____
4. Consume too much fuel _____
5. Other (specify) _____

Disadvantage

1. first compliant
2. second compliant
3. third compliant

5.5. If you are using for baking, what are the main advantages?

1. Conserve fuel _____
2. Convenient to use _____
3. No heat and clean _____
4. Convenient for multiple uses _____
5. Other (specify) _____

Advantage

1. first important
2. second important
3. third important

6. Improved stove information

6.1. Are you familiar, well informed and knows about the improved ("Mirt") fuel saving stove about the existence and how to use it? _____

(Yes / No) _____ 1. Yes 2. No

6.2. If your answer is "yes", from where do you get the information? _____

Code Source of information

- | | | |
|---|--------|-------|
| 1. TV/radio _____ | 1. Yes | 2. No |
| 2. Display in shop market place _____ | 1. Yes | 2. No |
| 3. Demonstration activity in local associations _____ | 1. Yes | 2. No |
| 4. Development agents _____ | 1. Yes | 2. No |
| 5. Friends/relatives _____ | 1. Yes | 2. No |
| 6. Other (specify) _____ | 1. Yes | 2. No |

6.3. Is the household involved (is a member of) local association?

(Yes/ No) _____ 1. Yes 2. No

6.4. If “yes” to question 6.3, above

6.4.1. Which association the household involved in?

- 1. Idir _____ 1. Yes 2. No
- 2. Iqub _____ 1. Yes 2. No
- 3. Both Idir and Iqub _____ 1. Yes 2. No
- 4. Mahiber _____ 1. Yes 2. No
- 5. Other (specify) _____ 1. Yes 2. No

6.4.2. Do you actively and effectively participate in demonstration activity of these local associations?

(Yes /No) _____ 1. Yes 2. No

6.5. Do you use the improved (“Mirt”) stove in your house? (Yes/ No) _____ 1. Yes 2. No

6.6. If your answer is “No” for 6.5. What is your reason not to have or use the improved? (“Mirt”) stove?

- 1. Income _____
- 2. The stove inconvenience _____
- 3. Housing problem _____
- 4. Fuel wood cost _____
- 5. Having better appliance _____
- 6. Other (specify) _____

Reason

- 1. Most important
- 2. Second important
- 3. Third important

6.7. Did you use your own money or with credit to purchase the stove? (How much money?----)

- 1. I use my own money
- 2. Through Credit
- 3. Both credit and my money
- 4. Other (specify)

6.8. In your living area is there a professional person, who produces the improved (“Mirt”) stove? (Yes/ No) _____ 1. Yes 2. No

6.9. If your answer is “yes” to question No. 6.8.

A. Do you get any professional assistance from the producer? (Yes/ No) _____ 1. Yes 2. No

B. What professional assistance do you get?

- 1. Training how to use _____ 1. Yes 2. No
- 2. Maintenance _____ 1. Yes 2. No
- 3. Demonstration or any problem _____ 1. Yes 2. No
- 4. Other (specify) _____ 1. Yes 2. No

PART VII
PERCEPTION AND ATTITUDE

7.1. Is the improved ("Mirt") stove is more compatable and better than other appliance? _____

1. Yes
2. No
3. No idea

7.2. Is the improved ("Mirt") stove is more complex for you to use and maintain? _____

1. Yes
2. No
3. No idea

7.3. If you adopt the improved ("Mirt") stove, do you tell to other persons to use it?

(Yes /No) _____ 1. Yes 2. No

PART VIII
OBSERVATION OF ENUMERATOR

OBSERVATION OF THE ENUMERATOR

COMMENT OF THE ENUMERATOR

Thank you.....for your kind cooperation.

APPENDIX II

Let's define that indirect utility function for the j^{th} household can be

specified as follows:

$$U_{ij} = U_i(Z_j, H_j, C_j, D_j, \epsilon_{ij}) \dots\dots\dots 1$$

$$U_{1j}(Z_j, H_j, C_j, D_j, \epsilon_{1j}) \dots\dots\dots 2$$

Equation (2) represents the household utility function with the baking appliance (stove) in the house is the improved ("Mirt") fuel wood stove.

$$U_{0j}(Z_j, H_j, C_j, D_j, \epsilon_{0j}) \dots\dots\dots 3$$

Equation (3) represents the household utility level with the baking appliance (stove) in the house is the traditional or open hearth fuel wood stove.

