Studies on Prospects and Challenges of Uptake of Domestic Biogas Technology

(The case of SNNPR, ETHIOPIA)

Zerihun Desalegn

A Thesis

submitted to Indira Gandhi National Open University in partial fulfillment of the requirement for the degree in Master of Arts in Rural Development

Addis Ababa, Ethiopia

November 2014

DECLARATION

I hereby declare that the dissertation entitled STUDIES ON PROSPECTS AND CHALLENGES of UPTRAKE of DOMOSTIC BIOGAS TECHNOLOGY submitted for the partial fulfillment of M.A. in Rural Development to Indira Gandhi National Open University, IGNOU New Delhi is my own original work and has not been submitted earlier either to IGNOU or to any other institution for the fulfillment of the requirement for any course of the study. I also declare that no chapter of this manuscript in whole or in part is listed and incorporated in this report from any earlier work done by me or others.

Place: ADDIS ABABA, Ethiopia Signature: ________________________

Date: 17/11/2014 ________ Enrollment No.: 109100714_______________

Name: ZERIHUN DESALEGN

HAWASSA, ETHIOPIA

CERTIFICATE

This is to certify that Mr. Zerihun Desalegn student of M.A. RD from Indira Gandhi National Open University, New Delhi was working under my supervision and guidance for his Project Work for the Course MARD-001. His Project Work entitled STUDIES ON PROSPECTS AND CHALLENGES of the UPTAKE of DOMOSTIC BIOGAS TECHNOLOGY which he is submitting, is his genuine and original work.

Place: ADDIS ABABA, Ethiopia Signature: ________________________

Date: 17/11/2014 __________ Name: (Dr.) Mengistu Hulluka

Address of the Supervisor: ADDIS ABABA, Ethiopia

Acknowledgement

It is a pleasure to express my heartfelt gratitude to those who made this thesis possible. First of all I would like to thank my supervisor Mengistu Hulluka (Dr.) whose guidance, encouragement and support enabled me to develop a deeper understanding of the subject and whose patience, during prolonged data collection, helped me to collect all the valuable data.

I express my sincere gratitude to the staff of Energy Department/ RBPCU of SNNPR Mines and Energy Agency who helped me in providing essential information and in actively participating in the focus group discussion (FGD). Here, I want to mention the help of Mr. Girma Dichiro, who currently retired, in sharing me his work experience and some of the lost data in the biogas sector.

I still want extend my gratitude to the energy staff of the four woredas; A/Minch zuria, Soddo zuria, Aleta Wondo and Meskan, Mr. Yemane Abera (head of Gamo Gofa zone Energy Department), and Shimeles Debella (head of rural credit department in OMFI), as the data collection could not be a reality without their sincere support.

I would also like to thank Mr. Debrework Debebe, a lecturer in the department of Governance and Development Studies of Hawassa University, for sharing his research experiences and encouragement during analysis of the data.

Finally, I want to express my gratitude to all my family for the support throughout my research work. Especially, I am indebted to my wife for her patience and support in encouraging me and taking care of our son in the course of the study.

Contents

List of Tables

List of figures

List of Charts

List of Abbreviations and Acronyms

AD: Anaerobic Digestion

ABPP: African Biogas Program Partnership

AEMFI: Association Ethiopian Micro Finance Institutions

a.s.l: Above Sea Level

BCE: Biogas Company Enterprise

BoA: Bureau of Agriculture (SNNPR)

BoFED: Bureau of Finance and Economic Development (SNNPR)

BLT: Branches, Leaves and Twigs

BSP: Biogas Support Program

°C: Degree Centigrade

CBO: Community Based Organization

CH_4: Methane gas

CO_2: Carbon dioxide

CRGE: The Climate- Resilient Green Economy)

CSA: Central Statistics Agency

E.C.: Ethiopian Calendar

EFAP: The Ethiopian Forestry Action Plan)

ETB: Ethiopian Birr (Currency)

FAO: Food and Agriculture organization of UN

FSS: Financial Self Sustainability

GDP: Gross Domestic Product

GGC: Gobar Gas Company

GHG: Greenhouse Gas

GI: Galvanized Iron

GNP: Gross National Product

GoE: Government of Ethiopia

GTP: The five years Growth and Transformation Program of the Ethiopian Government

H_2: Hydrogen Gas

Hivos: The Netherlands Humanist Institute for Development Cooperation

Hr.: Hour

IEA: International Energy Agency

IRENA: International Renewable Energy Agency

H_2S: Hydrogen Sulfide Gas

JPOI: Johannesburg Plan of Implementation

Kg: Kilo Gram

Km: Kilo Meter

KWh: Kilo Watt Hour

LPG: Liquid Petroleum Gas

LVIA: Lay Volunteers International Association

m: Meter

m^3:	Cubic Meter
MFI:	Micro Finance Institution
MJ m^{-3}:	Mega Joule per cubic meter
MDG:	Millennium Development Goal
MEA:	Mines and Energy Agency (SNNPR)
mm:	millimeter
MoFED:	Ministry of Finance and Economic Development of (GoE)
MW:	Mega Watt
mm/yr:	millimeter per year
NBE:	National Bank of Ethiopia
NBPE:	National Biogas Program of Ethiopia
NGO:	Non Governmental Organization
OECD:	The Organization for Economic Co-operation and Development
OMFI:	Omo Micro Finance Institution
OSS:	Operational Self Sustainability
p.a.:	Per annum
PID:	Program Implementation Document
PPR:	Plastic Pipe
RBPCU:	Regional Biogas Program Coordination Unit
REDD:	Reducing Emissions from Deforestation and Degradation
RET:	Renewable Energy Technology
SNNPR:	Southern Nations and Nationalities People Regional State

SREP: Scaling-Up Renewable Energy Program

SNV: The Netherlands Development Organization

T: Tera (10^{12})

Tcal: Tera Calories

TJ: Tera Joule

TWh: Tera Watt hour

UN: United Nation

UNCDF: UN Capital Development Fund

USD: American Dollar

vol.: Volume

WSSD: World Summit on Sustainable Development

Abstract

The rate of uptake of domestic biogas technology in Ethiopia, particularly in SNNPR, was very sluggish despite numerous benefits derived from biogas technology and the country's huge technical potential. Mass dissemination of biogas technology in Ethiopia was almost non- existent before the implementation of NBPE in 2008. Only 104 biogas digesters were installed in different parts of SNNPR in the period between 1976 and 2008. Though improvements in mass dissemination have been seen after the implementation of NBPE, only 1.34 % of the potential is tapped regionally. Of the 152,000 potential households in the region, installation of 2043 domestic biogas digesters had become reality up to the end of 2013. This paper reviews the prospects and challenges of the uptake of domestic biogas technology in SNNPR, Ethiopia. The study was conducted by surveying non-beneficiary households, the private sectors (BCEs, appliance suppliers and manufacturers), MFIs and governmental and non-governmental organizations from four woredas of the region in which NBPE is under implementation. The willingness of prospect households in investing biogas digester installations, the challenge faced by farmers in covering up front costs for digester installation, role and challenges of private and micro finance sectors, the commitment of government and the participation of and challenges faced by the stakeholders in supporting the biogas sector were the major areas of investigation. The findings of this research show that there are prospects that could favour the mass dissemination of the technology. Among the major prospects, the international context, the existence of huge technical potential for mass adoption of the technology, the government's commitment in supporting the deployment of renewable energy technologies, the availability of MFIs, and the development of infrastructure are identified as the enabling factors for quick and mass dissemination of the

technology. As against the prospects in favour of the dissemination effort, there remain several challenges retarding the dissemination process and resulted in low level development of the biogas sector. Low level awareness of the people, need for high investment cost for plant installation and the associated financial shortage, weak private sector participation, wrong dissemination strategies, and limited participation and support of stakeholders are the major challenges faced by the biogas sector in SNNPR.

Chapter 1 – Introduction

1.1. Background and Rationale

It has been frequently estimated that around 2 billion people have no access to modern energy services and about 1.5 billion people live without access to electricity (World Bank, 2006). Yet, the majority of the African population, especially in sub-Saharan Africa, is without access to electricity and other modern forms of clean energy. The amount of electricity used in the industrialized countries is 150 times higher than that of Africa. Sub-Saharan Africa continues to rely heavily on low quality traditional sources of energy such as wood fuel. Seventy six percent (76%) of the population depends on wood fuel as a source of energy (ENDA, 2005).

Furthermore, there appears to be a positive relationship between national income and modern energy consumption in Africa. Countries with high GNP tend to consume more modern energy than countries with low incomes. The majorities of African countries are low income countries and therefore consume less energy (Karekezi, 2002).

Furthermore, the energy sector in Africa shows regional diversity and can be best clustered into three distinct regions. The first is North Africa, which is heavily dependent on oil and gas. The second is South Africa which relies on coal while the rest of Sub-Saharan Africa is largely reliant on biomass. In 1997, South Africa and North Africa accounted for over 50% of Africa‘s total modern energy production (Karekezi, 2002).

In developing countries, over 500 million households still use traditional biomass for cooking and heating (UNEP, 2009). Ethiopia, like the rest of Africa, is no exception to this situation. In Ethiopia, 95 percent of national energy consumption is derived from fuel wood, dung, crop residues, and human and animal power. The remaining 5 percent is from electricity, 90 percent of which is generated by hydropower (World Bank, 2006). For more than 90% of the Ethiopian population the only energy used for cooking, heating and lighting is obtained from biomass, in which 99% is derived from fuel wood, charcoal, crop residue and leaves, fuel wood occupying the leading position (WHO, 2000).

The heavy dependence on biomass for domestic energy needs and other purposes has resulted in deforestation, land degradation, environmental and health problems. According to World Bank, (2006) the use of biomass spurs deforestation and soil erosion and contributes to a significant environmental health problem: exposure to smoke and indoor air pollution, which causes elevated under age five mortality and a high incidence of respiratory diseases, mainly women and children.

Globally, 55% of the wood extracted from forests is for fuel, and fuel wood is responsible for 5% of global deforestation (FAO, 1999). Reductions in access to fuel wood supplies can negatively affect poor subsistence users as well as adversely affecting those generating income from fuel wood to bridge their income between seasons. In the 1970s, population pressures and increases in oil prices were already considered to be major drivers of deforestation (Arnold et al, 2003).

Combustion of biomass fuels in confined often unventilated indoor areas and at low thermodynamic efficiency leads to high concentrations of smoke and other pollutants (World Energy Council, 1999-2005). The dependence on such polluting fuels is both a cause and a result of poverty, as poor households often do not have the resources to obtain cleaner, more efficient fuels and appliances. Reliance on simple household fuels and appliances can compromise health and thus hold back economic development, creating a vicious cycle of poverty (Fact sheet N°292, 2005). This pollution from solid fuel use is a significant risk factor for acute respiratory infections, which accounts for a remarkable 7% of the global burden of disease and is most firmly associated in younger children (WHO, 2004). Multiple epidemiological studies across the world have linked indoor air pollution to such illnesses as acute lower respiratory infection (currently the leading cause of death among children fewer than 5 years), chronic obstructive disease, lower birth weights, and higher risk of tuberculosis (Domanski et al. 2005). Though many sources of indoor air pollution exist, studies such as those conducted by the World Health Organization (WHO) have identified coal and biomass burning for heating and cooking as the lead contributor to indoor air pollution in developing countries' rural households (Domanski et al. 2005). The WHO estimates that 1.6 million deaths a year worldwide and 1.4 billion illnesses can be attributed to the household burning of such solid fuels (Desai et al 2004). Clearly, the health costs of bad indoor air quality can be detrimental to a rural family, making the transition to clean energy sources such as biogas even more pertinent.

Achieving a sustainable energy future for all is a universal goal that is placed on the agenda of United Nations organisations by international consensus. Both Agenda 21 and the Johannesburg Plan of Implementation (JPoI) regard an efficient use and supply of energy that are reliable, affordable and less polluting as indispensable components of sustainable development. To achieve this goal, more and better integrated energy-environment planning and an increased use of renewable sources in the overall energy supply system are important elements that should be incorporated into any country's energy-environment development strategy (Najam and Cleveland, 2006).

Rural Energy Technologies (RETs) are energy-providing technologies that utilize energy sources in ways that do not deplete the Earth's natural resources and are as environmentally benign as possible. These sources are sustainable in that they can be managed to ensure they can be used indefinitely without degrading the environment (Renewable Energy Association, 2009).By exploiting these energy sources, RETs have great potential to meet the energy needs of rural societies in a sustainable way, albeit most likely in tandem with conventional systems. The decentralized nature of some RETs allows them to be matched with the specific needs of different rural areas (UNCTD, 2010).

Among other types of renewable energy technologies, biogas technology can be mentioned here to meet the energy needs of the society, and to tackle environmental and social problems caused by over utilization of biomass as fuel. Biogas technology can serve as a means to overcome energy poverty, which poses a constant barrier to economic development in Africa. Biogas production from agricultural residues, industrial, and municipal waste (water) does not compete for land, water and fertilizers with food crops like is the case with bioethanol and biodiesel production. Currently there is serious shortage of food in developing countries which will continue into the future. Therefore, food production is much more important and should compete out completely the production of energy crops for biodiesel and bioethanol. Unlike other forms of renewable energy, biogas production systems are relatively simple and can operate at small and large scales in urban and rural locations, there are no geographical limitations to the employment of this technology nor is it monopolistic (Mshandete A.M and Parawira W., 2010)

.

Biogas, a methane rich gas (heat content of 18.6 - 26.04 MJ m^{-3}) produced by anaerobic fermentation of organic material, is distinct from other renewable energy sources such as solar, wind, thermal, and hydro because of its importance in controlling and collecting organic waste materials that, if untreated, could cause severe public health and environmental pollution problems (Amingun and von Blottniz, 2007). Biogas produced from cattle, pig, and buffalo dung (and other excrement, e.g. human), together with the by-product bio slurry, can be a solution to poverty, climate change, poor access to modern energy services, and soil fertility problems (Lavinia W., 2013).

Traditionally, many of the rural households in the highland parts of Ethiopia use dung as fertilizer. Unfortunately, shortage of energy for cooking increasingly forced many of the households to use dung as energy source. Although chemical fertilizer has been widely promoted, only 32.8% of the rural households in Ethiopia used fertilizer in 1995 (CSA, 1999). In the Region some 202,183 tons of dung and 1,341,356tons of residues are burnt as fuel in rural areas. Between 55 and 87 percent of dung is collected from farmers' own land (SNNPR BoA, 2001). The burning of dung and plant residue is a considerable waste of plant nutrients. Losses to crop production from burning dung and soil erosion are estimated at over 600,000 tonnes annually, or twice the average yearly request for food aid in Ethiopia (Araya and Edwards, 2006). With more continuous cropping on the increase, organic material and nitrogen are rapidly getting depleted; phosphorous and other nutrients reserves get depleted slowly but steadily (Borlaugh and Dowswell, 1995). Biogas technology is a suitable tool for making maximum use of scarce resources (Eshete G and Kidane W., 2008). The slurry that is obtained after extraction of the energy content of the dung is still an excellent fertilizer, rich in nitrogen, phosphorous, potassium and humus, supporting general soil quality as well as higher crop yields (Marchain, 1992).

Even if today the biogas technology is proven to be very essential tool in improving the lives of the people, and even if regions favourable for biogas can be relatively easily identified, the uptake of domestic biogas technology is on its embryonic stage in Ethiopia, particularly in SNNPR. Biogas was first introduced in Ethiopia in to Ambo Agricultural College in 1957/58 in order to generate the energy required for welding agricultural tools and other equipment (Amera, 2010). Since then efforts have been made by the Government and NGOs to introduce and disseminate the technology in different parts of the country. However, the rate of dissemination was very sluggish till the launching of the National Biogas Programme of Ethiopia (NBPE) in 2008. According to J.U.Smith (2011), in the past two and half decades around 1000 plants (size ranging 2.5 - 200 m^3) have been built for households, communities and institutions by nine different GOs &NGOs. Today, 40% of the constructed biogas plants are non-operational. A range of different models of biogas digesters have been used: Indian floating drum, Chinese fixed dome, Camar Tech, Deenbandhu, Polyethylene (plastic bag) and LUPO fixed dome type . Even if Ethiopia has a technical potential of 1.1 million domestic biogas digester construction (Eshete G and Kidane W., 2008), the number of digesters disseminated up to the end of 2013 is about 9,000; 1000 digesters and 8,000 digesters before and after 2008, respectively. Situation in SNNPR is also similar even if the first biogas digester was installed as early as 1976 in Agricultural College’s compound of Woliyta Soddo town.

A range of factors have negatively influenced the adoption of the technology. In Africa, biogas technology dissemination has been relatively unsuccessful. Njoroge D.K., (2002), attributes the non-progressiveness of most biogas programmes to failure of African governments to support biogas technology through a focused energy policy, poor design and construction of digesters, wrong operation and lack of maintenance by users, poor dissemination strategies, lack of project monitoring and follow ups by promoters, and poor ownership responsibility by users. Above all, proper dissemination strategies had not been designed which would help in addressing challenges like technical and operational matters, financial matters, awareness matters, and institutional matters.

Accordingly, it would be very essential to deal with what prospects and challenges are there in favour and against higher dissemination rate of the technology. The international pressure for adopting and disseminating renewable energy technologies, the favourable technical potential of the country/region, availability of decentralized institutional structures for energy development and availability of decentralized financial institutions are some of the important prospects which would help in accelerating the rate of dissemination to the required level.

The potential of RETs to power rural development has been understood for many decades. However, it is only recently that significant effort has been made to mobilize the resources to realize this potential and there is still a long way to go (Kristoferson, 1997; Bhattacharyya, 2006; Boyle et al., 2006). From the perspective of climate change (Kyoto protocol), sustainability (WSSD and International Conference for Renewable Energies Bonn 2004) and development (the MDGs), the role of renewable energy technologies is increasingly becoming more important. These developments are the driving international forces for up-scaling of renewable energy technologies and for influencing social, cultural, political and economic institutions at the national level (Eshete G and Kidane W., 2008). According to Bugaje (2004), a lack of adequate energy services is certainly a constraint on development. It limits the capacity to meet the basic needs of those who need energy to undertake essential domestic, agricultural and educational tasks, to support health services, and to initiate trade flows. This realization has become a major driver towards increasing energy supply in Africa and the use of renewable energy technologies in particular.

Africa is a continent with abundant, diverse and unexploited renewable energy resources that are yet to be used for improving the livelihood of the vast majority of the population. The production of biogas via anaerobic digestion of large quantities of agricultural residues, municipal wastes and industrial waste (water) would benefit African society by providing a clean fuel from renewable feed stocks and help end energy poverty (Mshandete, A.M. and Parawira, W., 2009). Technical issues like the availability of feedstock, availability of land and water, and existence of conducive temperature for operation of biogas technology make Ethiopia a country with abundant potential for biogas dissemination. SNNPRS counts nearly 2.7 million households, out of which 75% keep cattle. Out of these 2.0 million cattle holdings, 38% are keeping four or more cattle heads. In the region, only 20% has reasonably close access to water. Based on the figures in Table 1, the technical potential for domestic biogas in SNNPRS would amount to approximately 152,000 installations (Eshete G and Kidane W., 2008).

Table 1.1: Data on cattle in SNNPRS

SNNPRS Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Amaro Special Woreda	1557	23714	17374	78473	73%	50	4.5	0	17374	100%
Basketo Special Woreda	419	10348	7509	23611	73%	56	3.1	7509	0	0%
Benchi Maji	23159	102783	81521	319902	79%	14	3.9	72986	8535	10%
Burji Special Woreda	1353	7980	6433	32970	81%	24	5.1	0	6433	100%
Dawuro	4380	81637	65541	292664	80%	67	4.5	0	65541	100%
Derashe Special Woreda	1526	23278	12396	66701	53%	44	5.4	0	12396	100%
Gamo Gofa	12153	257901	205707	850291	80%	70	4.1	93563	112144	55%
Gedeo	1356	141168	41506	117356	29%	87	2.8	41506	0	0%
Guraghe	7914	419708	335151	1353983	80%	171	4	130601	204550	61%
Hadiya	4026	253305	199648	733814	79%	182	3.7	199648	0	0%
Kaffa	10539	157734	128591	575024	82%	55	4.5	0	91495	71%
Kembata Alaba Tembaro	2493	193843	144008	472681	74%	190	3.3	144008	0	0%
Konso Special Woreda	2323	36261	22919	103413	63%	45	4.5	0	22919	100%
Konta Special Woreda	2287	17062	13780	52576	81%	23	3.8	13780	0	0%
Shaka	1530	29386	18755	65817	64%	43	3.5	13574	5181	28%
Sidama	6779	528046	404560	1573318	77%	232	3.9	244331	160229	40%
South Omo	23145	91237	60446	1392822	66%	60	23	8483	51963	86%
Wolayita	4525	297226	230520	658886	78%	146	2.9	230520	0	0%
Yem Special Woreda	753	16353	13315	51387	81%	68	3.9	13315	0	0%
Total SNNPRS	**112217**	**2688970**	**2009680**	**8815689**	**75%**	**79**	**4.4**	**1213824**	**758760**	**38%**
					Access to potable water					20%
					Technical potential domestic biogas SNNPRS region					**151752**

Source: PID, 2008

Another important factor which would help the larger up take of biogas technology is the availability of financial institutions, especially MFIs. The microfinance sector has grown 12 percent per year in total outreach over the last decade and now reaches over 500 million people across the globe with financial services (Helms and Brigit, 2006). The microfinance sector is also growing in Ethiopia since the enactment of the first MFIs licensing and supervision proclamation in 1996. Ethiopia's Microfinance industry has shown steady growth trends over the last several years that are marked by an industrial asset holding of 5.9 billion ETB as of fiscal year ending 2008 (AEMFI, 2010). According to Biruk T., 2010, up the end of 2010 there are 32 MFIs which have been registered by the NBE and are operating under the auspices of the proclamation.