The household is introduced about the improved ("Mirt") stove technology and knows improvement in household energy efficiency and environment; the household adopt the improved ("Mirt") stove technology if and only if:

$$U_{1j}(Z_j, H_j, C_j, D_j, \epsilon_{1j}) > U_{0j}(Z_j, H_j, C_j, D_j, \epsilon_{0j}) \dots\dots\dots 4$$

$$\begin{aligned} \text{prob}(\text{yes}) &= \text{prob}[(U_{1j} - U_{0j}) > 0 \\ &= \text{prob} [\alpha_1 + \alpha_{11}Z_j + \alpha_{12}H_j + \alpha_{13}D_j + \alpha_{14}C_j + \epsilon_{1j} > \\ &\alpha_0 + \alpha_{01}Z_j + \alpha_{02}H_j + \alpha_{03}D_j + \alpha_{04}C_j + \epsilon_{0j}] \end{aligned}$$

=

$$\text{prob}[(\alpha_1 - \alpha_0) + (\alpha_{11} - \alpha_{01})Z_j + (\alpha_{12} - \alpha_{02})H_j + (\alpha_{13} - \alpha_{03})D_j + (\alpha_{14} - \alpha_{04})C_j + (\varepsilon_{1j} - \varepsilon_{0j})] > 0$$

$$\text{Let } (\alpha_1 - \alpha_0) = \alpha^* \quad (\alpha_{11} - \alpha_{01}) = \alpha_1^* \quad (\alpha_{12} - \alpha_{02}) = \alpha_2^* \quad (\alpha_{13} - \alpha_{03}) = \alpha_3^*$$

$$(\alpha_{14} - \alpha_{04}) = \alpha_4^* \quad (\varepsilon_{1j} - \varepsilon_{0j}) = \varepsilon_j^*$$

$$\text{prob(Yes)} = \text{prob}[-\alpha^* + \alpha_1^* Z_j + \alpha_2^* H_j + \alpha_3^* D_j + \alpha_4^* C_j] < \varepsilon_j^*$$

$$= [1 - \text{prob}(-\alpha^* + \alpha_1^* Z_j + \alpha_2^* H_j + \alpha_3^* D_j + \alpha_4^* C_j) < \varepsilon_j^*]$$

$$= \text{prob}[\varepsilon_j^* < \alpha^* + \alpha_1^* Z_j + \alpha_2^* H_j + \alpha_3^* D_j + \alpha_4^* C_j] > \varepsilon_j^*$$

The last equality exploits the symmetric of the distribution. For symmetric distribution $F(X)=1-F(X)$. Suppose that $\varepsilon_j \sim N(0, \delta^2)$. To use the software packages, it is necessary to convert $\varepsilon \sim N(0, \delta^2)$ to a standardize normal (N

(0,1)) variable. Let $\theta = \varepsilon_j^* / \delta$. Then $\theta \sim N(0, 1)$ and

$$\begin{aligned} \text{prob}(\varepsilon_j < \alpha^* + \alpha_1^* Z_j + \alpha_2^* H_j + \alpha_3^* D_j + \alpha_4^* C_j) &= \\ \text{prob}(\theta < \frac{\alpha^*}{\delta} + \frac{\alpha_1^*}{\delta} Z_j + \frac{\alpha_2^*}{\delta} H_j + \frac{\alpha_3^*}{\delta} D_j + \frac{\alpha_4^*}{\delta} C_j) &= \\ = \Phi(\frac{\alpha^*}{\delta} + \frac{\alpha_1^*}{\delta} Z_j + \frac{\alpha_2^*}{\delta} H_j + \frac{\alpha_3^*}{\delta} D_j + \frac{\alpha_4^*}{\delta} C_j) & \end{aligned}$$

Where: $\Phi(\cdot)$ is the cumulative standard normal.

The estimation of parameters comes from the maximization of the likelihood function. With the sample size of N households and let $I_j=1$ if respondent j answer YES. The likelihood function becomes:

$$L [\alpha, \alpha_1, \alpha_2, \alpha_3, \alpha_4, / Z, H, D, C] = \prod_{j=1}^N [\Phi(\cdot)]^{I_j} [1 - \Phi(\cdot)]^{1-I_j}$$

For probit model

Maximization of the likelihood function yield unique estimates of the parameter function

$$\alpha^*/\delta, \alpha_1^*/\delta, \alpha_2^*/\delta, \alpha_3^*/\delta, \alpha_4^*/\delta.$$

Defining a new L_x (m+1) parameters vector $\theta^* = \{\alpha^*/\delta, \alpha_1^*/\delta,$

$\alpha_2^*/\delta, \alpha_3^*/\delta, \alpha_4^*/\delta\}$ Where m is the number of covariates in Z, H, D, C,

including the constant, and a new individual specific $1 \times (m+1)$ data vectors

$X_j = \{Z_j, H_j, D_j, C_j\}$, the log likelihood function for the linear random utility

probit model becomes:

$$\ln L [\theta^* / X] = \sum_{j=1}^N I_j \ln [\Phi(x_j \theta^*)] + (1 - I_j) \ln [1 - \Phi(x_j \theta^*)]$$

And the logit model becomes.

$$\ln (\theta^* / X) = \sum_{j=1}^N I_j \ln [(1 + e^{-(X_j \theta^*)})^{-1}] + (1 - I_j) \ln [(1 + e^{-(X_j \theta^*)})^{-1}].$$

APPENDIX III

Table A-3-1 Descriptive summary for rural households

Variable	Mean	Standard deviation	Minimum	Maximum
Income	656.12	603.2842	95	5000
Marital status	0.89166	0.3121	0	1
Family size	7.03333	2.8252	0	1
Separate kitchen	0.5750	0.4137	0	1
Compatibility	0.40	0.4964	0	1
Spouse education	0.35	0.4789	0	1
Age	47.32	13.570	20	80
Sex of household head	0.8083	0.3952	0	1
Fuel expense	17.69	15.22	0	110
Active participation	0.525	0.5014	0	1
Credit	902.075	1102.36	0	4000
Access to credit	0.525	0.5014	0	1
Electricity	0.3666	0.4137	0	1
Market	0.2166	0.4137	0	1
Members for collection	1.93	1.11	0	6
Education	0.6083	0.4901	0	1
Log income	6.2064	0.7390	4.5538	8.5171
Dwelling status	0.78333	0.413709	0	1
Number of Observation 120				

Table A-3-2 Descriptive summary for urban households

Variable	Mean	Standard deviation	Minimum	Maximum
Income	506.72	586.89	85	3500
Marital status	0.5666	0.4983	0	1
Family size	5.31	2.56	1	12
Separate kitchen	0.5777	0.4966	0	1
Compatibility	0.5111	0.50267	0	1
Spouse education	0.48888	0.502677	0	1
Age	50.43	13.25	20	83
Sex of household head	0.6777	0.4699	0	1
Fuel expense	41.04	27.80	0	130
Active participation	0.5111	0.50267	0	1
Credit	489.76	1014.99	0	7000
Access to credit	0.3444	0.4778	0	1
Electricity	0.7666	0.4253	0	1
Market	0.4444	0.49968	0	1
Education	0.6111	0.4902	0	1
Log income	5.883	0.7701	4.4426	8.1603
Dwelling status	0.4888	0.5026	0	1
Number of Observations 90				

Table A-3-6 Marginal estimation of adoption for rural households

Marginal effects after heckprob
 $y = \text{Pr}(\text{adoption}=1)$ (predict)
 = .1648452