Though prospects which would create conducive ground for mass adoption of biogas technology are readily available, there are many challenges to be addressed at the country level, particularly in the region. Among the many challenges surrounding the biogas sector, the need of higher construction investment and the related financial shortage by users, limited awareness of the people, low level of private sector development, limited ownership of local governments, limited partnership among development organizations are the most influencing factors.

An obvious obstacle to the large-scale introduction of biogas technology is the fact that the majority of the rural population cannot afford the cost of investment for a biogas plant. To consider biogas technology as an alternative fuel to the well-known traditional fuels; rural household might have different challenges among which financial limitations take the upper hand (Biruk T., 2010). The cost necessary for the construction of biogas plants frequently exceeds the means at the disposal of the investor, in other words s/he cannot cover them from his regular income or savings (GTZ and ISAT, 2010). While biogas technology appears to be competitive in economic terms, it is not financially viable to rural people who have limited capacity to be able to pay the high upfront cost of the biogas digesters (UNESCAP, 2007). In SNNPR, the cost of installation for a biogas plant with a size of $6m^3$ is 13,000 ETB (€ 500) on average (MEA/RBPCU, 2013). In relation to this what can be mentioned here as a challenge is that financial institutions target mainly economically active people and viable institutions. Although the microfinance sector is well developed in Ethiopia, availability of credit to renewable energy technologies is still limited (Biruk T., 2010).

Limited awareness of the rural people about the multi-faceted benefits of biogas technology is also another important factor inhibiting mass adoption of the biogas technology. Lack of education may present a barrier to uptake. Although formal credit markets have become increasingly accessible to farmers, farmers lacking a high level of literacy may find the complicated borrowing procedure and paperwork a major disincentive (Vien, 2011). This is supported by the observation that adoption increases with literacy rate (Bhat et al., 2001).

Among the various factors which could play a crucial role in mass dissemination of the biogas technology, private sectors take the lion share. Biogas companies, appliance manufacturers and financing institutions are the major actors under the umbrella of private sector. However, the involvement of the private sectors in this regard has been very limited and has contributed little in the context of Africa. According to Alexander D., 2012, entrepreneurial skills, which can greatly aid a private sector to develop itself, are lacking in Tanzania's National Biogas Program and not really aiding the development of the sector. Similarly, the role of private sectors in developing the biogas sector is an infant stage in Ethiopia though promising progress is seen with the coming of NBPE.

It is obvious that biogas technology has strong linkages in developing rural communities as it positively touches social, economic environment components of communities' lives. This is the reason why mass adoption of the biogas technology needs higher integration and collaboration of many and different kinds of partners like public organizations, NGOs and private sectors. Unfortunately, the extension of the biogas technology has not been satisfactory in Ethiopia as large numbers of NGOs, private companies and consulting firms have not been involved in the sector to the level required.

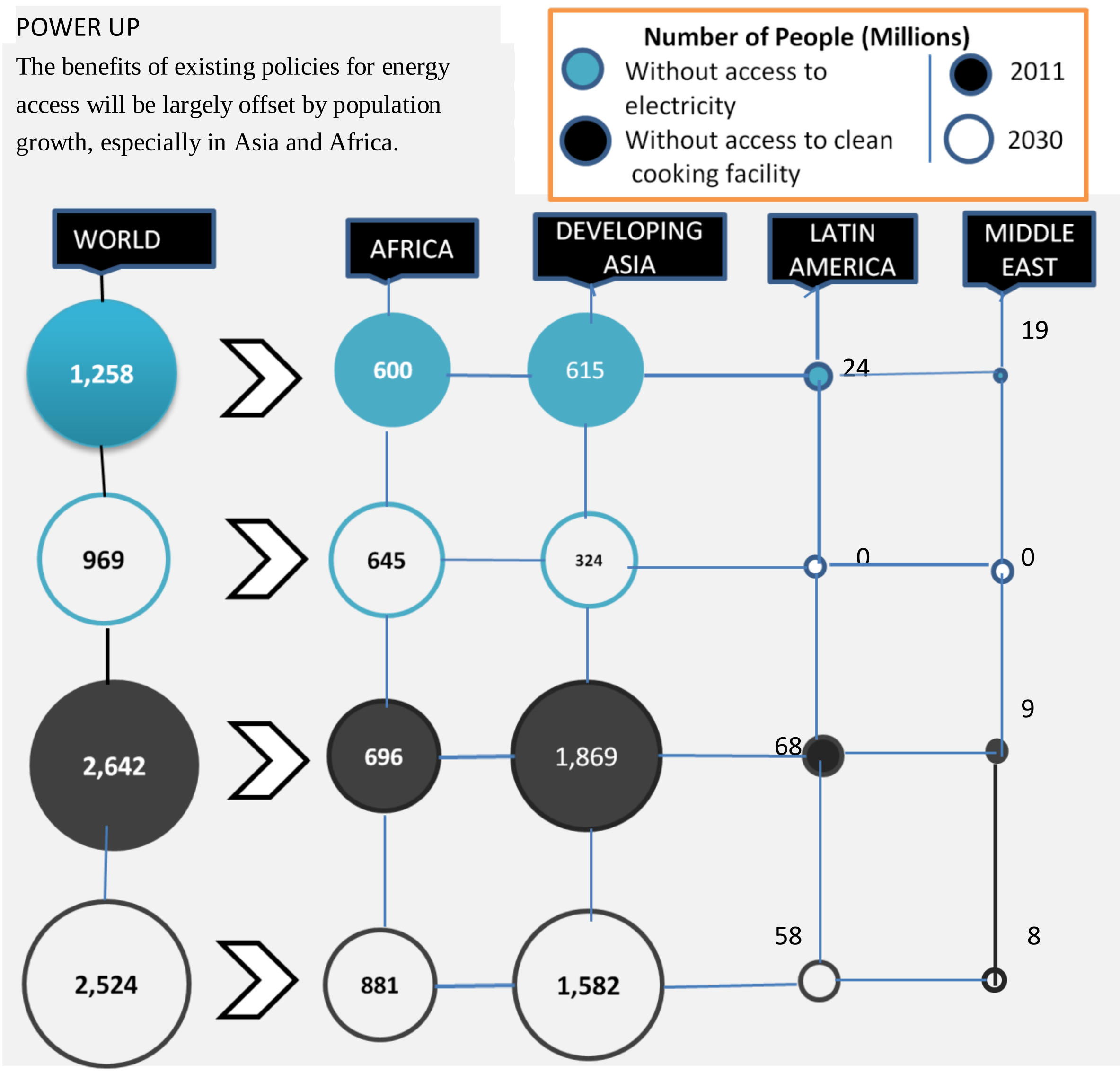
Hence, this research will try to investigate what prospects and challenges are there in mass adoption of biogas technology in SNNPR and additionally, it will make possible recommendations to effectively utilize the favourable situations and to tackle the challenges existing currently. Moreover, the questions under investigations have not been addressed so far by any researcher at least the case of SNNPR.

1.2. Statement of the problem

More than one-third of people in the world start life without access to electricity and clean fuels for cooking, heating and lighting (IEA, 2013). United Nations secretary-general Ban Ki-moon was one of them, studying at night by a dim, smoky oil lamp as a boy in 1950s post-war Korea (Reid D. and Richenda V.L., 2014). Nearly 1.3 billion people, mostly in Africa and south Asia, lack access to electricity and the development benefits it can provide to improve health, education and economic opportunity. Almost as many people have power only intermittently. And around 2.6 billion people use solid fuels - mostly biomass, dung and coal - for cooking and heating, including one third of the population of China (IEA, 2013).

The International Energy Agency (IEA) estimates that almost 1 billion people will still be without access to electricity in 2030, in part owing to rapid population growth, mostly in sub Saharan Africa and south Asia. The number of people without access to clean cooking stoves and fuels is similarly projected to drop only slightly, from 2.6 billion to 2.5 billion. Energy inequality falls most heavily on rural women and girls, who may spend many hours a week collecting firewood far from home, risking their personal safety. Inhaling smoke from conventional cooking fires and kerosene lamps causes respiratory disease, heart disease and burns, and led to 4.3 million premature deaths globally in 2012 (WHO, 2014), which is more than malaria, tuberculosis and HIV/AIDS combined (Reid D. and Richenda V.L., 2014).

Figure 1.1: Global Energy Poverty



Source: Reid D. and Richenda V.L. (2014), COMMENT

For many Africans, energy is not a given fact. Africa is responsible for almost half the people that are lacking electricity. The number rose to 589 million in 2008. Of all the Africans lacking access to electricity, Sub Saharan Africa makes up 99.6%. This is in spite of the increase of the electrification rate to 40% in 2008. Rural electrification is with 22.7% far behind urban electrification (66.8%). Of all the people in Africa that are lacking access to electricity, 99.6% is living in Sub Saharan Africa. These are not connected to the grid, especially when living in the rural parts of the continent. Of all the people in Sub Sahara Africa, 90% of the rural population does not have access to electricity. In overall, this figure is 74%. Rural communities are the ones that are hit hardest in respect to access. There are multiple problems: the high number of people living in the rural areas; the lack of finances; the unwillingness to pay; low per capita energy consumption and the lack of electrification in the rural areas. These problems are not solved easily. Biomass is still the most important source of energy for these people (Belward et al., 2011).

Ethiopia is water -richest country in East Africa. Estimations of the forest cover accounts to as much as 40% of the country around 1900. Today, less than 3% of the natural forests remain intact. Available statistics indicate that the share of biomass in the global energy consumption has remained roughly the same over the last 30 years. Biomass energy accounted for an estimated 14% and 11% of the world's final energy consumption in 2000 and 2001, respectively. In Sub-Saharan African, about 50% of all primary energy comes from biomass. In Ethiopia, however, dependency from biomass amounts to 95% (Benjamin J., 2004). The situation in SNNPR is much worse than the country's profile. Regionally, traditional fuels provide 99.8% of the total (rural and urban) domestic energy supply, with 88% derived from woody biomass, 10% from crop residues, 1% from dung and 0.1% from charcoal. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of declining stocks of wood fuel and the increasing opportunity costs in its collection or purchase (Eshete G. and Kidane W., 2008).

The traditional biomass (more precisely fire wood), essential in meeting the local energy demand in many regions of the developing country and serving about 2.4 billion people in developing countries as a primary source of energy, already has become a scarce (and expensive) commodity, forcing the fuel wood carriers, mostly woman and children, to go for longer and longer distances. Additionally, the over utilization of the biomass for energy leads to a reduction in agricultural productivity as a result of using dung and crop residue as fuel instead of using these as soil nutrients. Due to the use of dung as a source of domestic energy it is estimated that 10% of the annual grain production is lost in Tigray region (Birhane et al., 2005). The total demand for fuel wood in Ethiopia cannot be met by the sustainable exploitation of forest resources, village wood lots and fuel wood plants. Overall, the over-utilization of biomass resources leads to soil erosion, loss of arable land, loss of land productivity, decreasing yields, loss of water retention capacity of the soil, siltation of dams and reservoirs, a general land degradation and finally to desertification.

At present, the demand in Ethiopia for fuel wood is around 58 million m^3 per year, while sustainable supply lies at only about 11 million m^3. Sustainable supply for fuel wood refers to the amount of wood in the form of branches, leaves and twigs (BLT) taken out of the forest, without damaging the structure of the trees. Or, in other words, at the end of one year, after fire wood has been removed constantly from the forest, the capacity of the forest is the same as at the beginning of the year. By utilizing appropriate calculation methods, one can estimate the sustainable yield of fuel wood in Ethiopia – as was done by the Ethiopian

Forestry Action Plan (EFAP) in 1996. They calculated the annual deficit to be about 47 million m^3 in the year 2000 and more than 58 million m^3 in 2005 (Benjamin J., 2004).

The associated harmful environmental, health and social effects with the use of traditional biomass and fossil fuel has enhanced the growing interest in the search for alternate cleaner source of energy globally. In 2011, Ban Ki Moon launched the UN initiative Sustainable Energy for All. It sets out three objectives for 2030: universal access to modern energy services; doubling the global rate of improvement in energy efficiency; and doubling the share of renewables in the global energy mix (Reid D. and Richenda V.L., 2014).

Africa has many renewable energies sources that can be used. Solar, hydro, wind and biogas are just a few of them. Each energy form has its own price tag, and it is up to the countries to choose the best one. Renewable energies can be a solution to the problems that come with the current energy sources. The grids in the countries are unreliable, and biomass has many negative effects. With cleaner renewable energies, you take away health and environmental issues. Plus, if you have your own solar or biogas energy you will be independent from the grid. This means that you will have no more black outs. Renewable energies in a small form can be easily managed by households. This makes the jump to renewable energies even more interesting for developing countries. Of those small scale renewable energy solutions, biogas seems the most feasible one. It is very small scale, not high tech like solar cells, and you can adjust many things to your likings. The assumption for the energy context is as follows: because of the many benefits of renewable energy (and biogas in particular), and the characteristics of the people, the demand for biogas digesters will increase when enough information is given (Alexander D., 2014).

Biogas generation has simply been seen as a by-product of anaerobic digestion of organic waste. Having proven to be a practicable and promising technology, it has been very successful and a very reliable and clean source of energy when proper management programmes are pursued. There are vast biomass resources including organic waste in Ethiopia that have the potential to use as feedstock for biogas production and to reduce the over reliance of wood fuel and fossil fuel, and to help reduce the greenhouse gas emissions which may be affecting climate change.

In Africa particularly in Ethiopia, biogas technology dissemination has been relatively unsuccessful though the technology has proven to be very essential to improve the livelihood of the rural people. This is attributed to failure of government to support biogas technology through a focused energy policy, especially before the National Energy Policy of 1994, poor design and construction of digesters, wrong operation and lack of maintenance by users. In addition, poor dissemination strategies, high investment cost of the technology, lack of project monitoring and follow ups by promoters and implementers, and poor ownership responsibility by users have also lead to the dissemination challenges.

According to Eshete G. and Kidane W. (2008), SNNPR state would have the technical potential of constructing about 152,000 household biogas plant installations. However, only 104 biogas plants have so far been established by governmental bodies and different NGOs since the first biogas installation in Woliyta Soddo in 1976 (1968 E.C.) for the purpose of education in Agricultural College's compound. Between 2008 and 2013, 1939 biogas digesters had been constructed in the region (MEA/RBPCU, 2013). From the 1949 digesters, 1724 biogas digesters were constructed by the ongoing NBPE and 215 digesters by NGO called Lay Volunteers International Association (LVIA) which had been working in Halaba special woreda. Up to the end of 2013, therefore, 2043 biogas digesters were installed in the region.

Therefore, it would be very essential to assess the challenges which have inhibited the biogas technology dissemination since its first installation in 1976 (1968 E.C) in the region. Identification of the prospects readily available on hand and identification of the challenges inhibiting faster dissemination of the technology shall help to effectively utilize the opportunities and to design strategies to tackle the challenges, respectively.

1.3. General Objective

The overall objective of this study is to assess the prospects for mass dissemination of domestic biogas technology, to identify the challenges in the regional context and to make possible recommendations for mass dissemination of biogas technology.

1.3.1. Specific Objectives

To assess the prospects for mass dissemination of the technology at the regional level;

To identify the prospects for mass dissemination of the technology at the regional level;

To assess the challenges that hinder mass dissemination of the biogas technology;

To determine the challenges that hinder mass dissemination of the technology;

To provide recommendations for mass dissemination of biogas technology in the region.

CHAPTER 2: LITERATURE REVIEW

2.1. The Energy Scenario in Ethiopia

Africa is a continent with abundant, diverse and unexploited renewable energy resources that are yet to be used for improving the livelihood of the vast majority of the population (Anthony M. and Wilson P., 2010). Africa has 1.1 million GWH of exploitable hydro-power, 8 billion cubic meters of natural gas reserves and over 60 billion cubic meters of coal. This is in addition to a wealth of biomass, solar and wind resources. Only 7 percent of the hydraulic and 0.6 percent of geothermal energy potential is exploited. Africa has the highest mean annual solar radiation in the world per year. It is estimated that 95 percent of the daily global winter sunshine above 6 KWh/m2 falls in Africa (Ejigu, 2005). Furthermore, the energy sector in Africa shows regional diversity and can be best clustered into three distinct regions. The first is North Africa, which is heavily dependent on oil and gas. The second is South Africa which relies on coal while the rest of Sub-Saharan Africa is largely reliant on biomass. In 1997, South Africa and North Africa accounted for over 50% of Africa‘s total modern energy production (Karekezi, 2002).

According to Nair (2009) and FAO (2012), Africa has a whole range of renewable energies that they can use. Some of them are presented in table 2 and it gives the challenges, costs and potential for the five best known renewable energies in Africa.

Table 1.2: Renewable energies in Africa which are most common

Renewable Energy	Challenges and Constraints	Costs	Potential
Solar	Lot of land needed for construction. Not yet a big market.	Expensive, because the market is still small.	High; despite high costs, is solar one of the most easily accessed renewable energy form. Efficient form of energy.
Wind	Variable resource: you never know when there is wind and how much.	Costs are decreasing as the market is growing at a rapid rate.	Egypt, Morocco and Tunisia already started. Other countries are to follow. Easy accessible form of energy.
Biogas	Need for (zero-grazing) animals. Water is not always available.	Small digester cost as less as 45$. Bigger ones can be more expensive.	Making energy from waste. Bio slurry as a fertilizer. Clean.
Geothermal	High initial costs. Long project of finding the right places. Geological uncertainties are always present. Amount of heat can diminish	Initially high. Surveying of areas is costly. Operating costs are low. Per kWh 2-10 $ct.	Kenya and Ethiopia are using geothermal energy. Countries with rift valleys are very potential. Tanzania, Zambia, and Uganda are some of the countries that are potential.
Hydro	The costs to set up the program are high. Financially not self- sustaining. Dependent on water flows.	Initially high; upkeep is relatively low. Per kWh: 800	High. Supposedly, only 7% of Africa's hydropower is utilized.

Source: Nair, 2009; Belward et. al., 2011

Similarly, Ethiopia is endowed with various energy resources. The gross hydro-energy potential of the country is about 650 TWh per year, of which 25% could be exploited for power production (CESEN, 1986). This enormous potential ranks Ethiopia as one of the world's leading countries in hydro potential. The most promising hydropower development potential is found in the Blue Nile, Omo, and the Wabi Shebelle river basins (MEDaC, 1999). The energy potential of the country so far discovered comprises between 30 and 50 billion m^3 natural gas, more than 1000 MW geothermal power, and several hundred million tons coal and oil shale (Mariam, 1992). The total solar radiation reaching the territory is 2.3 TWh per year while wind energy potential is estimated at 4.8 million Tcal per year (CESEN, 1986). The country's woody biomass energy resources are about 14 million Tcal in standing stock and 0.93 million Tcal in terms of annual yield. The annual agricultural waste available for energy is about 176,000 Tcal per year. Although the country has abundant energy resources, its potential is not yet well developed due to lack of capacity and investment. For example only less than 1% of the total hydropower potential of the country is known to have been utilized so far.

The energy sector in Ethiopia is composed of three main sub-sectors: biomass, petroleum and electricity. Energy consumption is very low, with an estimated total per capita consumption of only about 0.2 tone oil-equivalent.

Woody biomass represents the principal form of cooking and lighting fuel in the country's rural areas, and an increasing fraction of the population is being confronted with the difficult choice between eating its food poorly cooked or travelling long distances to collect fuel for cooking. The scarcity of fuel wood has led to an increased utilization of dung and agricultural residues for cooking, which could otherwise have been used to enhance the nutrient status and texture of the soil and contribute positively to agricultural production. The total amount of energy generated from dung directly burned in household stoves is estimated at 56.3 TJ in the year 1998/99 and was about 8% of the total energy consumption in Ethiopia.

With a rapidly increasing population, cultivation is expanding in the region. Marginal and steep lands are increasingly being brought under cultivation, leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is taking place at the expense of communal lands on which most woody biomass resources are located, leading to a decline in these resources. Regionally, traditional fuels provide 99.8% of the total (rural and urban) domestic energy supply, with 88% derived from woody biomass, 10% from crop residues, 1% from dung and 0.1% from charcoal. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of declining stocks of wood fuel and the increasing opportunity costs in its collection or purchase (Eshete G. and Kidane W., 2008: 5-6 & 9).

The big share of biomass fuels such as firewood, crop residues and dried dung in the country as well as in the region has obliged the rural mass to entirely depend on traditional fuels for their energy consumption. This use of energy is often coupled with many problems such as deforestation, land degradation, various health and social problems as well as raising the level of greenhouse gas emissions. As a solution to the problem, promotion and dissemination of renewable energy technologies are devised. Among other sources of renewable energy, biogas can be used as a replacement for these fuels and can help solve many of the problems that are associated with biomass fuels.

Rural areas of developing countries like Ethiopia are very dependent on biomass fuels such as firewood and dried dung for their energy consumption. Biogas can be used as a replacement for these fuels and can help solve many of the problems that are associated with biomass fuels.

2.2. The Biogas Technology

2.2.1. Anaerobic Digestion (AD)

The biogas digester is a physical structure that is also commonly referred to as a biogas plant or anaerobic digester. A biogas digester is essentially an underground and airtight pit that a user puts crops, animal manure, human faeces, and water into (FAO, 1997). Anaerobic digestion (AD) is a microbiological process whereby organic matter is decomposed in the absence of oxygen. This process is common to many natural environments such as swamps or stomachs of ruminants. Using an engineered approach and controlled design, the AD process is applied to process organic biodegradable matter in airproof reactor tanks, commonly named digesters, to produce biogas. Various groups of microorganisms are involved in the anaerobic degradation process which generates two main products: energy-rich biogas and a nutritious digestate (Amalia G. etal, 2014). Biogas is a mixture of gases that is composed chiefly of: methane (CH_4) with an amount of 40 - 70 vol. %, carbon dioxide (CO_2) with an amount of 30 - 60 vol. % and other gases with an amount of 1 - 5 vol. % including hydrogen (H_2) with an amount of 0 - 1 vol.% and hydrogen sulfide (H_2S) with an amount of 0 - 3 vol.% (Kossmann, W. et al or ISAT/GTZ 1999).

This conversion of complex organic compounds into methane and carbon dioxide requires different groups of micro organisms and is carried out in sequence of four stages: Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis. During hydrolysis organic substrate is converted into smaller components , then acidogenic bacteria use these smaller compounds and produce volatile fatty acid, ethanol, CO_2 and H_2. Acetogenic bacteria convert these fermentation products in to acetic acid, CO_2 and H_2. Finally methanogenic bacteria use hydrogen and acetate (most important substrate) and produce methane and carbon dioxide. A variety of factors affect the rate of digestion and biogas production. The most important is temperature. Biogas production is carried out at different temperatures: temperature range 45 - 60 °C is referred to as 'thermophilic,' whereas that carried out at temperature range 20 - 45 °C is known as 'mesophilic' and at low temperatures (<20 °C) is referred to as 'psychrophilic' digestion (Safley and Westerman 1992). Once a suitable bacteria culture has been developed inside the biogas digester, biological waste is mixed with water in a 2:3 ratio and retained for approximately 50-60 days (FAO 1997). It is estimated that 50-70 percent of the raw material fed into the biogas digester is eventually converted to usable biogas, resulting in an efficiency utilization rate 5 to 7 times greater than traditional burning of biomass energy (EWB, 2004).

2.2.2. Calorific value of biogas

The calorific value of biogas is around 6.0 - 6.5 kWh / m3 , depending on the percentage of methane present, which on average is in the range of 55 - 70 Volume -% (Deublein and Steinhauser, 2011) and this corresponds to about half a litre of diesel oil (Kossmann, W. et al (unknown) or ISAT/GTZ 1999). The net calorific value depends on the efficiency of the biogas burners or other appliances used to process the biogas. A gas generator, for example, can convert about 2 kWh into useable electricity, while the remaining energy is emitted as heat (Amalia G. etal, 2014).

Table 1.3 shows examples of calorific value of different fuel sources as compared to biogas as well as the approximate mass of that fuel corresponding to 1 m^3 of biogas.

Table 1.3: Calorific Value of different fuels

Fuel Source	Approximate Calorific Value	Equivalent to 1 m^3 Biogas (approx. 6 KWh/m3)
Biogas	6-6.5 KWh/m3	
Diesel, kerosene	12 KWh/Kg	0.50 Kg
Wood	4.5 KWh/Kg	1.30 Kg
Cow dung	5 KWh/Kg dry matter	1.20 Kg
Plant residues	4.5 KWh/Kg dry matter	1.30 Kg
Hard coal	8.5 KWh/Kg	0.70 Kg
Propane	25 KWh/m3	0.24 Kg
Natural gas	10.6 KWh/m3	0.60 Kg
Liquified petroleum gas	26.1 KWh/m3	0.20 Kg

Source: Deublein and Steinhauser, 2011

2.2.3. Biogas Production with Substrate

Many substrates are generally used as feedstock in biogas plants and the potential for biogas production varies with feedstock. Generally animal waste, human waste, kitchen waste and some crop residues are used in small scale biogas plants. Gas production rate varies with the type of substrate used in the biogas plant. Normally 1 m3 of biogas is enough to cook three meals for a family of 5-6 members (Practical Action Org, 2006). A possible combination of substrate to produce 1m^3 of biogas is presented below.

Table 1.4: Biogas production with different substrate

Substrate	Gas production rate (1/Kg waste) (1)	Manure Availabilty (Kg/animal/day) (2)	No. of animal required
Cattle dung	40	10	2-3
Buffalo dung	30	15	2-3
Pig dung	60	2.25	7-8
Chicken droppings	70	0.18	80
Human excreta	28	0.4	90

Source: FAO, 1997 and 2-Nagamani & Ramasamy, no date)

2.2.4. Benefits of Biogas Technologies

Anaerobic digestion of organic waste provides many benefits. This includes the generation of renewable energy, a reduction of greenhouse gases, a reduced dependency on fossil fuels, job creation, and closing of the nutrient cycle. It transforms organic waste material into valuable resources while at the same time reducing solid waste volumes and thus waste disposal costs. Biogas as a renewable energy source not only improves the energy balance of a country but also contributes to the preservation of the natural resources by reducing deforestation and to environmental protection by reducing pollution from waste and use of fossil fuels (Al Seadi et al., 2008).

Biogas plants provide multiple benefits at the household, local, national and global level. These benefits can also be classified according to their impacts on gender, poverty, health, employment and environment (Matthew S. M. and Wim J. N., 1999).

2.2.5. Development of Anaerobic Digestion in Developing Countries

The process of anaerobic digestion has been practiced for decades in developing countries. Reports describe an early anaerobic digester in Mumbai, India, built in 1859 for sewage treatment. Since then, the technology has become widespread throughout Asia. Different biogas support programmes focus on rural families with a few cattle where animal manure and human faeces are used as feedstock together with the addition of small amounts of kitchen waste. The development drivers for introducing such systems to provide people with biogas, is to reduce consumption of firewood and the respective deforestation, decrease indoor air pollution and improve soil fertility.

After roughly 25 years of step-wise improvements and practical experience, the technology is still attracting interest as a contribution to renewable energy production and creating independence from fossil fuels. The Ministry of Agriculture, China, added an estimated 22 million biogas systems between 2006 and 2010 to reach a total of some 40 million installed systems in early 2011. India is home to approximately 4 million systems, and Vietnam has installed 20 000 systems annually to reach more than 100,000 by 2010. Cambodia, Laos, and Indonesia have smaller biogas programmes, nevertheless installing about 1 000 systems in each country in 2010. Nepal’s Biogas Support Programme, which involves the private sector, microfinance organizations, community groups, and NGOs, has resulted in a steady increase in installed biogas systems during the last decade. Approximately 25 000 systems were constructed in 2010, bringing the nationwide total to nearly 225 000 (REN21, 2011).

In Africa, where anaerobic digestion is less prevalent, a biogas support programme was launched in May 2007. Based on the experience in Asia, the African “Biogas for Better Life” initiative aims at installing two million biogas plants in rural households by 2020 (v. Nes and Nhete, 2007). In Latin America, apart from small biogas plants for rural households, numerous agricultural waste projects have been implemented and in the urban environment biogas is being extracted from several landfills (landfill gas).

Since biogas digester systems provide a reliable renewable energy resource that can be used for cooking, heating, lighting, and powering diesel engines, amenities such as reading light, heat for schools, and cheap fuel for machinery becomes available. Access to biogas also significantly reduces the need for conventional energy sources such as fuel wood, which degrades forest resources and require hours of strenuous labor to collect. Moreover, the anaerobic digestion process does not convert all of the organic material in the process into biogas. Material that is not converted is known as sludge, and is a potent organic fertilizer that can significantly enhance a farm's productivity (compared to conventional application of animal and human wastes). Biogas digesters produce high-grade fertilizer, which has been shown to be both safer and more productive than the original manure.

In addition to providing cheap fuel, improving farm productivity, and increasing household income, the use of biogas digester systems can significantly increase a rural farmer's environment and health conditions. Major environmental and health benefits accrued from biogas digester include reductions in indoor air pollution, water contamination, and deforestation. (Robert A White, 2008).

2.3. The Prospects and Challenges of the Uptake of Biogas Technology

As discussed above it is of paramount importance to identify and act up on the suitable ground favouring mass deployment of the biogas technology. Mass dissemination of the technology could be a reality if the prospects are properly and effectively utilized and hence, the rural people who are deprived of basic energy services will benefit from the effort. Equally important in this regard is to identify the major challenges which have retarded the mass adoption of the technology. Therefore, this chapter will discuss the prospects and challenges in the biogas sector.

2.3.1. The Prospects

In Africa, biogas technology dissemination has been relatively unsuccessful. Njoroge D.K., 2002, attributes the non-progressiveness of most biogas programmes to failure of African governments to support biogas technology through a focused energy policy, poor design and construction of digesters, wrong operation and lack of maintenance by users, poor dissemination strategies, lack of project monitoring and follow-ups by promoters, and poor ownership responsibility by users. Despite the relative stagnation of biogas programmes in Africa, the future prospects are encouraging. Aside energy (cooking and lightning, fuel replacement, shaft power), several biogas plants in recent years have been constructed as environmental pollution abatement system in several countries including Ghana, Kenya, Tanzania, Rwanda, Burundi, and South Africa (Amigun et al, 2007). Between 4000 - 5000 digesters is estimated to have been built in Tanzania (Marree et al, 2007), while Kenya is said to have disseminated about 2000 digesters as at October 2007 (ETC, 2007).

As against the challenges facing the dissemination of the biogas technology in the region, prospects identified before and during the actual implementation of the different biogas development programmes could play remarkable role in mass dissemination of the domestic biogas digesters in the region. The renewed interest for renewable energy technologies at the international level, commitment of the government of Ethiopia (GoE), favourable energy policy of the country, development of infrastructures, the technical potential of the region, availability of fund to subsidize the construction investment and availability of various micro credit institutions shall help the development of the biogas sector to the required level.

2.3.1.1. The International Context

The growing interest in renewable energy technologies (RETs) has been stimulated by global awareness that fossil fuels are not infinite and the recognition that the use of fossil fuels constitutes one of the major sources of green house gases that contribute towards global warming (Orleans M. and Emmanuel K. B., 2008). In September 2000, the connection between clean sources of energy and rural energy access was explicitly made in the form of the United Nations General Assembly's commitment to a global partnership to achieve a series of eight goals and targets known as the Millennium Development Goals (MDGs), by the year 2015. Reducing rural poverty through rural development is viewed as a key requirement to achieving these goals, and underpinning this is the need for expanding access to modern energy services. MDG 7 - ensuring environmental sustainability - promotes RETs as a way of expanding access to these services (World Bank, 2004b; United Nations Public - Private Alliance for Rural Development, 2009; United Nations, 2009).

This connection between clean energy and rural development has been further reinforced by international commitment to the Johannesburg Plan of Implementation (JPOI) adopted at the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. The JPOI reiterated support for Agenda 21, the outcome document of the 1992 United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, as well as the MDGs, specifically noting the importance of modern energy services for rural development.

In response to the WSSD, the Conference for Renewable Energies Bonn 2004 addressed the issue of how developing and industrialized countries can pursue the increase of renewable energies, their potential and improved utilization. The outcomes of the conference, again attended by governments, consist of three facts: firstly, a political declaration addressing issues leading to the broader and enhanced utilization of renewable energies; secondly, an international action plan whereby governments, international organisations, and stakeholders from the civil and private sectors pledged commitment towards these goals; and finally, policy recommendations on renewable energies for stakeholders responsible for developing new approaches and strategies (Eshete G. and Kidane W., 2008).

Governments committed themselves to providing one billion people with access to energy over the period 2003 to 2015. In practical terms this translated in, for example, the commitment of the Netherlands Government to serve 10 million poor people in developing countries with appropriate and affordable energy services (DGIS, 2003).

In Africa, water pollution and access to energy resources present challenges to human health, environmental health, and economic development. In 21 sub-Saharan African countries, less than 10% of the population have access to electricity. The need for alternative renew-able energy sources from locally available resources can not be over emphasized. Appropriate and economically feasible technologies that combine solid waste and wastewater treatment and energy production can simultaneously protect the surrounding water resources and enhance energy availability. Biogas technology in which biogas is derived through anaerobic digestion of biomass, such as agricultural wastes, municipal and Industrial waste (water), is one such appropriate technology Africa should adopt to easy its energy and environmental problems (Parawira, 2004).

There is a consensus that achieving the Millennium Development Goals (MDGs) in Africa will require a significant expansion of access to modern and alternative renewable energy. Biogas is a renewable, high quality fuel, which can be utilised for various energy services such as heat, combined heat and power, or a vehicle fuel. This would reduce the use of fossil-fuel-derived energy and reduce environmental impact, including global warming and pollution, improve sanitation, reduce demand for wood and charcoal for cooking and provide a high quality organic fertilizer (Mshandete A.M. and Parawira W., 2010). In Africa the interest in biogas technology has been further stimulated by the promotion efforts of various international organisations and foreign aid agencies through their publications, meetings and visits. To date, some digesters have been installed in several sub- Saharan countries, utilising a variety of waste such as from slaughter houses, municipal wastes, industrial waste, animal dung and human excreta.

The above situations have pressured Ethiopia positively as the country is one of the sub-Saharan countries suffering from energy access problem. Accordingly, the Government of Ethiopia (GoE) designed Scaling-Up Renewable Energy Program (SREP) in 2012 to be implemented within the planning horizon of GTP (2011 - 2015).

SREP is embedded in Ethiopia's GTP, which sets the major outcomes for the energy sector in the short-term, as well as the CRGE, which provides a road map for the country's long-term low-carbon growth path. The GTP, which is the current GoE development plan for the period 2010/11-2014/15, aims to increase the power generation capacity of the country from the present level of 2000 MW to 10,000 MW by the end of 2015. The aim is to address both domestic demands while exporting surplus power to neighboring countries and beyond. The need to expand the transmission and distribution system is also emphasized in order to deliver the energy generated to the consumer in an efficient and reliable manner. The GTP further envisages increasing the customer base of the power utility from the current level of 2 million to 4 million and the universal electricity access rate from 45% to 75%.

It further aims at increasing the dissemination of renewable energy technologies and increasing access to modern energy sources in order to reduce the deforestation rate and mitigate carbon emissions. At the end of the GTP period at least 80 % of households where majority of women and girls will be beneficiaries of modern energy services from dissemination of efficient cook stoves and other RE sources since in most cases they are in charge of collecting firewood and other types of fuel. This has an effect on their lives namely in terms of health, less access to school for girls, risk of violence and abduction. Furthermore, in many cases, the time used in the collection of firewood could be used for economic activities (for women), and better attendance to school (for girls).

The GoE has initiated the Climate- Resilient Green Economy (CRGE) initiative to protect the country against the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle-income status before 2025.

As part of the CRGE initiative, Ethiopia has outlined a strategy to build its green economy. It follows a sectoral approach identifying and prioritizing initiatives that could help the country achieve its development goals while limiting the 2030 greenhouse gas (GHG) emissions to today's level.

The CRGE foresees to develop up to 25,000 MW of Ethiopia's generation potential by 2030. Of this hydro holds 22,000 MW, geothermal 1,000MW and wind 2,000MW. It is believed that the planned generation expansions will have developed demand within the country in the long term. In the short term various regional market potential assessment studies have equivocally indicated the presence of a market in Ethiopia's neighborhoods and beyond. Most of Ethiopia's neighbors' electricity expansion plans are significantly dominated with conventional thermal generations. The ever soaring fuel prices will therefore place Ethiopia's cheep renewable generation at an advantageous position in the market that is going to be created in the region when the ongoing interconnection projects are finalized. The replacement of conventional thermal generations having high GHG gas emission with zero emission renewable generations will entitle the importing countries to get additional benefits through carbon credits. As the pricing of the power exchange between countries depends on the benefit sharing scheme, Ethiopia could indirectly get these benefits through the power purchase agreements that are going to be made with the importing countries.

In the formulation of the CRGE, since the rural energy usage will remain to be dependent on traditional fuel, specially for cooking purposes, large abatement of emission is expected through improving fuel efficiency and shifting fuels (from fuel wood to biogas etc) for cooking stoves. In the CRGE a program is anticipated aiming at scaling up the dissemination to 9 million stoves by 2015 and to 34 million stoves by 2030. The program, in addition to the emission reduction, is expected to increase the rural household income up to 10%, reduce deforestation and create an industry for the manufacturing of cook stoves.

In general four initiatives for fast-track implementation have been selected under the CRGE: (i) exploiting Ethiopia’s vast hydropower potential- (ii) large-scale promotion of advanced rural cooking technologies; (iii) efficiency improvements to the livestock value chain; and (iv) reducing Emissions from Deforestation and forest Degradation (REDD). These initiatives will have the best chances of promoting growth immediately capturing large GHG emission abatement potentials, strengthening Ethiopia’s leading role in sustainable growth, and attracting climate finance for their implementation. To ensure a comprehensive program, initiatives from all other sectors will also be developed over time into concrete proposals.

Successful implementation of SREP will pave the way for improving the energy mix of the national power system by incorporating geothermal and wind power in a sustainable way, thereby increasing the system’s reliability and resilience towards climate change. It will also accelerate the electrification of the country by making more energy available in the system. With the radically scaled-up dissemination of improved cook stoves though training and capacity building of SME's that will facilitate the development of private sector participation and will bring transformation and sustainable exploitation of the country's biomass resources, SREP will help alleviate the social, economic and environmental problems faced largely by the rural population, especially women and girls by allowing them to spend time in productive activities and improving their health. At the same time a significant contribution to Ethiopia's goals of achieving the reductions in green-house gas emissions as set in the CRGE strategy document (MWE, 2012).

2.3.1.2. The Government's Commitment and Its Policy

For development programmes to be successful, the commitment of governments, through focused policy, is so essential. In this regard, the government of Ethiopia (GoE) has showed its commitment by formulating the energy policy since 1994 though the issue of renewable energy technology and its development has got the required attention only recently. Unfortunately, as emphasized by Eshete G. et al, 2006, despite policy largely being in place at the higher "political" level, the issue seems not to get the required attention and priority. This has results in totally inadequate funding for even the smallest surveys or dissemination programmes. The executing bureaus thus are typically seriously resource-limited (for project financing, transportation, staffing, etc) resulting more in frustration than implementation. With the improvement of awareness on environmental concerns at higher official level, the encouraging ground created for energy technology development and dissemination by the policy has been utilized. Therefore, the major issues under the policy will be discussed in this section.

The recent energy policy of Ethiopia is drafted in 1994 and the document can be considered as the first energy policy that was formulated taking the concerns of all sectors in to account. Even if the energy policy is dynamic by its nature and the current energy is with some shortcomings, it has generally created conducive environment for energy sectors development since 1994.

The main policy issues; the energy resource development, the energy supply, the energy conservation and efficiency, the comprehensive policy measures and energy institutional issues, which are mentioned explicitly in the policy document, shall be an important tool for approved and under considerations proclamations to date. The fuel wood conservation, conversion of biomass in different forms of energy purposes, hydro-power development, other energy sources development (like geothermal, coal, solar, wind), oil exploration and development of the natural gas are the main issues considered under the energy development. The conversion of biomass in different forms of energy purposes, for instance, gives emphasis to enhance conversion efficiency in charcoal making, encourage and promote the modern use of agricultural residue and dung to produce biogas. One of the objectives of the energy development of traditional fuel, as mentioned in the energy policy document under article 6.1.1 sub section 2, is:

"To reduce the negative effects of agri-residue use for energy on soil fertility measures will be taken to modernize and increase the efficiency of the utilization of agri-residue as energy sources."

The Energy policy also dedicates a special section for the encouragement of the private sector to be involved in the development of the energy resources of the country, a field that has been and still is seen to be mainly the responsibility of the government.

Following the 1994 energy policy various institutions, proclamations and programs have been established in different periods. According to IRENA, 2010, the polices in place to promote renewable energy in Ethiopia since the Rio conference of 1992 includes the establishment of the Ethiopian Electric Agency established in 1997/2003 (latter named the Ethiopian Energy Authority in 2013), the Ethiopian Rural Electrification Board in 2003 (which has given a proclamation number of 317/2003), the Universal Electricity Access Program in 2005, the Bio-fuel Development Strategy in 2007, the Bio-ethanol 5% Blending Mandate in 2009 and the Bio-ethanol 10% Blending Mandate in 2011.

Another salient feature of the policy is that it has clearly indicated the government organization in charge of development of energy resources, formulation, implementation and revision of energy policy, and preparation and implementation of strategies. Until a change of government in 1991, there were neither energy sector policies nor institutional arrangements that separated policy making organs from those of operations. Ever since the mid 1990s, in a bid to enhance efficiency and harmonize operations in the energy sector, policy making organs were separated from operation organs (GTZ, 2007). Currently, the Ministry of Water, Irrigation and Energy is working as an organization in charge of the responsibilities discussed above.