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]		X
memforco	-.1689048	.13719	-1.23	0.218	-.437799	.099989	1.93333
familyssi	.0266238	.02497	1.07	0.286	-.02232	.075568	7.03333
dwellsta*	.1161811	.18063	0.64	0.520	-.237843	.470205	.783333
sepkitch*	-.190998	.20795	-0.92	0.358	-.598582	.216586	.575
compatib*	.378838	.21061	1.80	0.072	-.033952	.791628	.4
spousedu*	.3991598	.34755	1.15	0.251	-.28202	1.08034	.35
age	-.0182151	.01361	-1.34	0.181	-.044881	.008451	47.325
headh*	.1928373	.21164	0.91	0.362	-.221965	.60764	.808333
acredit*	.1913719	.14765	1.30	0.195	-.098008	.480752	.525
educatio*	.4864443	.35383	1.37	0.169	1.17993	.207042	.608333
lincome	.547904	.40259	1.36	0.174	-.241164	1.33697	6.2065
marstat*	0	0	.	.	0	0	.891667
activepa*	.2602285	.11917	2.18	0.029	.026667	.49379	.441667
electric*	0	0	.	.	0	0	.366667
market*	0	0	.	.	0	0	.216667
activepa	(offset1)						.441667

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Table A -3-7 Probit estimation of information for urban households with robust

Probit regression
 Number of obs = 90
 LR chi2(11) = 84.97
 Prob > chi2 = 0.0000
 Pseudo R2 = 0.7183
 Log pseudolikelihood = -16.65883

informat	Robust dF/dx	Std. Err.	z	P> z	[95% C.I.]	
marstat	-.4414532	.9832645	-0.45	0.653	-2.368616	1.48571
familysi	.1776237	.1837009	0.97	0.334	-.1824233	.5376708
spousedu	1.062626	.8507201	1.25	0.212	-.604755	2.730006
age	-.0222864	.0234615	-0.95	0.342	-.0682701	.0236974
headh	-.9937398	.9328816	-1.07	0.287	-2.822154	.8346745
activepa	3.662871	.9719474	3.77	0.000	1.757889	5.567853
acredit	-.8013587	.6871486	-1.17	0.244	-2.148145	.5454278
market	2.643552	.7971588	3.32	0.001	1.08115	4.205955
electric	.8316106	.7565603	1.10	0.272	-.6512204	2.314442
educatio	.0800357	.5823168	0.14	0.891	-1.061284	1.221356
lincome	.8481769	.6806452	1.25	0.213	-.4858633	2.182217
cons	-6.573056	3.982075	-1.65	0.099	-14.37778	1.231668

Table A-3-4 Marginal estimation of information for urban households with robust

Probit regression, reporting marginal effects
 Number of obs = 90
 Wald chi2(11) = 52.38
 Prob > chi2 = 0.0000
 Pseudo R2 = 0.7183
 Log pseudolikelihood = -16.65883

informat	dF/dx	Std.Err.	z	P> z	x-bar	[95% C.I.]	
marstat	.0741886	.1034029	-0.71	0.476	.566667	-.276855	.128477
familysi	.0308363	.0241327	1.37	0.170	5.31111	-.016463	.078136
spousedu	.1871134	.1230341	1.39	0.164	.488889	-.054029	.428256
age	-.003869	.0039241	-1.02	0.309	50.4333	-.01156	.003822
headh	-.1412843	.1032944	-1.49	0.135	.677778	-.343738	.061169
activepa	.7187329	.1031423	5.48	0.000	.511111	.516578	.920888
acredit	-.1635659	.1318592	-1.47	0.142	.344444	-.422005	.094873
market	.4512897	.1159042	3.93	0.000	.444444	.224122	.678458
educatio	.0140567	.0890654	0.16	0.871	.611111	-.160508	.188622
lincome	.1472474	.0992137	1.77	0.077	5.88359	-.047208	.341703
electric	.1881645	.1638361	1.59	0.112	.766667	-.132948	.509277
obs. P .6333333							
pred. P .9014728 (at x-bar)							

Table A-3-5 Probit estimation of sample selection for urban households

Probit model with sample selection Number of obs = 90
 LR chi2 (12) = 84.27
 Censored obs = 33
 Uncensored obs = 57
 Wald chi2(12) = 28.04
 Prob > chi2 = 0.0055