Even if the energy policy document drafted in 1994 is of most importance, it has some shortcomings to be improved. According to JICA, 2011, the shortcomings include shortage of qualified person for formulating proper policies for the various energy sub-sectors, insufficient assessment of energy resources and technologies and lack of timely updating. Renewable energy has become economically competitive with conventional fuels only in about the past five years, and reaching dispersed rural populations poses logistical challenges. If policies remain unchanged, the UN objectives will not be met. According to W. Wolde-Ghiorgis, 2002, the current national energy policy for Ethiopia needs complete revision as it does not address energy requirements for subsistence and development, especially energy requirements in rural areas for modern productive activities.

With its some short comings, however, the energy policy drafted in 1994 has created a workable ground for mass dissemination of renewable energy technologies, particularly biogas digester dissemination. With the continued commitment of the Government of the Federal Democratic Republic of Ethiopia (GoE) to meet the increasing energy demands of the country (both grid and off-grid), expansion of domestic bio-digesters among the rural communities is therefore in line with the national strategies and policies towards unlocking its potential for sustainable energy resources (PID,2014).

2.3.1.3. The Technical Potential

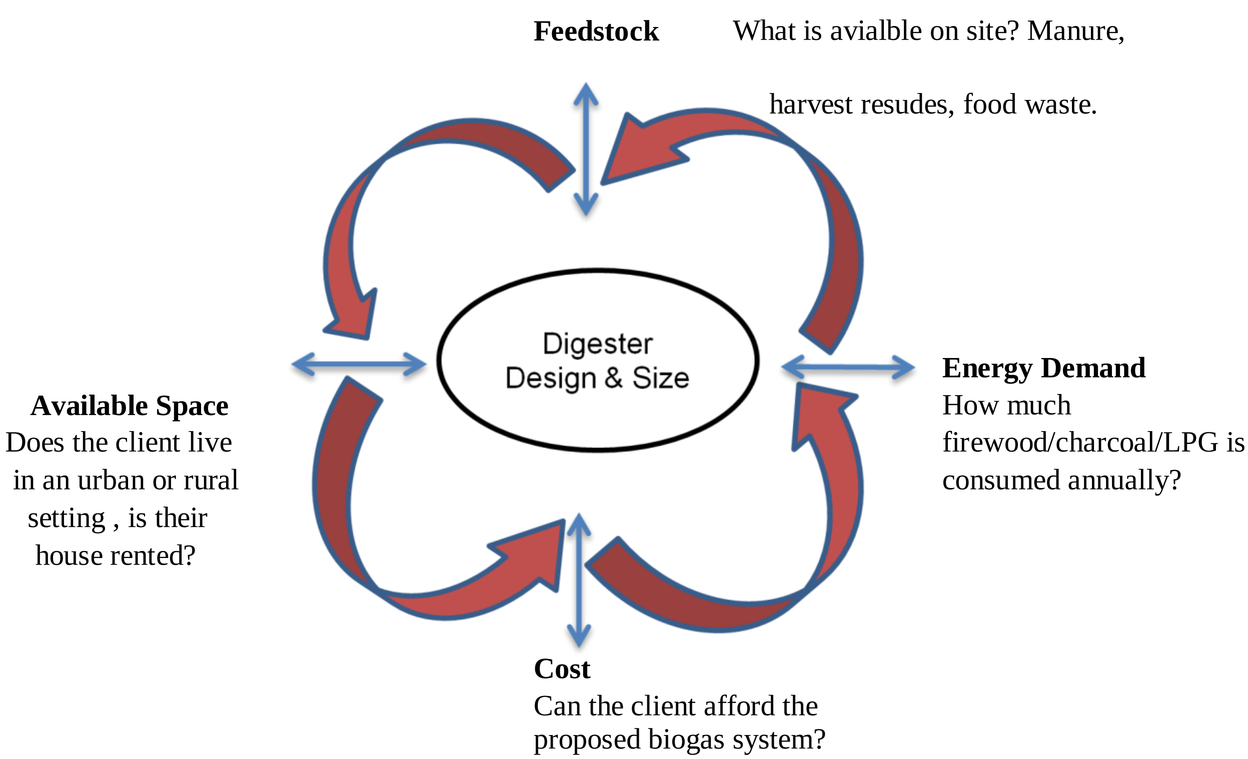
As a definition, the technical potential is the estimation of the total national capacity technically feasible. Technical resource considerations include the availability of a constant supply of manure, the availability of water with which to dilute the manure, the suitability of the ambient temperature, and the availability of sufficient space for effluent disposal and usage (Eshete G. and Kidane W. (2008). According to Heegde & Sonder (2007), availability of dung and water to run a biogas installation are two basic requirements. For a biogas plant to be attractive to a household, it should be able to provide at least 0.8 to 1 m^3 biogas daily. To generate this amount of biogas, the household should have stabled cattle to achieve this. This requirement is met by a large percentage of households, especially in East Africa.

Livestock plays an important role in the Ethiopian farming system. The total cattle population in SNNPR was estimated to be 10,421,589 heads (BoFED, 2012). According to Eshete G. and Kidane W., 2008, cattle are an integrated part of the farming systems in the highlands of Ethiopia. Although on average 77% of agricultural holders in Ethiopia own cattle, the proportion varies widely throughout the country. Cattle-owning smallholders are common in the highlands but ownership varies widely due to household and local resource constraints. In Ethiopia, cattle are used for milk, beef, draft power, and breeding. In view of the low level of mechanization and chemical fertilizer usage, it will be quite impossible for most rural households to farm without cattle.

Domestic biogas installations use a fair amount of water as both the hydraulic and the micro-biological process require a feeding with a 1 : 1 mixture ratio of dung and water (not necessarily of “drinking water” quality, though). Even at minimal feeding of the smallest installation, the water requirement is already 25 liters a day and larger installation can consume up to over 100 liters of process water daily. To ensure biogas plants do not add to the burden of household chores, therefore, as a rule of thumb, the water source should be within 20 minutes walking distance - about 1 km- of the installation (TDBP, 2009). Availability of water is mainly area dependent, and in most parts of Ethiopia, recurrent droughts have to be taken into consideration. Although, a comprehensive national groundwater resources study has not been conducted, some surveys suggest that there is ample groundwater potential in many parts of Ethiopia. Additionally, there are many locations where permanent rivers and streams flow in the highlands of Ethiopia. Fetching water required to mix with the daily input of 20 kg fresh dung in a 1:1 ratio should not take more than 20 to 30 minutes. There are definitely many farm locations that meet this requirement, but there will also be many that do not. Careful and strict selection of the locations for the installation of the biogas plants should help avoid disappointments (Eshete G. and Workneh K. (2008).

Climatic conditions for the production of biogas in Ethiopia are favourable, as rather high temperatures remain throughout the year, even at higher altitudes. The temperature regime required for biogas production is not a major problem in Ethiopia. Many of the areas in the highlands of Ethiopia have average temperatures in the range of 15-20°C throughout the year. However, night temperatures may drop to 10°C or slightly lower during the rainy season in areas with altitudes of more than 2500 m a.s.l. Provided the plant is properly located and covered with soil, this should not prevent the biogas plants from functioning throughout the year (Eshete G. and Workneh K. (2008).

Figure 2.1: Factors that determine the optimum design and size of biogas digester



Source: Tumwesige & Casson, perscomm, 2011

Physical space requirement on the farms for the construction of biogas plants is not a limiting factor in Ethiopia. Most rural households have gardens in their backyard. Often these rural households use their manure (or bio-slurry in the case of biogas households) as fertilizer for their vegetables and crops (Eshete G. and Workneh K. (2008).

2.3.1.4. Development of the Micro Finance Sector

The microfinance sector has grown 12 percent per year in total outreach over the last decade and now reaches over 500 million people across the globe with financial services. The micro finance sector in Africa is as diverse as the region itself, with a wide range of institutional and service delivery models addressing the complex and interconnected political, economic and cultural systems impacting poverty (Ellen M. et al, 2007).

The government of Ethiopia has been taking various measures to alleviate poverty in which expanding microfinance institutions is among them. It is indicated that although the development of microfinance institutions in Ethiopia started very recently, the industry has shown a remarkable growth in terms of outreach particularly in number of clients (Wolday A., 2007).

As discussed in section 1.1, the micro finance sector in Ethiopia has shown great increments since the enactment of the first proclamation in 1994 and consequently, Ethiopia has said to be the second largest micro finance users in Sub-Saharan Africa. Moreover, the continuous and periodic revision of the proclamations by Ethiopian Government in response to the changing and developing economic activities have helped the establishment of many MFIs. The proclamation 626/2009, which replaced the former proclamation 40/1996, and the new directive issued by the National Bank of Ethiopia on May 2002 can be mentioned in this regard. The former one allowed MFIs to extend their services to rural areas, whereas the latter one improved the regulation limits on loan size, repayment period and the lending methodology.

Currently, there are about 30 microfinance institutions registered under the national Bank of Ethiopia. Out of the 30 microfinance institutions, the five namely, OMFI, Agar, Meklit, Wisdom and Sidama Microfinance institutions are located and operating in South Nations and Nationalities and Peoples Regional State (SNNPR). OMFI is the largest microfinance institution in the region and operating in all zones and woredas[1] of SNNPR. It has 14 branches, 157 sub branches, covering 3400 kebeles (lowest administrative units). At present, the institution is serving more than 488,930 active credit clients. It has shown a remarkable progress in terms of outreach since its establishment (OMFI, 2012).

The expansion of the microfinance sector could help to develop the biogas sector by bridging the financial shortage of many actors in the sector. The potential biogas users and the private sector would be the primary beneficiaries as various MFIs could have different credit modalities and procedures, which would create alternatives by availing suitable loan size and softer interest rate.

2.3.1.5. Infrastructure Development

Low levels of infrastructure development is one of the most important constraints for rural energy development because poor rural infrastructure services increase investment and transaction costs in energy services and technologies.

[1] *Woredas: Administrative regions under regional governments. Hierarchy in administrative structure is: national, regional, zonal, woreda, and kebele (lowest level).*

As biogas technology is one of the renewable energy technologies, the development of infrastructure has implications to the biogas sector. Although the digesters themselves do not need to be moved once they are set, they are both the materials and the masons that have to cross the distance. If this is done on unpaved roads or no roads, this will make their job more difficult, more time-consuming and more expensive (Alexander D., 2014). However, the status of infrastructure development in Ethiopia is gradually improving and its development would create better environment for actors, like private sector, in the biogas sector. In addition to this, the development of the water infrastructure would attract more potential farmers to own biogas technology as accessibility of water is one of the determining factor for mass dissemination of the technology.

The International Monetary Fund forecasts that Ethiopia will achieve real GDP growth of more than 8% annually over the next five years. Of the countries with more than 10 million inhabitants, only China and India are expected to grow at a faster pace. Furthermore, Ethiopia’s recent track record demonstrates that it can achieve double-digit growth rates. Between 2005 and 2010, the real GDP grew by 11% p.a. In the past five years, 40% yield increase in agriculture was achieved. Ethiopia is the world’s tenth-largest producer of livestock, and its major exports are coffee, sesame seed, leather, flowers, and gold. From 2005 to 2010, it improved its infrastructure, more than doubling electric power generation capacity, expanding the telecommunication network from 0.5 million users to 25 million and adding over 11,000 kilometers to the existing road network (EPA, 2011).

According to the BoFED, 2009/2010 and 2011/2012, the regional infrastructure development has shown consecutive progress in the last few years. The improvements in the road network and water access, for instance, show this fact. The regional total road network length had increased from 7,956Km, of which 633 Km is asphalt, in 2010 to 9,330 Km, of which 1009 Km is asphalt, in 2012. Similarly, the average water supply access of the region had increased from 41 % in 2010 to 51 % in 2012.

2.3.2. The Challenges

That sustainable energy supply and (agricultural) production methodologies, at any level, will become a critical factor in sustainable development is steadily becoming mainstream global awareness. Biogas technology for rural farming households would have the potential to fit into picture in a modest but significant manner. To play this role, dissemination of domestic biogas would need up-scaling far beyond what currently is happening in most countries (Felix t. H., 2005).

Although the economic, environmental, and health benefits that an Ethiopian farmer can accrue from adopting a biogas digester system are clear, there remains several barriers that prevent mass biogas digester adoption. Issues like high construction investment, lack of awareness among rural households about the technology's long term benefit, the under developed nature of the biogas market, low level of private sector development, inappropriate dissemination strategy and design selection, poor supply networks, increasing number of non operational biogas plants and turn over and dropouts of skilled labour forces would inhibit the large scale deployment of the biogas technology in the country in general and in the region in particular.

2.3.2.1. High Investment Cost and Associated Financial Shortage

One (not necessarily the only) important stumbling block for large-scale dissemination of domestic biogas, particularly in poorer rural areas, is the combination of significant upfront investement for the installation with the limited access to financing opportunities for farmers (Felix t. H., 2005).

According to I. Barfuss et al, 2012, households in rural areas of Ethiopia largely collect their own fuel, with female household members being mainly responsible for the chore. By investing in biogas plants, households could save time and energy, and have a supply of slurry that can be used as fertilizer in agricultural production. A cost-benefit analysis of biogas plants yields positive net present values for households collecting their own energy sources. Even higher net present values are obtained for households purchasing all of their energy needs; these households stand to gain significantly from the financial benefits of energy cost savings with biogas technology.

Clean energy systems are becoming increasingly reliable, available and affordable both in absolute terms and also relative to most popular fossil-fuel alternatives. However, high upfront costs compared to traditional fuels, low purchasing power of poor people and lack of viable RET financing mechanisms are still major barriers to dramatically scaling-up access (Clean Start, 2012). An obvious obstacle to large scale introduction of biogas technology is the fact that the poorer strata of rural populations often cannot afford the initial investment cost for biogas plant. This barrier remains despite the fact that biogas systems have proven to be economically sound investments in many cases (UNESCAP, 2007).

The cost of the technology is steadily rising in Ethiopia since the launching of the National Biogas Program of Ethiopia (NBPE) in 2009. Disregarding regional variations, as emphasized by mid-term review of the phase-1 of NBPE in 2011, bio-digester construction costs including cement, other construction materials and labour have nearly doubled during the review period. The regional annual reports of 2011, 2012 and 2013 show that the average investment cost for $6m^3$ is steadily increasing; ETB[2] 11,300, ETB 12,100 and ETB 13,000 in 2011, 2012 and 2013, respectively.

Unless the participation of MFIs is assured in the biogas sector, the upfront cost, which is identified as a major obstacle to mass dissemination of renewable energy technologies (more specifically biogas), could not be solved. It has been said the microfinance sector has grown tremendously in Ethiopia since the enactment of the first proclamation made in 1994. However, this phenomenon alone could not assure the accessibility of credit service to people in need of it. Gobezie (2009) claims that the current number of MFIs can be considered as significant growth by any standard; nonetheless, when we look at the number of MFIs, since the enactment of the Microfinance proclamation, number wise, no one will deny that the number of MFIs is increasing, yet considering the potential demand particularly in rural areas, the available MFIs can only satisfy an insignificant portion of the people who are in dire need of financial services.

Access to modern energy services can be greatly enhanced if people also have access to microfinance loans to pay for these services. Over the last 20 years, microfinance has played an important role in enhancing the economic opportunities available to poor people, but the experience to date with loans for energy services and products is limited.

[2] *1 USD = 20 ETB*

On the energy side, especially for people living in rural areas, energy services may not be available because energy companies do not typically view them as a strong, viable market for their products and rarely offer company-provided financing options. Microfinance institutions, however, can expand access to energy for poor clients by offering credit and/or loans for energy products and by partnering with local energy companies to help them branch out into new markets that include poor and rural people. As linkages are built between the microfinance and energy sectors, financial institutions may be more willing and able to channel capital into loans for energy services (Ellen M. etal, 2007).

The financial, institutional and human resource capacities of Ethiopian MFIs are limited. With regard to their financial capacity, all Ethiopian MFIs are funded by different means; in addition to this they have indicated that there is a requirement for financial assistance from different sources if they have to participate in the NBPE. As of end of 2008, no MFIs in Ethiopia is FSS, this can be attributed to the global financial melt- down in that year, only 78% of the MFIs analyzed in the 2010 Microfinance Performance Analysis report of AEMFI are OSS which is lower a lower standard measurement of sustainability. The limited institutional capacity of Ethiopian MFIs is demonstrated by the low level application technology such as MIS in their organization, only one of the largest MFIs is using fully automated MIS and the other largest MFI is on the way to fully automate its MIS, despite this, they are still in need of institutional capacity building. When evaluated from for their human resource capacity with reference to biogas users, all MFIs would like to develop their human resource capacity before they participate in the NBPE. Generally, Ethiopian MFIs have a higher borrower to staff numbers' ratio when evaluated against the bench mark for African MFIs. Due to their limited human resource capacity around 43% of the surveyed

MFIs do not conduct a market research or users' survey before they design a new loan product (Biruk T., 2010).

According to mid-term review (MTR) of the NBPE, 2011, limited credit facilities have been arranged and used despite painstakingly slow development. According to status reports of RBPCOs, a total of US$ 2.4 million is either arranged or being used to finance the construction and installation of biodigesters for a total of 1,710 households in the four programme regions. While Micro-Financing Institutions (MFIs) showed interest and provided consumer loans to households in Oromia and SNNPR regions, Amhara and Tigray regions were forced to allocate revolving fund credit from their own resources due to reluctance of MFIs to lend money to biogas users in the two regions.

During the first phase of the program, over 8,000 biodigesters have been installed, with growing numbers every year indicating the positive uptake by rural households, the increasingly active involvement of masons and companies and, most importantly, the establishment by the Government of Ethiopia of credit lines for biodigesters. However, with a technical potential of one million of rural households, currently only a small percentage of (0.8%) of the potential households are benefiting from the direct and indirect benefits from domestic biogas (PID, 2014).

Even if credit facility by MFIs is an important element in enhancing the uptake of biogas digesters, currently only 2 MFIs are participating in facilitating credit to biogas users in the SNNPR. Out of the five MFIs operating in the region, Omo and Mekilit MFIs have arranged credit facilities to biogas users since 2010. The Omo MFI operates in all woredas of the region where as Mekilit MFI operates only in one of the biogas program woredas, Meskan woreda , of the region. In addition to this, the Omo MFI has faced shortage of finance during loan disbursement of credit to biogas users in different periods.

2.3.2.2. Limited Awareness

Biogas is viewed as an alternative energy source by using natural waste which can fulfill the domestic needs and can be an alternate to gas especially in area where Sui gas has still not reached. However, the perceptions and awareness about bio gas potential users is yet limited. They were not so aware of the plant and thus were not confident in sharing their views about it. The prospective users had either just heard the name, or have seen it in the neighborhood village. Mostly all of them shared that the sources of awareness was much limited. Their source of information was either word of mouth or some seen the biogas plant installed at the user’s place. Only a few mentioned that people from BCC/ NRI come and create awareness about biogas plant (Shadab F.and Team, 2010).

The rural communities in Ethiopia have low access to energy, both for subsistence and productive purposes, and rely almost entirely on biomass fuels. The consumption of wood fuel has far exceeded its supply. Excessive dependence on biomass energy involves a trade-off in agricultural productivity, the crop residues and animal wastes being diverted from farms, where they supplement soil nutrition, to provide energy needs. Similarly, as fuel wood scarcity has become increasingly serious, rural households who depend on collecting wood freely have to travel longer distances to obtain it, thus causing loss of human availability for productive work. Furthermore, fuel wood scarcity will advance further deforestation and lead to a general environmental degradation (MWE, 2012).

Though the development of private sectors have been identified as one of the deriving tool for mass dissemination of domestic biogas technology, their participation in promotion, manufacturing, marketing, construction supervision and users training is very limited. Low entrepreneurial and business skill, wrong attitude about biogas technology business and limited financial capacity are attributed to the limited contribution made by private sector, especially the biogas digester constructing masons (MEA/RBPCU, 2013).

Awareness of the benefits and impacts of renewable energy technologies by final consumers is not to the desired level though the reality to energy access situations and its impacts are as explained above. The mass dissemination of biogas technology could not be realistic even in areas where the NBPE is under implementation unless awareness of the people is raised to the required level. In woredas where NBPE is under implementation, most of the people know about some of the benefits obtained by installing biogas digester because of two reasons; the promotional activities made so far by MEA and SNV and the previously installed biogas plants have started promoting themselves. However, the slow dissemination rate, as compared to the huge potential, signals the need for more efforts and innovate approaches with regard to promotion.

2.3.2.3. Low level private sector development

One of the factors that favor mass adoption of biogas technology is the active role played by the private sector. In the context of Ethiopia, the role of the private sector; including the biogas companies/masons, appliance manufacturers, suppliers of construction materials and appliances, is either non-existent or contributed little in the biogas sector before the implementation of the NBPE. Since then promising progress has been seen though much has to be done in order to enhance its role. Biogas appliances like biogas stove, dome pipe and water drain are supplied by manufacturers created after the implementation of NBPE. The building materials shops are supplying construction materials like cement, iron bar, pipes, and emulsion paints, etc, which are used during biogas installations. Similarly, the biogas masons transforming themselves in to biogas construction enterprises and as a result of this, 12 BCEs, which are licensed under construction category, were created in regionally.