Log pseudolikelihood = -33.63697

						Robust
adoption	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
age	-.0593611	.0379454	-1.56	0.118	-.1337328	.0150105
marstat	2.263982	1.236114	1.83	0.067	-.1587555	4.686721
familysi	.3366401	.1729713	1.95	0.052	-.0023774	.6756576
dwellsta	.2791171	.8090489	0.34	0.730	-1.30659	1.864824
sepkitch	1.17484	.8018762	2.03	0.043	-.3968086	2.746488
compatib	.6088237	1.117118	0.54	0.586	-1.580688	2.798335
spousedu	.5289612	.8129664	0.65	0.515	-1.064424	2.122346
headh	-4.327399	1.461699	-2.96	0.003	-7.192277	-1.462522
fuelexp	.0131462	.0166326	0.79	0.429	-.0194532	.0457455
acredit	1.179544	.758584	1.55	0.120	-.3072529	2.666342
educatio	3.484392	1.241389	2.81	0.005	1.051315	5.917469
lincome	.2721032	.6331548	0.43	0.667	-.9688574	1.513064
_cons	-5.224254	3.193623	-1.64	0.102	-11.48364	1.035133
activepa	(offset)					
informat						
marstat	-.4286643	.8178782	-0.52	0.600	-2.031676	1.174347
familysi	.1765413	.136889	1.29	0.197	-.0917562	.4448388
spousedu	1.048235	.9874462	1.06	0.288	-.8871236	2.983594
age	-.0221105	.0235583	-0.94	0.348	-.068284	.0240629
headh	-.9716964	1.147533	-0.85	0.397	-3.22082	1.277427
activepa	3.65241	.7598789	4.81	0.000	2.163075	5.141746
acredit	-.8260403	1.114081	-0.74	0.458	-3.009599	1.357519
market	2.617077	1.41075	1.86	0.064	-.147942	5.382096
electric	.8047146	1.190112	0.68	0.499	-1.527862	3.137292
educatio	.0949537	.8640634	0.11	0.912	-1.598579	1.788487
lincome	.8235751	1.122381	0.73	0.463	-1.376252	3.023402
_cons	-6.424711	6.698139	-0.96	0.337	-19.55282	6.7034
/athrho	.0848789	3.270068	0.03	0.979	-6.324336	6.494094
rho	.0846757	3.246622			-.9999936	.9999954
Wald test of indep. eqns. (rho = 0): chi2(1) =				0.00	Prob > chi2 = 0.9793	

Table A-3-6 Marginal estimation of adoption for urban households

Marginal effects after heckprob
 $y = \text{Pr}(\text{adoption}=1)$ (predict)
 = .06579136

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
age	-.0075976	.00807	-0.94	0.346	-.02341 .008215	50.4333
marstat*	.2965268	.32528	0.91	0.362	-.341003 .934057	.566667
familysi	.0430865	.04423	0.97	0.330	-.043602 .129775	5.31111
dwellsta*	.0360381	.11953	0.30	0.763	-.198243 .270319	.488889
sepkitch*	.141423	.21595	0.65	0.513	-.281825 .564671	.577778
compatib*	.0786422	.11404	0.69	0.490	-.144865 .302149	.511111
spousedu*	.0692883	.08191	0.85	0.398	-.091247 .229824	.488889
headh*	-.9210872	.14922	-6.17	0.000	-1.21355 -.62862	.677778
fuelexp	.0016826	.00168	1.00	0.316	-.001604 .00497	41.0444
acredit*	.2034827	.19023	1.07	0.285	-.169357 .576323	.344444
educatio*	.4391211	.33911	1.29	0.195	-.225513 1.10376	.611111
lincome	.0348264	.11255	0.31	0.757	-.185765 .255418	5.88359
activepa*	.1323577	.15334	0.86	0.388	-.168189 .432905	.511111
market*	0	0	.	.	0 0	.444444
electric*	0	0	.	.	0 0	.766667
activepa (offset1)						.511111

(*) dy/dx is for discrete change of dummy variable from 0 to 1

APPENDIX IV

(For all Annex 4 Tables the sources is survey data)

TABLE A-4-1 <i>Collection area and sources for fuel wood and other energy sources of fuel for the households and their coping strategy</i>	Urban Household			Rural household		
	Informed household		Non-informed	Informed household		Non-informed
	Adopters	Non-Adopters		Adopters	Non-Adopters	
BACKYARD	3	9	7	14	12	17
OWN FARM (FIELD)	6	3	9	8	8	21
OPEN FIELD	3	3	7	10	2	14
COMMUNAL FOREST AREA	-	-	-	2	-	-
PURCHASE	19	11	10	2	-	10
OTHER	-	-	-	-	--	--
Total	31	26	33	36	22	62
COOPING STRATEGY						
SUBSTITUTE WITH OTHER FUEL	9	12	7	10	6	12
CONSERVE FUEL USE	8	6	5	8	4	8
STOCK ON FUEL	14	5	17	18	12	36
DO NOTHING	-	3	4	-	-	6
OTHER	-	-	-	-	--	-
Total	31	26	33	36	22	62

TABLE A-4-2 Energy Source for the households use as substitute when they face shortage mostly ad time taken to collect fuel

TYPE OF FUEL	Total	Urban household		Rural household		
	31	26	33	36	22	62
	Informed household		Non-informed	Informed household		Non-informed
	Adopters	Non-Adopters		Adopters	Non-Adopters	
FUEL WOOD	13	10	8	15	10	21
COW DUNG	13	13	17	17	8	25
OIL SEEDS	-	-	-	-	-	-
LEAVES	3	2	6	4	4	14
SAWDUST	1	-	-	-	-	-
ELECTRICITY	1	-	-	-	-	-
CHARCOAL	-	-	-	-	-	-
OTHER	-	1	2	-	-	2
Total	31	26	33	36	22	62
Time taken to collect fuel						
Less than half hour	9	8	-	28	2	
Half hour-1 hour	3	6	4	6	8	3
1:01hour-2hour	-	1	3	-	4	36
Above two hour	-	-	16	-	6	13
Non -collectors	19	11	10	2	2	10

TABLE A-4- 3 Disadvantage (problem) in baking for non-adopters and non-informed households with their baking appliance

RANK OF THE REASONS	URBAN HOUSEHOLD		RURAL HOUSEHOLD	
	NON-ADOPTERS	NON-INFORMED	NON-ADPTERS	NON-INFORMED
FIRST				
EXPOSURE TO ACCIDENT	2	2	1	7
IT IS HOT WHILE BAKING	12	18	7	24
SMOKE PROBLEM	4	1	4	10
CONSUME TOO MUCH FUEL	7	11	10	19
OTHER	1	1	-	2
TOTAL	26	33	22	62
SECOND				
EXPOSURE TO ACCIDENT	5	4	2	1
IT IS HOT WHILE BAKING	13	10	6	27
SMOKE PROBLEM	1	14	2	-
CONSUME TOO MUCH FUEL	5	5	11	33
OTHER	2	-	1	1
TOTAL	26	33	22	62
THIRD				
EXPOSURE TO ACCIDENT	6	7	1	13
IT IS HOT WHILE BAKING	1	3	9	9
SMOKE PROBLEM	11	12	10	20
CONSUME TOO MUCH FUEL	7	5	2	18
OTHER	1	6	-	2
TOTAL	26	33	22	62

TABLE A-4-4 Rank of Advantages that households obtained from adoption of improved ("Mirt")stove Technology

ADVANTAGE	URBAN ADOPTERS	RURAL ADOPTERS
FIRST		
CONSERVE FUEL	9	12
CONVINIENT TO USE	6	4
NO HEAT AND CLEAN	14	20
CONVINIENT FOR MULTIPLE USE	2	-
OTHER	-	-
TOTAL	31	36
SECOND		
CONSERVE FUEL	8	13
CONVINIENT TO USE	10	14
NO HEAT AND CLEAN	12	9
CONVINIENT FOR MULTIPLE USE	1	-
OTHER	-	-
TOTAL	31	36
THIRD		
CONSERVE FUEL	4	7
CONVINIENT TO USE	3	17
NO HEAT AND CLEAN	1	6
CONVINIENT FOR MULTIPLE USE	6	-
OTHER	17	6
TOTAL	31	36