Despite the slow progress, promising achievements were made in the front of market and sector developemnt. As a result, interest among private sector individual masons and construction companies has grown significantly during the period under review. Although their numbers are still very low and capacities weak, the programme has been able to attract, train and actively engage at least two to three Biogas Construction Enterprises (BCEs) and half a dozen masons in biogas business during the past two and half years. In all regions a number of masons are merging into BCEs. Despite growing interest of the private sector to engage in biogas business, much more remains to be done to attract more private sector operators and build their capacities in the future (MTR, 2011).

Even if the role of private sector is growing gradually, the private sector does not show great presence in rural Ethiopia. It is said that biogas appliance manufacturer has been created in the region since the implementation of NBPE; however, it is only in the regional capital, Hawassa. Moreover, imported appliances like biogas lamp have not been manufactured yet in Ethiopia though high demands are there for these appliances. Additionally, the BCEs are currently participating only in construction even though supplying and manufacturing of biogas appliances and construction materials are the areas in which much is expected from them.

2.3.2.4. Inappropriate Dissemination Modalities and Design Selection

Selection of appropriate dissemination modalities and construction design has its own contribution for the successful adoption and dissemination of domestic biogas technology. However, the dissemination strategies and design selection, especially before the implementation of NBPE, had been inappropriate and had badly affected the early adoption and later dissemination of the technology in the country. In their report on the feasibility study of a national programme for domestic biogas in Ethiopia, Eshete et al, 2006, explained that dissemination of biogas in Ethiopia can, in extremis, be grouped in two approaches. The older approach, mainly practiced by government agencies (EREDPC, Energy Bureaus and Agriculture Bureaus), could be characterized as a stand alone, technology driven. The objective often is to pilot / demonstrate the technology in certain areas. The newer methodology, practiced in particular by World Vision, would then be more a development approach in which households are offered a full "development package" that would serve as a springboard towards a "happy and self sufficient" life. Additionally, they emphasized that single-actor construction and construction in isolation were the characteristics of the two approaches. Single-actor construction is to mean that most installations were constructed by the "own organization" as opposed to involving local craftsmen and private entrepreneurs in the process in both approaches. Most of the visited installations constructed before the implementation of NBPE were constructed by non-local organizations in a "project" modality. Once the project is executed, the organization typically withdraws from the area, and with them construction and maintenance knowledge and skills. Moreover, building biogas plants in isolation as opposed to clustered (say 20 biogas plants in one limited area) construction makes dissemination, supervision, extension and maintenance processes unnecessarily complicated and biogas plants expensive.

Another shortcoming of previous approaches was the inappropriate selection of construction design. In periods before NBPE, for instance, the construction design mainly used by Bureau of Agriculture and World Vision were the Indian floating drum design and fixed dome design, respectively. Heterogeneous design selection had made large scale dissemination more complex and had resulted in poor service.

The selection of inappropriate dissemination strategies and construction design is still an issue in the context of SNNPR. According to MEA, 2012, 215 plastic model biogas plants were disseminated in Halaba special woredas by an NGO called LVIA in the period between 2010 and 2012, of which 185 plants (86%) are non-functional.

2.4. The Role of Micro Finances

2.4.1. Microfinance as a Tool for Livelihood Improvement

Various studies indicated that lack of financial resources is the major impediment in extricating the rural poor from poverty. It is strongly believed that the availability of loan help the rural poor people in entering a new income generating venture to the betterment of their socioeconomic status. In line with this premises microfinance institutions are enjoying widespread acceptance as an antipoverty strategy in general and women empowerment in particular (Dereje K. et al, 2013).

People living in poverty, like everyone else, need a diverse range of financial instruments to run their businesses, build assets, stabilize consumption, and shield themselves against crises. Microfinance offers many of the financial services needed by the poor - working capital loans, consumer credit, savings, deposit facilities money transfer services, pensions, and insurance. By reducing vulnerability and increasing earnings and savings, financial services allow poor households to make the transformation from every-day survival to planning for the future (Ellen M. et al, 2007).

Studies showed that strong demand exists for microfinance services among the poor around the world. Usually micro financing is regarded as the provision of financial services to low income clients or solidarity lending groups including consumers and the self employed (Aremendariz and Morduch, 2009). These groups traditionally lack access to banking and related services. Scholars and policy makers who promote microfinance believe that such access will help poor people to improve their living. The success of the Gremeen Bank in Bangladesh has become proof for the importance of micro financing for poverty alleviation. The result of this lending has enhanced its priority and gained momentum in the policy agenda of several countries in Africa, Asia and Latin America (Todaro and Smith, 2009).

2.4.2. Impact of Microfinance in Ethiopia

Ethiopia is one of the least developed countries. The per capita income of the country, though it showed improvement in recent years, is USD 370 which is lower than the regional average of US$1,257 (World Bank, 2013). The study conducted by Ministry of Finance and Economic Development of Ethiopia (2012) shows that the proportion of poor people (poverty head count index) in the country is estimated to be 29.6% in 2010/11. The proportion of the population below the poverty line stood at 30.4% in rural areas, according to the study. The poverty that prevails in the country has been caused due to various reasons. Some argued that the cause of poverty in developing economies among other things is that the poor does not have access to credit for the purpose of working capital as well as investment for its small business (Jean-Luc, 2006).

The country has been undergoing market-oriented reforms following the downfall of Marxist junta known as the 'Derg'. Based on its understanding of the implication of the pre-dominantly agrarian economy guided by the firm belief that surpluses created in the agricultural sector would go a long way to support industrial development in the country, the current Ethiopian Government has adopted a national economic development policy of Agricultural Development Led Industrialization (ADLI). Hence, poverty reduction has remained to be the declared core objective in the government every five year plan since 1991. In those development programs and strategy papers, microfinance is considered as a means that is expected to play essential role in reducing poverty in the country (MoFED, 2002a; Asmelash, 2003). In Ethiopia, extension program in the agriculture sector was in place to increase agricultural production and productivity, induce technology adoption, improve input supply and utilization, increase income, reduce poverty and attain food security. To achieve the intended objectives different strategies and policy tools were devised and have been in action for the last two decades (Tesfaye B., 2012).

Microfinance indicated among the specific means that is given greater emphasis and expected to play essential role for reducing poverty in rural areas of the country. Accordingly, MFIs have become components of development strategies of the country and micro financing programs were initiated for delivering credit services to the poor. At present, because of policy support, Ethiopia has shown increase in MFIs and has now the second largest microfinance users in sub-Saharan Africa (Wolday, 2002; Bamlaku, 2006; Getaneh, 2004).

Tefaye B., 2012, in his study about Impact of Microfinance on Rural Household Poverty Reduction, explained that Omo Microfinance Institution services have brought some positive impacts on improving income, asset building and on wealth status of the clients. Majority of its customers perceived their livelihood status is in continuous progress due to an improvement on their income and household assets. The number of poor and destitute has shown significant decrease from 43.3% to 2.5% and 4.2% to 0.5% respectively.

2.4.3. Microfinance as a Tool for Mass Adoption of Biogas Technology

Energy, being a common human need, enjoys a global demand from the poorest of the poor to the richest of the rich. It is also an established fact that the energy cost is rising, which puts an unbearable burden on household budget especially of middle and lower income strata of societies. Rising energy cost, depleting fossil fuel reserves and environmental concerns have unleashed search for cleaner, cheaper and sustainable source of energy. Closely tied to this search is the question of affordability: making investment to create or switch to a newer source of clean energy. The role of credit therefore becomes central to promoting alternative energy sources: solar, wind, biogas etc. World experience amply demonstrates that availability of and access to credit has helped achieve accelerated growth on both sides of the sector: demand (accelerated growth in use of biogas) as well as supply (portfolio diversification of vendors and microfinance institutions, i.e., MFIs) (Shadab F.and Team, 2010).

According to UNCTAD (2009), financial incentives are necessary to achieve deployment of RETs as it is provided to reduce the costs and risks associated with the specific RET being used. These financial incentives were targeted at both users and developers. Access to bank loans made biogas plants in Nepal affordable to rural customers. High stove cost in Eritrea and Guatemala meant stoves had to be subsidized at 85-90 per cent to make them affordable to rural households.

The cost necessary for the construction of biogas plants frequently exceeds the means at the disposal of the investor, in other words he cannot cover them from his regular income or savings. This could also apply to the larger replacement investments occurring at certain intervals during the economic lifetime of the plant. Besides the non-recurring i.e. a-periodical costs, the running costs of the plant have to be borne. This solvency outflow however, is set against solvency inflow in the form of regular revenue. A solvency analysis can show how far the net solvency outflow has to be financed and how much scope there will be from net solvency inflow. Usually the construction and operation of biogas plants involve a demand for financial means which can only be covered by borrowed capital (GTZ, 1997).

According to WISONS, 2006, the USAID support project on ‘’Capacity Building for Micro Financing of Renewable Energy Technologies’’, which was implemented by Winrock International in collaboration with the governmental Alternative Energy Promotion Center (AEPC) and the biogas sector partnership, Nepal, was designed to expand the installation and use of biogas plants by increasing access to micro-finance to lower income purchasers. Though the project’s target was to facilitate 1,500 biogas loans amounting to USD 200,000, leveraging USD 500,000 in total investment in 2005, the project had exceeded this target by facilitating the construction of 1,572 biogas plants through micro credit.

Financing is a very important part of the process of dissemination of domestic biogas plants. Promotion of biogas leads to increased awareness, which leads to evaluation and decision making and eventually to adoption. After adoption, financing is required before construction and installation can take place. Investment costs and accessible credit schemes play a vital role in motivating a potential farmer to install a biogas plant (J.U. Smith et al, 2011).

Although biogas currently attracts a 40 percent investment subsidy, micro-credit is a crucial element in successfully reaching Nepal's poorest. In areas that already have a well-developed biogas market, the only reason why those without biogas are not buying the technology is because they lack the money. Any serious expansion of biogas use in Nepal will require more micro-credit opportunities (UNCDF, 2013).

According to Sundar B., 2005, credit support for making biogas systems affordable to poor farmers is considered as one of the principal success factor in the Nepalese Biogas Support Program. In 1990 it was realised that major reductions in production costs were not possible without adversely affecting the life expectancy, performance and reliability of the biogas system. The options for reducing costs to consumers were through financial measures such as investment subsidies, credits and by increasing the market that could lead to economies of scale. Credit is being provided through Micro Finance Institutions (MFIs) for farmers who do not have money to pay upfront cost for the system.

Biogas users and microfinance clients have very similar demographic profiles. As soon as MFIs are educated about biogas users' credit needs, they realize the potential and diversify their credit portfolios to include biogas credit as well. Concerted efforts by biogas promoters are required in order to facilitate MFIs' development of credit products (Dhakal et al, 2008). Once this happens, biogas usage witnesses wide-spread adoption quickly. This pattern is common across cultures in Asia, Africa and Latin America (Hilman et al, 2007).

If appropriately designed, loans offered by MFIs can provide clients with access to high quality modern energy services by closely matching loan payments to existing energy expenditures or income flows. Such loans can offset the high upfront cost associated with cleaner, more efficient technologies, such as biogas, micro hydropower, wind, solar, or liquefied petroleum gas (LPG) (Ellen M. et al, 2007).

The biogas production scenario in the first phase (2009 to 2013) of the on-going NBPE has shown this fact. According to the annual report document of SNNPR Mines and Energy Agency (RBPCU), out of a total of 147 digesters built in 2010, about 54% (80 digesters) were built in December alone, which was the period in which the first credit facility was arranged by Omo MFI to biogas users. In SNNPR, out of 1724 biogas disseminated in the period between 2009 and 2013, the number of digester disseminated before installment of credit (before December, 2010) to biogas users is only 96. Moreover, out of 1,724 biogas plant produced in the period between 2009 and 2013, the number of digesters installed via credit facility was 1,372 (about 80%). Of course, it could be said that facilitation of loan to biogas users has not been the only reason that has contributed for better up take of the technology. However, it is not deniable that it takes the lion share for better progress of the uptake of domestic biogas digesters in the region.

2.5. The Role of Private Sectors

2.5.1. Private sectors and Biogas Digester Adoption

The Organization for Economic Co-operation and Development (OECD) defines the private sector as ‘a basic organizing principle of economic activity where private ownership is an important factor, where markets and competition drive production and where private initiative and risk taking set activities in motion’. The critical point is that it is markets, through the process of competition, that determine what is produced and consumed. This is what distinguishes market-based economies from other organizing principles. The term private sector, therefore, covers all private actors - the poor and the rich, individuals and businesses – engaged in risk taking to earn profits and incomes. It applies to the smallholder farmer as well as to the very large, multinational corporation (OECD, 2004).

The rural private sector includes a whole continuum of economic agents, ranging from subsistence or smallholder farmers, rural wage-earners, livestock herders, small-scale traders and micro entrepreneurs; to medium-sized, local private operators such as input suppliers, microfinance institutions, transporters, agro-processors, commodity brokers and traders; to other, bigger market players that may or may not reside in rural areas, including local or international commodity buyers and sellers, multinational seed or fertilizer companies, commercial banks, agribusiness firms and supermarkets (IFAD, 2007).

The world over, the private sector is the major contributor to GDP and employment and so is the engine of the economy. Growth, as measured by increases in GDP, is simply the sum of the increase in value added by the activities of all participants engaged in production and market exchange. The greater the capability of private actors, including the poor, to add value and create wealth, the faster will be the pace of growth. The private sector is more than businesses. It includes the poor and multinationals participating alongside each other in markets (OECD, 2004).

With the need for self-sustaining models of development becoming clearer, energy and financial services providers and governments alike are looking for market-based alternatives to deliver clean and low-carbon energy solutions to the poor who lack energy access (Julie M. and Oliver W., 2013).

Market-led approaches are suited to rolling out clean-energy technologies across the developing world, if affordable financing is made available and supported by local and national policies. To achieve universal energy access, investment capital must be matched to a pipeline of viable energy projects and enterprises (Reid D. and Richenda V.L., 2014).

The private sector biogas companies, cooperatives, and biogas appliance and component manufacturers can play a significant role in supporting the success of the biogas programme, even though they are presently few in number. Private construction companies can play a role in construction and house-to-house promotion of the technology. Past experience shows that once a project is executed, the organisation withdraws from the area without passing on the construction and maintenance knowledge that is crucial to sustain the project. To reduce such eventuality, project organisations should support the local private sector, which can continue to provide services after the construction of the plant is completed. The role of the private sector is crucial for market sustainability (Eshete G. and Kidane W., 2008).

There is a need to focus on the ultimate goal of having a commercially viable sector. This vision should be shared by all stakeholders. Regulation, consumer demand and the supply of the market all need development, and this could perhaps be achieved by allowing the private sector take the lead and supporting the development of an enabling environment.

2.5.2. Experiences from Nepal

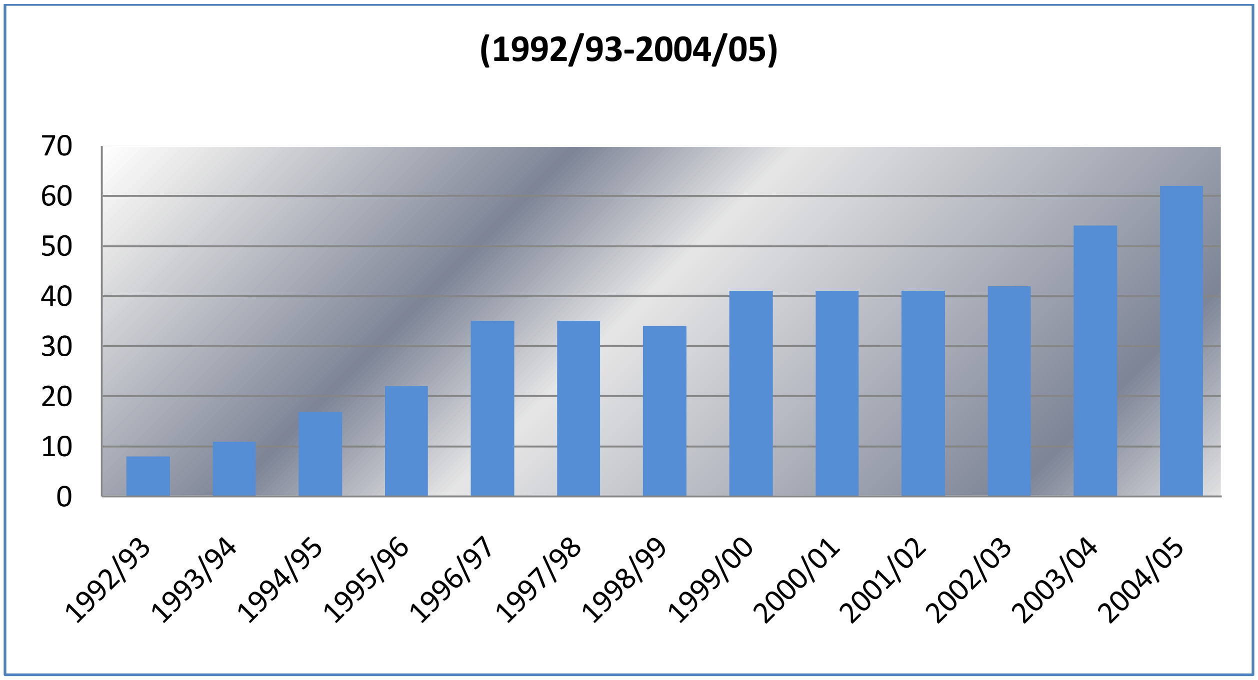
Nearly a third of Nepal's 31 million people live below the poverty line, with certain marginalized groups and geographic regions facing higher rates of poverty (Julie M. and Oliver W., 2013).Currently, 87 percent of people in Nepal get their energy from the burning of traditional biomass fuels like wood and charcoal; not even one percent of energy is derived from renewable sources. The majority of people use firewood for cooking followed by liquefied petroleum gas (LPG), cow dung, biogas and kerosene. Kerosene is used much more in cities, however, since it is costly and frequently unavailable to those living in rural areas (Government of Nepal, Ministry of Finance Economic Survey, 2012). The Government is actively seeking to encourage both urban and rural development measures in response to these worrying situations. Providing modern and reliable clean energy solutions is one such way to spur development. They give the poor much-needed and affordable access to energy while also supplying small businesses a number of growth opportunities (Julie M. and Oliver W., 2013).

Nepal has promoted biogas for over 50 years with considerable success. From its humble beginnings in 1955, biogas first caught the Government's attention in 1975 during the global oil crisis, resulting in the establishment of Nepal's first biogas company in 1977. This eventually grew into a fully-fledged national initiative, the Biogas Support Programme, in 1992. The SNV Netherlands Development Organization established the Programme with support from the Government of The Netherlands. The governments of Nepal and Germany, through German development bank (KfW), also started funding it in 1997. Hundreds of NGOs, community-based organizations and cooperatives are involved in one way or another (Saroj R., 2013).

Set up in 1996 by the Ministry of Environment of Nepal, the Alternative Energy Promotion Center (AEPC) acts as an intermediary institution between policy makers and private businesses and non-government organizations (NGOs) working on the ground. Nepal's government first began to tackle the issue of energy access in the late 1990s, making the need for new kinds of renewable energy technologies for the rural poor a key part of its national development plan. This was later followed by the 2006 Rural Energy Policy, which sought to promote private business' role in expanding energy solutions and to replace the inefficient and unsustainable use of biomass energy with cleaner energy sources. It also promotes community-managed energy service delivery (Julie M. and Oliver W., 2013).

Biogas program in Nepal is implemented with the involvement of various actors. Among them, the private sector plays a crucial role and the actors in the private sector include biogas companies, appliance manufacturers and financing institutes. The quantity and quality of these actors has increased gradually since the establishment of Biogas Support Program (BSP) in 1992. Before the start of BSP, there was only one company that was established with the initiation of Agriculture Development Bank of Nepal called GGC. Once BSP was established, it adopted an approach of opening opportunities for private biogas companies to participate in the program. The aim of involving more private companies was to increase the number of plant installation through open market competition and commercialization of the biogas sector. The number of biogas companies increased gradually every year and reached to 62 in 2005. Similarly, the number of appliance manufacturers had increased from 1, at the beginning of BSP, to 15 in 2005. These manufacturers produce appliances like biogas stove, dung mixer, gas tap, water drain device, main gas pipe and lamp.

Chart 3.1: Growth of Number of Biogas Companies in Nepal



Source: Sundar Bajgain, 2005

In addition to the biogas companies and appliance manufacturers, financing institutes had played a significant role in mass adoption of biogas digesters in Nepal. One of the important features of the BSP has been its innovative financial engineering and judicious application of consumer subsidies to help develop the market for biogas plants. Working with the Agriculture Development Bank of Nepal and the Rastriya Banijya Bank (RBB), both government banks, a loan and subsidy program was structured that was targeted at supporting the small and medium - scale rural farmers. This loan and subsidy programs has been a very critical element in developing the commercial market for the biogas plants in Nepal. Besides these two government banks, more recently BSP is working with more than 140 MFIs for biogas lending. These MFIs, mostly cooperatives, located in rural areas and lend biogas credit to their members in easy and transparent way. MFIs do not only lend the credit but also disseminate the biogas technology and identify demand for biogas plants to be constructed.

Despite some weakness, private sector involvement has contributed a lot in the development and successful execution of biogas program in Nepal. High quality plant installation, proper after sale services, proper training to users on operation and maintenance, and training on slurry utilization, toilet construction and connection with biogas plant and market development are the main contribution of private biogas companies. Similarly, effective credit lending in field level by MFIs and awareness creation by NGOs are also important activities that have helped biogas to reach the current stage. Nepal became independent from imports for high quality appliances that are being produced by 15 manufactures (Sundar B., 2005).

By mid-July 2013, Nepal had some 298,000 household-sized biogas plants constructed in all 75 districts. There are about 100 biogas companies qualified to participate in the Biogas Support Programme and they have around 200 offices in different parts of the country. Over 260 microfinance institutions are providing credit to biogas users. Annually, 22,000 biogas plants fo use in households are constructed, a jump from around 16,000 five years ago. Recently, two biogas users' surveys revealed that 94 percent to 98 percent of these household-sized plants constructed under the Support Programme are still operating, albeit occasionally with lower level of feeding (input) and gas production (output). These surveys also report that 91 percent to 94.5 percent of people using biogas plants constructed during 2004 and 2005 are satisfied with their performance (Saroj R., 2013).

Nepal's biogas success story has been used as an example of best practice across the world and is now waiting for another smart intervention to provide further impetus. This is a great opportunity for the government and other development partners to make a big dent in renewable energy access for the poor in Nepal (Julie M. and Oliver W., 2013).

Chapter 3 - Research Methodology

3.1. Background of the Study Area

Covering a total area of 109,015 square kilometers with a share of 10% of the country, Southern Nations, Nationalities and People's Region (SNNPR), located in the southern and south-western part of Ethiopia, roughly lies between 4˚.43" - 8˚.58" north, latitude and 34˚.88" – 39˚.14" east longitude. The region is bordered with Kenya in South, the South Sudan in the southwest, Gambella region in the northwest and surrounded by Oromia region in the northwest, north and on the east. SNNPR is administratively divided in to 14 zones (which are sub-divided into 131 woredas), 4 special woredas/districts and 22 town administrations. The 14 zones include Sidama, Gamo Gofa, Wolyta, Gurage, Hadiya, Kambata Tambaro, Dawuro, Gedio, Silite, South Omo, Bench Maji, Kafa, Sheka and the 4 special woredas include the Segen People's zones and Basketo, Yem, Konta and Halaba. The state capital of the region is Hawassa, which is administered under the city administration at the status of zonal administration. According to the zonal and special woredas' reports of 2011/2012 (2004 E.C), the region is composed of 3709 rural kebeles and 315 urban kebeles. Regarding urban areas, there are 243 certified towns with municipality and growing municipality city status.

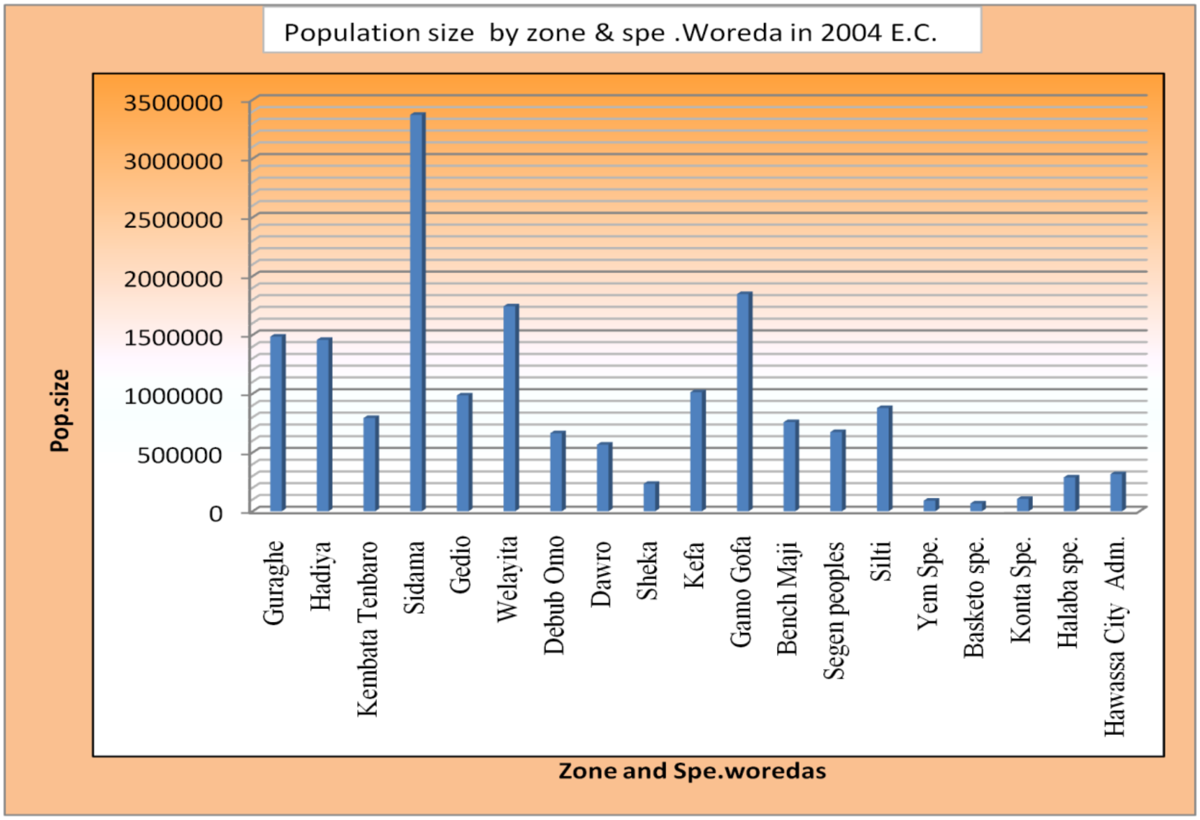
The population size of the region is 17,332,584 (CSA, 2007), accounting to nearly 20% of the country's total population. The rural population growth rate is 2.9% per annum and some 89% of the population lives in the rural areas while the remaining 11 % lives in urban areas. The average population densities of the region became 159 persons per sq.km, which makes the region one of the most populous parts of the country. Regarding the population distribution, in the year 2012, only 6 zones having a population size between 1 million and 3.3 million constitute 62 % of the regional population.

The region comprises a multinational population of about 56 ethnic groups with their own distinct geographical location, languages, cultures, and social identities. These varied ethnic groups are classified into the Omotic, Cushitic, Nilo-Saharan and Semitic super language families. Among which, the Omotic and Cushitic are the most populous and diversified ones with the largest area coverage in the region (BoFED, 2012).

Geographically, the region has a diverse physical appearance. It consists of mountain ranges, rift valley, plateaus and flat lowlands. The eastern, the central western and western parts of the parts of the region have a rugged surface while the central high lands consist plateaus and gentle slopes. The rift valley, which is part of the great east African refit system, cuts the region in to two running from the northeast of the south of the region. The lowlands that run along the border with Kenya and the South Sudan are generally falls between 4250 meters above Sea level at mount Ghuge in Gamo Gofa zone and 500 meters above sea level near the border with Kenya, in South Omo zone (ibid).

Ecologically, the region is divided in to three major ecological zone, Wurch/Tundura (3500 and above), Dega/temprate (2500 – 3500), Woyenadega/moderately temprate (1500 – 2500), Kolla/tropical (600 – 1500) and Harur/semi-arid (below 600) meters above sea level. Dega is found in the high land, while Kola and Harur are in the lowlands. Woyenadega lies between Dega and Kola. The Wurch type of climate is found at the tips of the high rising mountains such as mount Ghuge (ibid).

Chart 4.1: Population size by zone & special Woreda



Source: BoFED, 2012

The climate of the region is highly influenced by its diverse topographic features as it is elsewhere in Ethiopia. Temperature and rainfall follow the geo-physical appearance. Temperatures range between 28^0C and 41^0C in the lowlands and 11^0C and 23^0C in the highlands. Areas like Omo River in South Omo and Surma in Bench Maji zones experience higher temperatures during dry seasons. Some pockets in the highlands like mount Ghuge in Gamo Gofa zone experience lower temperatures of even less than 100C in the cold seasons. Rainfall similarly follows the geographic set up of the region. It ranges from 400 mm/yr in the lowlands of the South Omo and Bench Maji zones to 2,200 mm/yr in the highlands of Sheka zone. The length of the rainy season decrease from west to east with the highest being 9-11 months in Sheka (CSA, 2011).

Figure 4.1: SNNPR and its location in Ethiopia

Map Source: UN, 2011

There are 3,552,963 household in the region with an average household size of 4.9 persons per household. The central and eastern highlands of the regions are densely populated while the lowlands especially in Bench Maji and South Omo zones are generally sparsely populated. Moreover, the average number of family size varies significantly from one zone to another and from one special woreda to another. For instance, the highest average family size was observed in Kambeta Tembaro and Hadiya zones, with an average of 5.4 and 5.5 persons per household, followed by Dawuro and the Segen people area zones with a family size of

5.4 and 4.9 persons per household, respectively. The lowest average family size was observed in Bench Maji and Sheka zones, both having 4.1 persons per household (BoFED, 2012).

According to the report of BoFED, 2011, 68% of the population depends on agriculture and the remaining 18% and 14% depends on services and industry respectively. The region grows cereals like teff, wheat, barley, maize, sorghum, etc. Root crops like enset, cassava, sweet potato, are highly produced in the region. Coffee is the main cash crop in the region. SNNPR is one of the largest coffee producing areas in the country. The most known type of coffee, the Yirga Cheffe, is premium produce in Gedio zone. Other cash crops like spices (Ginger, coriander, etc), banana, etc are grown in the region. Livestock also plays a major role in the economy of the region. The pastoral communities of South Omo and Bench Maji zones mainly depend on livestock production while in other parts of the region livestock production is exercised on a mixed basis.

3.1.1. A/Minch zuria woreda

Arba Minch zuria woreda, one of the 15 woredas of Gamo Gofa zone, is roughly lies between 5.70’’ – 6.21’’ north, latitude and 37.31’’ – 37.67’’ east, longitude and it covers an area of 1214 square kilometers. The woreda is administratively divided into 29 rural kebeles, of which 10 kebeles are Kolla. The capital of the woreda is Arba Minch town, which is also the capital of Gamo Gofa zone, and its distance from the regional capital, Hawassa, is 275 kilometers.

Ecologically, the woreda is divided in to three zones with an elevation ranging from 1,001m up to 2,500m. The climatic condition is within an average temperature range of 15.1^{0}C to 25^{0}C and an average annual rainfall range of 801mm to 1,600 mm. A total of 188,890 people lives in 38,604 households and inhibited a total area covering 967.7 square kilometers. The number of persons per household is 4.9 and 195 persons live per square kilometers (BoFED, 2012).

According to BoFED, 2012, the main economic activities in the woreda largely depend on agriculture and mixed agriculture. Mixed agriculture is common in the woreda as the farmers exercise not only crop productions but also livestock productions. Moreover, the woreda is known of its fruit productions, especially banana and mango. The net revenue earned by woreda's people in the year 2011/2012 is birr 15,562,600 (39.5%).

Regarding biogas digester dissemination, the first fixed Chinese model biogas digester was installed in the Shelle Mella kebele of the woreda in 1981by Evangelical Mekaneyesus Church. Before the implementation of NBPE, a total of 3 digesters were installed in two kebeles (Shelle Mella and Kolla Shelle) the woreda and these digesters are currently non functional. Arba Minch zuria woreda is the first woreda in the region where the NBPE has started its first digester installation in 2008 as demonstration. Accordingly, 13 'SINDU' model biogas digesters were installed in two kebeles in 2008 as demonstration. During the implementation period (between 2009 and 2013) of the first phase of the NBPE, a total of 200 digesters were disseminated in 9 kebeles of the woreda. Therefore, a total of 216 domestic biogas digesters were installed in the period between 1981 and 2013.

3.1.2. Soddo zuria woreda

Soddo zuria woreda, one of the 12 woredas of Wolyta zone, is roughly lies between 6.72'' - 6.99'' north, latitude and 37.59'' – 37.86'' east, longitude and it covers an area of 404 square kilometers. The woreda is administratively divided into 31 rural kebeles. The capital of the woreda is Soddo town, which is also the capital of Wolyta zone, and its distance from the regional capital, Hawassa, is 170 kilometers.

Ecologically, the woreda is divided in to climatic zones with an elevation ranging from 1,501m up to 3,000m. The climatic condition is within an average temperature range of 12.6^0C to 20^0C and an average annual rainfall range of 1201mm to 1,600 mm. A total of 186,779 people lives in 37,716 households and inhibited a total area covering 404 square kilometers. The number of persons per household is 5 and 462 persons live per square kilometers (BoFED, 2012).

According to BoFED, 2012, the main economic activities in the woreda largely depend on agriculture and mixed agriculture. Mixed agriculture is common in the woreda as the farmers exercise not only crop productions but also livestock productions. The net revenue earned by woreda's people in the year 2011/2012 is birr 9261030 (21.7%).

This woreda is a woreda where the first domestic biogas digester was installed in the region in Agricultural College compound in 1976 for educational purpose. Since then, domestic biogas digesters were disseminated in the woreda by Bureau of Agriculture via Woliyta Agriculture Develeopment Unit and 8 Indian floating drum model digesters were installed in 5 kebeles of the woreda, of which 1 digester is still functional. These digesters were installed by Woliyta Agriculture Development Unit (WADU) and Sodo Rural Technology and

Promotion Center (SRTPC) and the 8^{th} digester was built in 2005. After the implementation of NBPE in the woreda in 2011, 83 digesters were installed in 21 kebeles of the woreda up the end of 2013. Hence, 91 domestic biogas digesters had been installed in the woreda in the period between 1976 and 2013.

3.1.3. Meskan Woreda

Meskan woreda, one of the 13 woredas of Gurage zone, is roughly lies between 7.99'' – 8.28'' north, latitude and 38.26'' – 35.58'' east, longitude and it covers an area of 447 square kilometers. The woreda is administratively divided into 40 rural kebeles. The capital of the woreda is Buta Jira town and its distance from the regional capital, Hawassa, is 158 kilometers.

Ecologically, the woreda is divided in to climatic zones with an elevation ranging from 1,501m up to 3,500m. The climatic condition is within an average temperature range of 7.5^{0}C to 17.5^{0}C and an average annual rainfall range of 1001mm to 1,200 mm. A total of 180,170 people lives in 37,735 households and inhibited a total area covering 404 square kilometers. The number of persons per household is 4.8 and 403 persons live per square kilometers (BoFED, 2012).

The main economic activities in the woreda largely depend on agriculture and mixed agriculture. Mixed agriculture is common in the woreda as the farmers exercise not only crop productions but also livestock productions. Moreover, the woreda is known of its piper productions. The net revenue earned by woreda's people in the year 2011/2012 is birr 8793980 (20.5%) (BoFED, 2012).

Meskan woreda is also another woreda where domestic biogas dissemination was installed before the implementation of NBPE and in this period 2 digesters with a model of Indian floating drum (all non functional) were installed by Bureau of Agriculture. Like that of Arba Minch zuria woreda, the NBPE had installed 12 'SINDU' model biogas digesters in 2 kebeles of the woreda in 2008 as demonstration. A total of 242 digesters had been installed in the first phase of the NBPE. In general, 244 domestic biogas digesters had been installed in the woreda between 1982 and 2013.

3.1.4. Aleta Wondo Woreda

Aleta Wendo Wereda is one of the 19 Weredas and 2 administrative towns in Sidama zone of SNNP region. The Wereda is bordered with Dale and Wensho Weredas in the north, Dara and Chuko Weredas in the south, Hula and Bursa Weredas in the east and Chuko in the west. It is located about 337 kilo meters away from Addis Ababa city, the country's capital and 60 kilo meters away from Hawassa, the capital of the region. Aleta Wendo town is at the center of the Wereda which is located along the Hawassa- Negele Borena road and it is one of the 20 administrative towns in the region.

The woreda is roughly lies between 6.52'' – 6.68'' north, latitude and 38.35'' – 38.54'' east, longitude and it covers an area of 231 square kilometers. The woreda is administratively divided into 27 rural kebeles.

Ecologically, the woreda is divided in to climatic zones with an elevation ranging from 1,501m up to 2,500m. The climatic condition is within an average temperature range of $15.1^{0}C$ to $20^{0}C$ and an average annual rainfall range of 1201mm to 1,600 mm. A total of 191,592 people lives in 38,309 households and inhibited a total area covering 231 square kilometers. The number of persons per household is 5 and 831 persons live per square kilometers (BoFED, 2012).

The main economic activities in the woreda largely depend on agriculture and mixed farming. Occupationally, 96 % of the population depends on agriculture. Mixed farming is common in the woreda as the farmers exercise not only crop productions but also livestock productions. The Woreda is known for its natural coffee production in the forest areas, which covers an area of 1,170.85 hectare (5 %). The Woreda is also known for the production of *Chat*, *Enset* , different kinds of fruits, cereals, pulses and sugar cane. The cattle population of the woreda is 99,082, of which 540 are improved breeds. The net revenue earned by woreda's people in the year 2011/2012 is birr 9894560 (24.1%).

The SRTC, under the Bureau of Agriculture had installed 1 Indian floating drum model domestic biogas digester before the implementation of NBPE in 2010. Currently this digester is not functional. A total of 211 digesters were installed in the woreda by NBPE since 2010. Up to the end of 2013, therefore, 212 digsters had been disseminated in the woreda.

3.2. Data Collection

In this particular research a combination of tools were employed to get the required data and information.

The main tool of data collection was the interview schedule, which was used to collect data from non-beneficiary households and private sectors. The interview schedules contain mostly close-ended questions, though some open-ended questions were included. To ease communication with rural households and some private sectors, the interview schedule was translated into Amharic, the National official language of Ethiopia. The data collection tool was pre-tested in selected households, microfinance institutions and private sectors prior to the main survey and the pre-test was conducted in kebeles outside the sampling frame.

Questionnaires, both close-ended and open-ended, were another important tool which was administered to collect data from leaders/senior experts of public sector organizations, microfinance institutions and stakeholders.

In addition to interview schedule and questionnaires, focal group discussion was used as data collection tool to meet the opinions, attitudes and perception of well experienced staff of the regional energy bureau or regional biogas program coordination unit.

Moreover, a substantial level of information was obtained from secondary sources, such as unpublished reports, journals, literatures and prior studies on mass dissemination of biogas technology. These were used as a means of triangulating the quantitative findings of the survey and to adopt welcoming experiences outside Ethiopia.

3.3. Research Strategy

The interest of this empirical research is to get an overall understanding of the prospects and challenges of the uptake of domestic biogas digesters in SNNPR. Non-biogas users, private sector, public organizations, administration offices, NGOs and educational institutions are the different actors that could accelerate or retard the mass dissemination of biogas technology. Therefore, identification of research strategy best suited to facilitate a study that aims to get an overall understanding of the prospects and challenges of domestic biogas technology dissemination is necessary.

Empirical research survey method was used as a research strategy. According to Groves et al. (2004), "A survey is a systematic method of gathering information from (a sample of) entities for the purpose of constructing quantitative descriptors of the attributes of the larger population of which the entities are members."

According to the definition, a survey is therefore concerned with systematically gathering information from a sample of entities to produce quantitative descriptors which can be applicable to the larger population of which the entities (samples) are members. A survey approach facilitates the generalization of the result to the whole population through the collection and analysis of data from sample entities which are believed to be representative of the population. However, this is not always true for some applications where there is a need to systematically gather information from all the population, this is called a census. Censuses are systematically efforts to count an entire population, often for purpose of taxation or political representation (Groves et al. 2004).

According to Adams, et al. (2007) survey method involves asking individuals questions face to face, by telephone or via questionnaires of individuals, and departments or companies to find out personal, company or sector information. With the above explanation, Adams et al. (2007) are trying to assert that the principle in survey strategy is to collate answers to a number of questions that can be delivered through different mechanisms (interview, questionnaires, etc) which lends itself to amore quantitative approach in terms of data analysis.

Therefore, the study used descriptive survey design. Survey design was used because of its in depth aspect of collecting personal information that helps in learning people's attitudes, beliefs, values, behavior, opinions, habits and desires. It would also help to cover wide area using representative samples.

3.4. Universe of the study

The Southern Nations, Nationalities and People's Region was the universe of this descriptive research. All woredas of the region were not included in the study, rather only few woredas having biogas digesters and already included in the on-going National Biogas Program of Ethiopia (NBPE) were the focus of this survey. Out of the 20 biogas program woredas included up to December 31st, 2013 in the on-going NBPE, 4 woredas were selected for this study. These woredas were Arba Minch zuria, Meskan, Aleta Wondo and Soddo zuria. In the survey, non beneficiaries of domestic biogas technology, biogas masons and companies, construction materials and appliance suppliers, manufacturers of appliances, partners from public sectors, MFIs, universities and Non Governmental Organizations from the selected four woredas were contacted to collect first hand and second hand information.

The above mentioned four woredas represent four zonal administrations of SNNPR, which consists of fourteen zonal administrations. Accordingly, Arba Minch zuria belongs to Gamo Gofa zone, Meskan woreda is from Gurage zone, the woreda Aleta Wondo belongs to Sidama zone, and Soddo zuria belongs to Woliyta zone. Additionally, financial and time constraints were considered in the selection of the woredas and hence woredas in the range of 300 km from the regional capital city, Hawassa, had been given priority.

3.5. Sampling and Sampling Size

Both probability and non-probability sampling technique were employed in order to get the required reliable data for the survey and to achieve the objectives of the study. Systematic sampling technique was employed from probability sampling and purposive sampling techniques.