TABLE A-4- 5 Sources for the households to Obtain Information about improved (“Mirt”) stove technology

SOURCE TO OBTAIN INFORMATION ABOUT IMPROVED (“MIRT”) STOVE TECHNOLOGY	URBAN HOUSEHOLD		RURAL HOUSEHOLD	
	ADOPTERS	NON-ADOPTERS	ADOPTERS	NON-ADOPTERS
<i>TV/RADIO</i>	3	2	2	-
<i>DISPLAY IN MARKET PLACES</i>	8	5	-	-
<i>DEMONSTRATION ACTIVITY</i>	15	13	4	6
<i>DEVELOPMENT AGENTS</i>	-	1	22	14
<i>FRIENDS OR RELATIVES</i>	5	5	8	2
<i>OTHER</i>		-	-	-
<i>TOTAL</i>	31	26	36	22

TABLE A-4-6 Reasons for households not to have (adopt) improve (“Mirt”) stove

REASONS	URBAN NON-ADOPTERS	RURAL NON-ADOPTERS
<i>INCOME</i>	14	17
<i>THE STOVE IS INCONVINIENCE</i>	-	2
<i>HOUSING PROBLEM</i>	11	3
<i>FUEL WOOD COST</i>	-	-
<i>HAVING BETTER APPLIANCE</i>	1	-
<i>OTHER</i>	-	-
<i>TOTAL</i>	26	22

TABLE A-4-7 Factors Affecting household to acquire information and adoption decision for improved (“Mirt”) stove

	RURAL HOUSEHOLDS		URBAN HOUSEHOLDS	
	Frequency	Percentage	Frequency	Percentage
1. Head of the household				
Male	106	88%	59	65%
Female	14	12%	31	35%
2. Dwelling status of the household				
Owners	84	70%	45	50%
Non-owners	36	30%	45	50%
3. Presence of separate kitchen in the house				
YES	72	60%	53	58%
NO	48	40%	37	42%
4. Source of fuel wood and other energy sources				
Purchase	12	10%	40	44%
Collection and purchase	14	12%	28	31%
Collection	94	78%	22	25%
5. Presence of modern source of energy (electricity)				
YES	52	57%	69	77%
NO	68	43%	21	23%
6. Active participant in local associations and activities				
YES	50	42%	46	51%
NO	70	58%	44	49%
7. Spouse educated or not				
YES	45	38%	50	56%
NO	75	62%	40	44%
8. The stove is compatible				
YES	41	34%	48	54%
NO	79	66%	42	46%
9. Having access to credit				
YES	70	58%	47	52%
NO	50	42%	43	48%
10. Marital status				
Yes	93	78%	58	64%
NO	27	22%	32	36%

Table A-5-1 projected sustainable fuel wood supply (1000m3s)