The purposive sampling was used to select the woredas which are included in the NBPE of SNNPR. Accordingly, four woredas and their respective capitals and Hawassa city, the capital of SNNPR, which were essential in meeting data related to the prospects and challenges in disseminating domestic biogas technology in SNNPR were selected. Moreover, leaders and senior experts of coordinating and implementing offices (from regional level to woreda level) were included to get their valuable opinion in the dissemination of domestic biogas technology in the region.

The four woredas were selected based on their high potential for dissemination of biogas in mass base and their high relative contribution to the overall plan achievement of the on-going NBPE in SNNPR since 2008. The high technical potential for domestic biogas dissemination of these four woredas were confirmed by a report on feasibility study of a national programme for domestic biogas in Ethiopia, baseline surveys and field level scanning for woreda selection for domestic biogas dissemination. The south NBPE had installed a total of 1724 biogas digesters in twenty woredas as of December, 2013. From the total digesters, the four woredas had a share of 766 digesters. Arba Minch zuria and Meskan woredas have joined the NBPE since 2008 and have shared a total of 467 digesters (Arba Minch zuria woreda contributed 213 digesters and Meskan woreda contributed 254 digesters). Aleta Wondo woreda, which joined the NBPE in November, 2010 has implemented 216 biogas installations. A total of 83 digesters have been installed in Soddo zuria woreda, which joined the NBPE in 2011. Before the launching of the NBPE in Ethiopia particularly in SNNPR, biogas installation was practiced in 48 woredas of the region by the Ministry of Agriculture and Rural Development, the former Rural Energy Development and Promotion Center, and NGOs as a Pilot project and demonstration.

The systematic sampling technique were employed to select the non- beneficiaries of domestic biogas in each of the four woredas and it assured the inclusion of the different perspectives and values reflected by these distinct groups on possessing the biogas technology as a mechanism in improving their livelihood. Selection of non-beneficiary groups through systematic sampling, were not done in all kebeles existing in each of the mentioned four woredas; rather, those kebeles possessing biogas plants up to the end of 2013 were targeted. Moreover, these non-beneficiaries were neighbors of existing biogas users and should meet the critical technical criterion (possession of cattle with sizes of 4 and above and water access in 20 minutes radius) set for biogas users. Accordingly, A/Minch zuria, Meskan, Aleta Wondo and Soddo zuria were represented by 9, 20, 15 and 14 kebeles, respectively.

The sample size of non-beneficiaries per selected woreda was based on the proportion of the biogas plants installed in each woreda until the end of 2013. Moreover, 15 % of the total digesters per woreda was taken as a non-beneficiary household sample because of the homogeneity of the sample; all non-beneficiary households meet the critical technical criterion of biogas digester installation. Accordingly, the non-beneficiaries selected from A/Minch zuria, Meskan, Aleta Wondo and Soddo zuria woreda for the study purpose were 32, 38, 32 and 21, respectively. In all, a total of 123 non-beneficiary households were selected from the selected four woredas for this particular study.

Additionally, purposive sampling technique was used to select key informants to address issues related to government's commitment in supporting the biogas sector, private sector development, financing biogas construction investment and partnership and stakeholder's participation.

A total of 35 organizational leaders/senior experts of different public sector organizations, which were directly or indirectly related with the dissemination of biogas technology, were included purposively in the study. These public organizations were from both regional level and woreda level and they are established to address development issues of energy, agriculture, women and children, health, trade and industry and rural youth employment offices. In addition to these organizations regional administration bureau and the four woreda administration offices were included purposively.

Suppliers of construction materials and biogas appliances, biogas construction enterprises as well as biogas appliance manufacturers were private sectors that were included purposively in this study. A total of 21 key informants representing 10 biogas construction materials and appliances supplying institutions, 6 potential biogas appliance manufacturing enterprises and 5 prospective biogas construction enterprises (BCE) were interviewed purposively. The study included 2 suppliers and 2 manufacturers per woreda. Similarly, 2 suppliers and 2 manufacturers from Hawassa city administration was also included. The BCE composition was 1 BCE per woreda and 1 BCE from Hawassa city.

With respect to financing of the biogas plant construction, 11 key informants from different micro-finance institutions were contacted purposively to collect data related to willingness and experiences in financing the biogas technology dissemination. These informants were included from 5 Omo Microfinance Institutions (regional OMFI office and 4 OMFI branch offices located in the 4 woredas), from 3 Vision Fund (former WISDOM) Microfinance Institutions (3 Vision Fund MFI offices located in the 3 woredas), from Sidama Microfinance Institutions, from Agar and Mekilit Credit and Saving Institution based in Butajera town, capital of Meskan woreda.

Partnership and stakeholder's participation are keys to meet issues related to promotion, capacity building, research and development. Purposive survey was made by involving 12 key informants from selected organizations working on these particular areas. The informants were selected purposively from 5 TVETs based in the capital of the selected woredas and in Hawassa city, 3 universities (Arba Minch University, Woliyta Soddo University and Hawassa University) and 4 NGOs based in the selected woredas and working in development areas directly or indirectly related to the benefits of biogas technology.

Individuals who are knowledgeable and experienced in coordination and implementation of the biogas technology development were also included in this study and 1 focal group discussion (FGD) was conducted. The FGD included a total of 5 individuals currently working in the regional Mines and Energy Agency- Biogas Program Coordination Unit and SNV Ethiopia as coordinator, experts/officers and technical advisor.

3.6. Data Collection: Tools and Procedures

Depending up on the nature of the topic to be researched, different types of data collection tools can be used in social research. In this particular research a combination of tools were employed to get the required data and information.

The main tool of data collection was the interview schedule which was used to collect data from non-beneficiary households and private sectors. The interview schedules were contained mostly close-ended questions, though some open-ended questions was also included. To ease communication with rural households and some private sectors, the interview schedule were translated into Amharic, the National official language of Ethiopia. The data collection tool was be pre-tested in selected households, microfinance institutions and private sectors prior to the main survey and the pre-test shall be conducted in kebeles outside the sampling frame.

Questionnaires, both close-ended and open-ended, were another important tool administered to collect data from leaders/senior experts of public sector organizations, microfinance institutions and stakeholders.

In addition to interview schedule and questionnaires, focal group discussion were used as data collection tool to meet the opinions, attitudes and perception of well experienced staff of the regional energy sector or regional biogas program coordination unit.

Moreover, a substantial level of information was obtained from secondary sources, such as unpublished reports, journals, literatures and prior studies on mass dissemination of biogas technology. These were used as a means of triangulating the quantitative findings of the survey and to adopt welcoming experiences outside Ethiopia.

3.7. Methods of Data Analysis

The data collected using the above mentioned tools were analyzed with the aid of appropriate methods of analysis. The data collected through interview schedules and questionnaires was coded, scrutinized, verified, edited and arranged serially. Then, Statistical Package for Social Sciences (SPSS) shall be employed to present results of the survey.

Besides, the qualitative data gathered via focus group discussion was copied and organized regardless of the basic research questions to discuss in comparison with the quantitative data obtained through the scheduled interviews and questionnaires.

3.8. Quality of Data

The adequacy of tool or technique for collection of data is ordinarily judged in terms of the criteria of reliability (consistency), validity and usability. The criterion of validity demands that measurement be meaningfully related to the research objectives; that is, it should measure what it purposes to measure. According to Adams et al. (2007), validity involves the degree to which you are measuring what you are supposed to, more simply, the accuracy of your measurement. Reliability estimates the consistency of the measurement or more simply, the degree to which an instrument measures the same way each time it is used under the same conditions with the same subjects (Adams et al. 2007). This is to say that a valid research is a research based on tested research strategy and data collection techniques and applying data analysis techniques that are deemed appropriate to the research, which in turn assures the acceptance of the research by the research community. This study is based on a survey research strategy and uses a questionnaire instrument for data collection; it has used a combination of quantitative and qualitative data analysis technique so as to avoid circumnavigating the concept of validity.

Reliability requires the repeated measurements yield results which are identical or fall within narrow and predictable limits of variability. Reliability estimates the consistency of the measurement or more simply, the degree to which an instrument measures the same way each time it is used under the same conditions with the same subjects (Adams et al. 2007). This is to say that reliability is essentially about consistency, when the outcome of the measuring process is replicable the measuring instrument is reliable, which doesn't necessarily imply that the research is valid. Regarding the way to deal with reliability, Yin (2003) provide a sound advice to 'make as many steps operational as possible and to conduct the research as if someone were looking over your shoulder. This simply emphasizes the need for a record of evidence that actually employed in the research. To ensure the reliability of the study, the researcher has provided sufficient information and the final questionnaire by the participating respondents of non-beneficiary households, private sectors, MFIs, public organizations, NGOs and educational institutions in the appendices.

The requirements of usability ensure objectivity in the use of a tool or technique and economy of time and cost in field situations. A good tool and its objective use in the collection of data ensure quality. Accordingly, this research had used a good tool for achieving the objectives of the study.

3.9. Limitations and Potential Problems

During the course of the study the researcher had encountered various challenges and limitations at different stages of the survey. Of the major challenges that had encountered during data collection, the gathering of data concerning the number of biogas digesters installed before the implementation of NBPE in the region in 2008 was the most important. It has been said that biogas digesters were installed in different parts of the region by different governmental and non-governmental organizations as demonstrations and as livelihood improvement mechanism. These digesters, amounting 104, were installed by Bureau of Agriculture, the former Ethiopian Rural Energy Development and Promotion Center and World Vision. The first cause of this problem was that the domestic biogas development and promotion has been run formerly by Bureau of Agriculture and latter by Energy Bureaus and with the change of the responsible government organization some of the documented studies and reports were lost. Secondly, efforts made to disseminate the technology were not integrated and NGOs, like World Vision, had promoted and disseminated the technology without proper consultation with the responsible government organization during that period. Accordingly, there was no single data source for the number of digesters disseminated, the type of the digester model and related matters.

Another challenge that has to be mentioned here is that shortage of finance during the process of data collection. Consequently, data collection from non-beneficiary households, especially from Meskan woreda, had taken more than two months.

Chapter 4 - Research Findings and Discussions

The first section of the findings presents the results of surveyed data concerning the non-beneficiaries of biogas technology and issues like the non-beneficiaries' living conditions , domestic animal sizes, and access of water sources, demand and supply of household energy and their awareness and willingness to invest on biogas technology. Secondly, the survey results of the status of private sectors and microfinance institutions in the biogas sector will be focused. The findings related to participation and contributions of partners and stakeholders in the biogas sector will be discussed thirdly. Lastly, the findings related to the role and commitment of government in the biogas sector will be discussed.

In this study, 123 households, who were neighbors of the beneficiaries of the domestic biogas technology users, were interviewed from four woredas of the region where the NBPE is being under implementation.

A total of 35 organizations were surveyed in order to collect valuable information about the government's commitment towards the biogas sector development. Organizational leaders and senior experts were participated in the survey and all the required data were collected from the selected organizations. These organizations were established to address the development agenda and affairs of administration, agriculture, water and energy, health, environment, women and children, and trade and industry.

The study also focused on the main actors playing as biogas private sectors and interview was made with 12 key informants representing suppliers of construction materials and biogas appliances, manufacturers of biogas appliances and constructors of biogas digesters. These private sectors are based in the selected four woredas' and in Hawassa city, the capital of the region.

In order to dig out the financing matters of bio-digester installation, the study surveyed 12 micro-finance institutions and structured interviews were made with the heads and senior experts of these institutions. From the surveyed five micro-finance institutions, the two microfinance institutions, Omo MFI and Mekilit MFI, are currently serving the biogas users in meeting the financial shortage to install biogas digesters. The Omo MFI operates in all woredas of the region and Mekilit MFI operates in few woredas of the region including one of the surveyed woreda, Meskan.

To find out issues pertaining promotion, capacity building and research and development in the biogas sector, the study surveyed 12 organizations currently engaged in educational and community development activities. Technical, vocational and educational training institutions (TVETs), universities, and non-governmental organizations were included in the survey and key informant interviews were made using structured interview schedules.

4.1. Socio Demographic Characteristics

With regard to socio-demographic characteristics of the respondents, which include household sex, age, household size, and educational level, out of 123 respondents, 109 (88.7%) household heads were male and 14 (11.3%) household heads were female (Table 5.1).

Table 5.1: Selected socio-demographic Characteristics of Respondents

Characteristics	Frequencies (N= 123)	Percent
Sex		
Male	109	88.7
Female	14	11.3
Age		
21-35	20	16.3
36-50	72	58.5
51-64	15	12.2
Greater than 64	16	13
Household size		
1-3	7	5.7
4-7	110	89.4
8-11	6	4.9
Above 11	0	0
Educational level		
Illiterate	35	28.5
Primary (1-6)	43	34.9
Junior secondary (7-8)	28	22.8
Secondary (9-12)	15	12.2
College diploma	2	1.6
Average HH size	5.2	

With regard to age of the respondents, majority of them, 91 % were between 21 to 64 years of age. On the other hand, respondents under the possible dependent ages were 9 %.

Concerning educational level of surveyed households, 28 % of them had never attended school, 35 % had completed primary school, 35 % attended high school and only 1.6 % of the respondents completed college diploma.

Among the responding households, 89% were found to have family size in the range of 4 to 7 members, 5% of the households had larger family size, which was between 8-11 members, and 6 % of the households had a family size of between 1-3 members. Thus, the average family size in the study area was 5.2 persons per household, which is slightly above the average of the region in 2012, i.e., 4.9 persons per household.

4.2. Living conditions and status of the households

4.2.1. Major Income Sources and Land Possession

When a look at the major income sources of the family is taken, all the surveyed households, i.e., 100%, were engaged in crop productions and animal husbandry. Moreover, 10% of the respondents run economic activities focused on income generating means, which are essential in supplementing earnings from crop productions and animal husbandry. Cereals (grains) constitute the main products of the surveyed households, with a share of 27.7 %. In addition, , production of other annual and perennial crops such as 'enset'[3] (19.5 %), vegetables and root crops (15.5 %), fruits (14.6%), coffee (13.8 %) and 'chat'[4] (8.9 %) appear to be important source of livelihood for the remaining sample households (43%) (Table 5.2).

[3]*'Enset' also called false banana, is a perennial crop in which its root is consumed as an important food and grows in south part of Ethiopia.*

[4]*'Chat' is a type of crop in which its leaves is chewed as stimulant and grows in most part of the country.*

Table 5.2: Living conditions of the households

Characteristics	Frequencies (N= 123)	Percent
Major income sources		
Crop and animal husbandry	113	91.9
Crop, animal and other income generating activities	10	8.1
Land belongingness		
Family	108	87.8
Rent	7	5.7
Family and rent	8	6.5
Land size		
Less than 0.25 hectare	13	10.6
0.25-0.5 hectare	48	39
0.6-0.75 hectare	16	13
0.76-1 hectare	19	15.4
Above 1 hectare	27	22
Type of productions		
Grain	34	27.7
Fruits	18	14.6
Coffee	17	13.8
Vegetables and root crops	19	15.5
'Chat'	11	8.9
'Enset'	24	19.5
Purpose of production		
Domestic consumption	23	18.7
For market	3	2.4
For domestic consumption and for market	97	78.9

Regarding the land issues, land ownership and land size are the major points to be focused. Accordingly, 87.8 % of the surveyed households have their own land, 6.5 % respondents cultivate their own land and land obtained in rent, and the remaining 5.7% of the households cultivate rented land. Concerning the land size, it is categorized in five ranges; less than 0.25 hectare, 0.25 - 0.5 hectare, 0.6 - 0.75 hectare, 0.76 – 1 hectare and above 1 hectare. Majority of the surveyed households possess land holdings in between 0.25 hectare and 0.5 hectare, i.e., 39 %, followed by 22 % of the households possessing land holdings above 1 hectare. Among the respondents, 15 % had land size between 0.76 and 1 hectare, 13 % owned between 0.6 and 0.75 hectare and 11 % of respondents possess landholdings with less than 0.25 hectare.

The survey also sought to capture the end use of agricultural produce. The results had shown that market oriented agricultural production through surplus production of staple crops over and above subsistence requirements, and the production of cash crops, such as fruits, coffee and 'chat' are a common practice among the sample households. Households (81.3 %) in the sampled weredas had obtained cash income from selling of crops, mainly grains, fruits, coffee and 'chat', which could possibly motivate farmers to cover the digester installation cost from their own pocket.

4.2.2. Status of the household

As part of the overall livelihood assessment, the survey also sought to capture characteristics of residences and their asset possession. The majority (58.5%) of residential housing units covered under the survey were houses with three rooms. Whereas, 24 % and 18 % of the respondents possess more than 3 and 2 dwelling rooms, respectively.

Table 5.3: Household's Status

Characteristics	Frequency (N=123)	Percent
Floor construction		
Mud and cow dung	65	52.8
Stone and cement	24	19.5
Bamboo tree	34	27.6
Wall construction		
Wood and mud	123	100
Blocks and cement	0	0
Roof construction		
Thatched roof	9	7.3
Corrugated sheet	114	92.7
Number of rooms		
Two	22	17.9
Three	72	58.5
More than three	29	23.6
Asset in the household		
Tape recorder/Radio	66	53.7
Television	24	19.5
Bicycle	26	21.1
Motorcycle	4	3.3
No asset	3	2.4

The majority of the surveyed households used locally available construction materials (wood, bamboo tree and mud/dung) especially for the construction of walls and floors. All room walls of the surveyed households were constructed by using wood and mud and only

19 % of the floors of the households were constructed by using concrete. For majority of the surveyed households the roof was constructed by using corrugated sheet, which takes a share of 93 %.

For the purpose of the present study, household assets refer to radio and television, as well as to farm transportation.

Accordingly, radio was available in more than 50 % of the sample households, which is less common than the situation in rural SNNPR where some 66% of households are reported as owning radio (CSA, 2007). Possession of bicycle for transportation purpose is also common in the sample households and it represents about 19 % of the total surveyed area (Table 5.3).

4.3. Livestock Ownership and Manure Management

4.3.1. Livestock Ownership

The size of livestock population in general and cattle population in particular is one of the most important factors that determine the availability of sufficient dung for the successful operation of biogas plants. Accordingly, the prevailing situation with regard to household ownership of livestock was assessed in terms of both number and type of animals owned by household in the sample.

All households in the sample invariably own more than one livestock asset. In terms of size and type of livestock population in the sample households, cattle constitute the predominant share in the household assets, followed by sheep owned by all households, and then donkeys (Table 5.4).

Table 5.4: Livestock Ownership of the Surveyed HHs

Characteristics	**Frequency (N=123)**	**Percent**
Type of animals		
Cattle	52	42.3
Cattle and sheep	25	20.3
Cattle and horse	6	4.9
Cattle and donkey	15	12.2
Cattle, sheep and goat	14	11.4
Cattle, sheep and donkey	6	4.9
Cattle, goat and donkey	2	1.6
Cattle, horse and donkey	3	2.4
Local breed cattle (number)		
One	5	4.1
Two	4	3.3
Three	8	6.5
Four	58	47.2
Above four	48	39.0
Hybrid cattle (number)		
None	101	82.1
One	8	6.5
Two	10	8.1
Three	3	2.4
Above three	1	0.8
Exotic cattle (number)		

None	117	95.1
One	2	1.6
Two	3	2.4
Three	1	0.8
All types of cattle		
Four	61	49.6
Five to eight	60	48.8
Above eight	2	1.6

The number, age and breed of cattle owned per household is the most important factor in determining the availability of dung required for the daily operation and dissemination of domestic biogas plants in the region. It is worth to remember that this survey focuses on households fulfilling the minimum requirement of cattle size, i.e., four local breed. In this study, therefore, the survey was made to assess the mix of the cattle bread owned by the sample households.

The cattle breeds were categorized as local breed, hybrid breed and exotic breed. All the surveyed households had at least four cattle (50 %), either local, hybrid or exotic breeds, which is more or less corresponds to figures for rural SNNPR (4-5) (Eshete G. et al, 2006). All households own local breed, whereas the hybrid and exotic breeds are owned by few households, 18 % and 5 %, respectively. The maximum number of the hybrid breeds or exotic breeds per household is only three.

Considering the fact that about 50 % of the households own four cattle, the result corresponds to the pattern of cattle ownership in SNNPR, where out of 3.6 million cattle holding households, 78% were reportedly keeping 4 or more cattle (Eshete G. et al, 2006).

Most importantly, it suggests that the region has huge potential for mass dissemination of domestic biogas technology and it could be taken as an indicator for a first estimate of the potential for biogas technology adoption.

4.3.2. Available Dung & Manure Management Practices

The most important factor in daily biogas operation is the availability of sufficient dung.

One of the critical indicators for promoting the viability and the uptake of biogas digesters among the target households is the quantity of dung available per day. According to Eshete G. and Kidane W. 2008, under the current holding regime, sedentary rural households would need at least 4 cattle stabled during the night to get the minimum 20 kg of fresh animal dung per plant per day required to produce enough gas for cooking or lighting. In view of this, the survey attempted to understand the prevailing practices among the sample households pertaining to the amount collected by source and frequency with which dung is collected as reported by the households interviewed themselves (refer to table 5.4).

The majority of the women (83%), including daughters, take the responsibility of dung collection and disposing although men and servants are to a certain extent involved. In addition to this, the survey findings show that nearly 81 % of the households collect dung every day.