Year	With Intervention									With Intervention								
	Farm Forestry	Industrial forests	Natural high forests	Community plantations	Wood lands	Bush land	Peri-urban plantation	Calchmen protect forests	Total	Farm forestry	Industrial plantation	High forests	Community plantations	Wood-lands	Bush land	Periurban plantations	Catch ment protect forests	Total
1992	1365	583	200	112	6016	4000	252	34	12528	1365	592	200	112	6016	4000	252	34	12571
1993	1365	568	200	112	5920	3936	252	34	12354	1365	575	200	112	5920	3936	252	34	12394
1994	1365	561	200	112	5825	3873	252	34	12187	1365	537	200	112	5825	3873	252	34	12200
1995	1365	553	200	112	5729	3809	252	34	12020	1365	498	260	112	5729	3809	264	34	12971
1996	1365	549	200	112	5633	3745	252	34	11857	1365	464	320	115	5633	3745	273	34	11949
1997	1365	541	200	112	5537	3682	252	34	11689	1380	425	380	118	5537	3682	283	34	11839
1998	1365	587	200	112	5442	3618	252	34	11567	1457	436	440	121	5442	3618	283	34	11831
1999	1365	562	200	112	5346	3555	252	34	11392	1558	388	500	124	5389	3583	283	34	11860
2000	1365	555	200	112	5250	3491	252	34	11225	1807	357	620	127	5337	3548	485	34	12255
2001	1365	539	200	112	5155	3427	252	34	11050	2057	310	680	130	5285	3514	485	1427	13828
2002	1365	533	200	112	5059	3364	252	34	10885	2375	282	740	134	5232	3479	485	1427	14094
2003	1365	535	200	112	4763	3300	252	34	10727	2696	261	800	137	5180	3444	485	1427	14369
2004	1365	575	185	112	5867	3236	252	34	10593	3030	304	800	139	5128	3409	485	1427	14722
2005	1365	579	170	112	4772	3173	252	34	10423	3459	350	800	143	5075	3375	688	1427	15317
2006	1365	581	155	112	4676	3109	252	34	10250	3864	353	800	146	5023	3340	688	2821	17034
2007	1365	557	140	112	4580	3045	252	34	10052	4405	325	800	146	4971	3305	688	2821	17457
2008	1365	575	1525	112	4485	2982	252	34	9895	4895	321	800	146	4818	3270	688	2821	17859
2009	1365	563	110	112	4389	2918	252	34	9709	5414	288	800	146	4866	3235	688	2821	16257
2010	1365	621	95	112	4393	2855	252	34	9593	5958	370	800	146	4814	3201	688	2821	18797
2011	1365	581	80	112	4198	2791	252	34	9378	6505	412	800	146	4761	3166	688	4214	20692
2012	1365	564	80	112	4105	2727	252	34	9202	7053	423	800	146	4709	3079	688	4214	21132
2013	1365	557	80	112	4006	2664	252	34	9036	7526	435	800	146	4656	3072	688	4214	21537
2014	1365	525	80	112	3910	2600	252	34	8844	7919	417	800	146	4504	3062	688	4214	21850

SOURCE: GEBREMARKOS W/ SELASSIE, ENERGY CONFERENCE 2002.

Table A-5- 2 PROJECTED DEMAND FOR FUELWOOD (1000 M3S)

WITHOUT INTERVENTION				WITH INTERVENTION		
YEAR	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL
1992	3389	41564	44953	3389	41564	44953
1993	3502	42948	46450	3502	42948	46450
1994	3727	44231	47958	3727	44231	47950
1995	3903	45615	49518	3903	45508	49411
1996	4091	47101	51192	4091	46850	50941
1997	4288	48629	52917	4288	48172	52460
1998	4492	50201	54693	4492	49523	54015
1999	4705	61816	56521	4705	50902	55607
2000	4926	53477	58403	4926	52300	57226
2001	5154	55156	60310	5154	53698	58852
2002	5390	57687	62269	5390	55121	60511
2003	5636	58647	64283	5636	56569	62205
2004	5890	60460	66350	5890	58040	63930
2005	6153	62320	68473	6153	59533	65686
2006	6420	64163	70583	6420	60958	67378
2007	6696	66049	72745	6696	62452	69148
2008	6980	67987	74967	6980	63934	70914
2009	7273	69949	77222	7273	65442	72715
2010	7575	71964	79539	7575	67243	74818
2011	7877	73935	81812	7877	69054	76931
2012	8187	75943	84130	8187	71031	79218
2013	8505	77988	86493	8505	73044	81849
2014	8830	80069	88899	8830	75092	83922

SOURCE: GEBREMARKOS W/ SELASSIE, ENERGY CONFERENCE 2002.

Declaration

I, the undersigned, declared that this thesis is my original work and has not been presented for a degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

Declared by

Name Dawit Wolubisheh

Signature Dawit

Date March /2007

Confirmed by Advisor:

Name Mulet Demeke

Signature Mulet D

Date March 2007

Place and date of submission: Addis Ababa, March 2007.