In the survey woredas, either local baskets or discarded 20 litre jerry cans are used to transport dung to pits or other collection points, and majority of the surveyed households, nearly 63 %, collect 20 - 40 Kg dung per day. Moreover, random measures were taken during the survey and the net average weight of one oil jerrycan or one basket-full of dung was estimated at about 20 Kg. Based on this conversion factor and dung collection frequency, the survey data on the average amount of dung collected/day/HH indicates that each household in the sample collects more than 20 kg of dung every day.

According to the survey result, about 70 % of the households use the collected dung to fertilize their crop land, nearly 7 % use it for making dung cake and the remaining households (18%) use it for both purposes. Dung is more commonly used as crop fertilizer than for making dung cakes (Table 5.5).

Drawing on both the quantity produced and the various end-use of dung, it appears that households in the survey weredas may be able to meet the requirements set for biogas digester installations. As emphasized by Eshete G. and Kidane W. (2008), the amount of dung that can be obtained in stables per head of cattle per day is likely to be in the range of 5 to 8 kg as most of the livestock roaming around on common grazing lands during the day. Hence, a family would need the manure of at least four heads of cattle. As indicated in table 5.4, since the households in the sample on the average own 4 or more cattle, the requirement for 5 to 8 kgs of dung per cattle, and hence a minimum of 20 kgs of dung per cattle is more likely.

Composting practice is very rare when consideration about manure disposal is taken into account. This is evident from the finding of the survey in table 5.5; only 9 % of the surveyed households collect the dung in excavated pit and majority of the households (82 %) collect the dung in the surface ground or piling dung in own household premises and then to be used as manure/farm land fertilizer.

Table 5.5: Manure Management and Responsibility

Characteristics	Frequency (N=123)	Percent
Dung collection responsibility		
Head of the household	12	9.7
Spouse	87	70.7
Daughter	15	12.2
Son	4	3.3
Other HH members/servants	5	4.1
Dung collection trend		
Everyday	99	80.5
Once per two days	8	6.5
Once per three days	7	5.7
Sometimes	9	7.3
Collected dung amount		
20-40 Kg	77	62.6
40-60 Kg	23	18.7
Greater than 60 Kg	23	18.7
Disposal method		
In pit	12	9.8
On surface ground	101	82.1
Throwing into open land	10	8.1
Purpose of collected dung		
Fertilizer	86	69.9
To prepare dung cake	22	17.9
Fertilizer and dung cake	9	7.3
None /missing	6	4.9

4.4. Water Sources and Access

Because of its importance in giving not only a picture of human wellbeing in terms of health and sanitation but also a basis to determine the potential for mass dissemination of biogas plants in the region, information on the situation in the region pertaining to water supply is critically important. This section presents the survey results on the situation prevailing among the sample households with regard to water supply for human and animal consumption including sources, sufficiency and travel distances involved.

4.4.1. Water supply sources

According to the survey data, the entire households had access to water sources either for domestic purposes or domestic animals. From the multiple responses of the surveyed households, it is possible to understand that the majority of the households (97 %) have alternatives to access water from different sources. The findings from the survey appear to be more or less similar with the reports of MoFED in 2008. The increase in the number of people who have access to potable water is reflecting that for the country as a whole, a very remarkable progress has been made in safe rural water supply coverage between 2000 and 2005/06 (MoFED, 2008; McKee, J., 2007; Leo B. & Barmeir J., 2010).

4.4.2. Water fetching frequency and quantity of water consumed

Except for small fraction of the surveyed households using own tap as the main source of water, the most common practice among the households is to fetch water from sources located outside own homestead premises. Household heads were, therefore, asked to estimate the frequency with which they or own household members fetch water in a week. Among the households surveyed, 96% fetch water everyday of the week while the remaining households (4%) fetch water once, twice or thrice a week. The development of water infrastructure in the region also assures this reality. According to SNNPR WB, 2013, the regional water coverage has increased from its 44.29 % in 2011 to 61% in 2014.

From the point of water requirement for daily biogas digester operation, the amount of water needed for mixing dung has to meet the requirement. According to Eshete G. andKidane W., 2008, the mixing ratio of dung to water should be one-to-one, i.e., 20 Kg of dung would need 20 litres of water. The findings of the survey in Table 5.4 show that majority of the households (96%) fetch water every day with sufficient amount and they would hardly face shortage of water for daily mixing of dung. Moreover, 42 % of the surveyed households had access to river and irrigation canal water sources in addition to other water sources, and these sources could highly supplement the availability of water for domestic animals and dung mixing.

4.4.3. Distance travelled in fetching water

One of the critical factors for the success of biogas digester dissemination is the proximity of households to water sources. As pointed out by Eshete G. and Kidane W. 2008, fetching water required to mix with the daily input of 20 kg fresh dung in a 1:1 ratio should not take more than 20 to 30 minutes. In view of this, distances that household members travel for fetching water was one of the key areas of inquiry in the survey and 97 % of the sample households fetch water from water sources in 15 minutes radius for the required purposes.

`**Table 5.6:** Water Sources and Supply of the Respondent HHs

Characteristics	Frequency (N=123)	Percent
Availability of water sources in nearby		
Yes	123	100
No	0	0
Type of water sources		
River sources	70	29.9
Spring piped water sources	28	12.0
Communal piped water sources	47	20.1
Private piped water sources	17	7.3
Rope pump water sources	35	14.9
Hand dug well water sources	9	3.8
Irrigation canal water sources	28	12.0
Fetching frequency in a week		
Once	1	0.8
Twice	2	1.6
Three times	2	1.6
Everyday	118	95.9
Distance of water sources		
Within 15 minutes radius	119	96.7
Out of 15 minutes radius	4	3.3

4.5. Demand and Supply of Household Energy

The use of biomass fuels as a source of domestic energy in the region will be focused in this section. It covers the major aspects of biomass demand and supply dimensions including types, amounts, sources, consumption patterns and prices of biomass fuels.

Considering the different sources and uses of domestic energy and based on the frequency with which these were mentioned by households in the sample (Table 4.4a), it is clearly apparent that HHs use a mix of several energy sources including various kinds of biomass, kerosene and electricity.

In this particular study, a survey was made to assess the type of biomass energy used for cooking and heating, as well as the type of energy used for lighting. Accordingly, the multiple responses presented in table 5.7 shows that about 94 % of the surveyed households use a mix of biomass energy and 100 % of the households use fuel wood for cooking and heating purposes. Following fuel wood, BLT (94 %) is mostly used by surveyed households. Minority of the surveyed households use charcoal (31 %) and dung cake (24 %) to meet energy for cooking and boiling. In summary, the biomass energy sources, fuel wood, BLTs, charcoal and dung cake, are represented by a share of 40.2 %, 37.9 %, 12.4 % and 9.5%, respectively.

Regarding energy for lighting, the majority of the respondents (61%) use gasoline. Among the surveyed households, 56% use electricity and the remaining 6 % use both gasoline and electrical energy for lighting their home at night.

4.5.1. Supply patterns and Time Spent in collecting biomass fuels

It has been indicated that traditional fuels provide 99.8 % of the total (rural and urban) region's domestic energy supply, with 88% derived from woody biomass, 10% from crop residue, 1% from dung and 0.1% from charcoal. Accordingly, special focus was given to the supply of fuel wood in this research and the following survey results were obtained from the sample households. Information about the supply dimension of fuel wood in the surveyed weredas was captured through the survey of prevailing practices among the sample households in fuel wood acquisition for own household energy including supply sources and time spent in collection.

With regard to mode of fuel wood acquisition, the survey data presented in table 5.7 indicates that generally, households obtain fuel wood through a combination of two approaches, such as collecting from the field and purchasing for own household consumption. However, collecting fuel wood for free is the most common practice among the surveyed households. Among the respondents, 39 % had obtained fuel wood by collecting from distant communal forests and 57 % of the households obtain by both methods, collection and purchasing. The minority of the surveyed households (7 %) had met their fuel wood demand only by purchasing.

In relation to responsibility of fuel wood collection, mainly the female members of the households (70.7%) are responsible for fuel wood collection. A study conducted by Birhane et al., 2005, supports the findings of the survey. According to their study, on average women work 13 hours a day and this workload is exacerbated by the scarcity of fuel wood. Girls are often taken out of school to assist their mothers in collecting firewood.

Respondents were asked to make estimation of amount of time spent in collecting fuel wood. The findings of the study had shown that 21 % of the surveyed household members spend more than 2 hours per week in collecting fuel wood. Moreover, about 6 % of the respondents cover distances with more than 4 Kms per week to collect and supply fuel wood (Table 5.7).

4.5.2. Cost of purchased fuel wood

Consumption of purchased fuel wood is a common practice among some households in the sample, although a great majority of households, as shown in table 5.7, obtain fuel wood through collection. According to the 2010 baseline survey of NBPE made by Becad consulting in A/Minch zuria woreda, wood and BLT take the lion's share in total expenditure on purchased biomass fuels. The major findings of the survey regarding weekly household cash outlay are that majority of the surveyed households, about 19 % surveyed households (35% of fuel wood purchasing households), spend ETB 30 to 40 per week for purchasing fuel wood. Additionally, as expressed by about 59 % of the surveyed households (96 % of fuel wood purchasing households), the fuel wood price appears to be on the rise even when compared to last year's fuel wood price.

Table 5.7: Demand and Supply of Household Energy

Characteristics	Frequency (N=123)	Percent
Biomass energy used for cooking and heating		
Fuel wood only	7	5.7
Fuel wood and BLTs	59	48.0
Fuel wood, BLTs and dung cake	19	15.4
Fuel wood, BLTs and charcoal	28	22.8
Fuel wood, BLTs, dung cake and charcoal	10	8.1
Energy used for lighting		
Gasoline	61	49.6
Electricity	56	45.5
Gasoline & Electricity	6	4.9
Supply pattern of fuel wood		
Collecting	48	39.0
Purchasing	9	7.3
Collecting and purchasing	66	53.7
Fuel wood collection responsibility		
Head of the household	13	10.6
Spouse	71	57.7
Daughter	16	13.0
Son	10	8.1
Other HH members/servants	4	3.3
Missing /those who purchase	9	7.3
Time spent for collecting fuel wood		

0.5 hour	33	26.8
1 hour	40	32.5
1.5 hour	11	8.9
2 hour	4	3.3
More than 2 hour	26	21.1
Missing /who doesn’t collect/	9	7.3
Distance covered to collect fuel wood		
Less than 1 Km	49	39.8
1 to 2 Km	34	27.6
2 to 3 Km	16	13.0
3 to 4 Km	7	5.7
More than 4 Km	6	6.5
Missing /who doesn’t collect/	9	7.3
Money spent to purchase fuel wood per week /ETB/		
10 to 20	21	17.1
20 to 30	22	17.9
30 to 40	23	18.7
More than 40	9	7.3
Missing /who doesn’t purchase/	48	39
Fuel wood price when compared to last year’s price		
Increased	72	58.5
Decreased	0	0
No price difference	3	2.4
Missing /who doesn’t purchase/	48	39

The above findings are also strengthened by findings of World LP Gas Association (2004). According to the findings of World LP Gas Association, existing expenditures by poor people on inefficient and low-quality energy sources are surprisingly high, both in terms of cost and time. Many poor people spend an inordinate amount of time foraging for traditional cooking fuels (fuel wood, charcoal, animal dung, agricultural residues) that could otherwise be spent more productively. Most estimates suggest that families in rural areas of developing countries spend on average approximately $10 per month on poor quality and unreliable energy services. This represents a significant percentage of their income. For example, among the rural poor with incomes of $10–$20 per month, expenditures on inefficient energy can represent 20 - 25 percent of household incomes, which underscores the ability of energy consumers, even if poor, to pay for modern energy services.

4.6. Biogas Technology: Awareness and Willingness to Invest

Issues pertaining to surveyed households' awareness and their willingness to invest on digester construction are the main focuses to be analysed and discussed.

Respondents of the survey households were asked whether they are aware of biogas as a source of household energy or not. As mentioned in table 5.8, 100 % of the surveyed households have prior information about the biogas technology and its benefits.

Slightly more than half of the households (58%) heard about biogas plant from members of their neighbourhood, while the source of information for the remaining households was biogas masons, mass media, kebele extension agents, and woreda agriculture/energy experts; 17 %, 13%, 6 % and 5 %, respectively. More than 80 % of the surveyed households were frequently mentioned the expected and commonly known end uses of biogas technology.

Table 5.8: Respondents' Awareness and Investment Willingness on Biogas Technology

Characteristics	**Frequencies (N= 123)**	**Percent**
Information about benefits of biogas energy		
Yes	123	100
No	0	0
Information source		
Beneficiary neighbor	101	58.0
Biogas mason	30	17.2
Kebele extension worker	11	6.3
Mass media /radio and television/	23	13.2
Woreda agriculture/energy officers	9	5.2
Benefits heard from the information source		
Lighting service	120	28.3
Cooking services	116	27.4
Fertilization	109	25.7
Prevents health problems	40	9.4
Reduces time wastage for fuel wood collection	39	9.2
Interest to get the benefits		
Yes	108	87.8
No	15	12.2
Reason(s) not interested in biogas energy		
Prefer other renewable energy sources /like solar/ than biogas	5	4.1
On grid electricity will reach the village soon	4	3.3
The cost of biogas installation is very high	3	2.4
Daily operation needs labour/supporter /labour intensive/	3	2.4
Missing /who are interested in biogas technology/	108	87.8

Interested but problem		
High installation cost	78	55.7
Protest from family members	16	11.4
Lack of information about the procedures	9	6.4
Other plan currently	9	6.4
No accessible road to supply construction materials	3	2.2
Neighbor's digester is defunct	4	2.9
No helper/labour for daily operation/feeding	6	4.3
Missing /not interested/	15	10.7
Installation's high cost is informed by		
Beneficiary neighbor	68	55.2
Kebele extension workers	4	3.3
Biogas mason	4	3.3
Woreda energy officers	2	1.6
Missing /not interested and others/	45	36.6
Installation cost based on the information source /ETB/		
Up to 13,000	51	41.5
Between 13,000 and 15,000	10	8.1
More than 15,000	17	13.8
Missing /not interested and others/	45	36.6

These benefits include lighting (28%), cooking (27%) and farmland fertilizations (26%). According to table 5.8, minority of the surveyed households had also mentioned other indirect benefits obtained from biogas digester installation. Reduction of time wastage (9%), especially by women and children, during biomass fuel collection and prevention of health problems (9%) occurred by indoor pollution were among the indirect benefits mentioned by the surveyed households.

The qualitative findings from FGD are more or less consistent with much of the quantitative data presented above, as can be noted from the remarks of one of the participants from staff of the regional biogas program coordination unit/RBPCU/,

"Promotion of biogas technology via various promotional tools like mass media, brochures and poster, were made so that awareness about the benefits of biogas technology have been raising especially in woredas where the NBPE is under implementation. In these woredas, all households have known at least one of the long term benefits of the technology."

Table 5.8 also presents the willingness and capacity of households to invest in biogas digester installations. About 88 % of the respondents were willing to own the benefits produced by biogas technology. As reported by these households, however, some bottlenecks have pushed them away from the acquisition of the benefits through the technology. Among the mentioned bottlenecks, more than half of the surveyed households (56%) reported that the cost required for biogas installation is very high. In addition to the issue of installation cost, there are other issues to be given due attention as they have also badly contributed to the mass adoption of the technology. These include protest from family members in owning biogas technology (11.4%), lack of information about the procedures and who to contact (6.4%), possession of other plans by the family to be executed (6.4%), lack of helper/labour for daily operation/feeding (4.3%), non functionality of neighbor digester (2.9%) and lack of accessible road to supply construction materials (2.2%) (Table 5.8).

The majority of the surveyed households (55%) also reported that their neighbours are the most important source of information about the need for high investment cost. Of the total surveyed households (56%) who have heard of the need for high investment cost for biogas digester construction, 65 % have heard that overall installation cost is up to ETB 13,000 (the current actual price). Installation cost of ETB between 13,000 and 15,000 was told to 13 % of the surveyed household and the remaining 22 % have heard that the installation cost is more than ETB 15,000. The survey findings reveal that significant numbers of households (22%) were get wrong and exaggerated information about investment cost, more than ETB 15,000.

Regarding those who were not willing to invest in biogas technology; accounting 12% of all surveyed households, the need for other renewable energy technologies (33.3 %), like solar technology, and extension of on grid electrification to their villages (26.67%) were the major reasons for being they were not interested in biogas technology as a source of energy and other benefits (Table 5.8).

According to the above table (table 5.8), 56 % of the surveyed households expressed that the need for high investment cost pushed them away from the benefits of the technology though they have keen interest in owning the technology. Table 5.9 show that of the 56 % surveyed households, 86% had heard about the arrangement of credit facility to cover the construction investment. Even though 86 % of the households have heard about the credit facility, insufficiency of the current availed loan amount (45%), high interest rate (25 %), indebtedness of the surveyed households (12%), banning of receiving and paying of credit interest by Islamic religion (9%) and shortage of sufficient income by the households to repay the credit (9 %) were the major bottlenecks for the households to not install domestic biogas digester as a renewable energy source and other benefits.

Table 5.9: Households' Awareness and Attitude about Biogas Credit Facility

Characteristics	Frequencies (N= 123)	Percent
Information about credit facility		
Yes	67	54.5
No	11	8.9
Missing / who have no information, not interested and others/	45	36.6
Reason(s) for not installing though credit is available		
The availed credit amount is not enough to complete construction	30	24.4
The credit interest rate is very high	17	13.8
Indebted so far from MFI	8	6.5
Shortage of income source to repay	6	4.9
Forbidden by religion to collect or pay interest	6	4.9
Missing / who have no information, not interested, no information about credit and others/	56	45.5

4.7. Private Sectors and Microfinance Institutions

In order to assess the participation, contribution and status of private sectors in mass dissemination of biogas technology, relevant questions have been developed and interviews were made with construction materials and biogas appliance suppliers, appliance manufacturers and biogas digester constructors. In addition to private sector's role in the biogas sector, assessment concerning the participation and status of micro finance institutions were made and key informant interviews were made with heads and senior experts of different microfinance institutions.

4.7.1. Private Sector and Bio-Digester Dissemination

In this survey interviews were conducted with ten construction materials and biogas appliances suppliers. Regardless of suppliers' awareness about the biogas technology and its development in their area, 100 % of the surveyed building materials and biogas appliance shops have prior information about the development of biogas technology in their woredas. Among these, 90 % of the surveyed shops supply construction materials including iron bars, gas pipes (GI or PPR), PVC pipes, emulsion paints and binding wires. However, there is limited supply of biogas appliances including biogas stoves, biogas lamp and its accessories, dome pipes, dung mixers, water drains, gate valves, etc. Regionally, three shops have had the experience of supplying biogas appliances, of which only one shop supplies biogas appliances currently. In this survey the owners of the supplying shops were asked about the reasons for limited supply of biogas appliances, and the findings of the survey reveal that 60 % of the surveyed shops do not know the addresses of the locally manufactured appliances' (like biogas stoves) producers and the sole distributor, located in Addis Ababa, of the imported biogas appliances (lamp set and its accessories). Of the surveyed shops, 40 % knew where to supply the appliances but they claimed that there is no sufficient demand for these appliances as the NBPE supplies most of the appliances.

Concerning manufacturing of locally produced biogas appliances, six manufacturers located in Hawassa, the capital of the region, and in the four woredas' capitals were interviewed. Four out of six manufacturers have had the experience of producing some of the locally manufactured biogas appliances, especially dome pipes. However, biogas stoves have been produced only by Selam Business Group, located in Hawassa. The main reasons, as emphasized by the respondents, for production of few types of appliances were because of lacking technical knowledge and skill by the manufacturers, as well as, limited demand for the appliances. Additionally, three of the manufacturers have stopped production of the appliances because of lack of demands for mass production of appliances. According to two metal workshops, they are not manufacturing biogas appliances as their organizations had not received any technical training on productions of appliances, and the production design had not been availed by any responsible body. In relation to technical training on biogas appliances productions, only one representative from Selam Business Group got the formal training, which was organized by SNV, the Netherlands Development Organization.

It is known that many actors took part in the biogas sector as private enterprise. Of the private enterprises,, biogas constructing masons/companies were the driving force for mass adoption of domestic biogas digesters. Accordingly, representatives of five prospective biogas construction enterprises /BCE/ were interviewed in order to gather data on different issues related to their status and roles in the sector. When the gender issue is taken into consideration, none of the surveyed BCEs had women members, either as a head or as a ordinary member. Regarding their technical knowledge about biogas technology, masons of all of the surveyed BCEs had got 15 days biogas construction theoretical and practical training in different periods organized by regional MEA and SNV.

These five BCEs have got biogas construction consent and license from responsible government organization, woreda Trade and Industry Office, in order to run their biogas construction business as a legal entity. According to SNNPRS Trade and Industry Bureau, the guideline has no article emphasizing licensing for biogas plant construction but the BCEs/masons are getting biogas digester construction license under the category of simply construction. The number of biogas digesters constructed by these BCEs ranges from 30 to 100 digesters since 2009, and 2 BCEs, out of 5 BCEs, ran their business not only in their resident woreda but also in other woredas as well. These BCEs do not have working offices, which could help them in registering new demands and in running other important activities. The demand collection is made in three ways; users come to the masons and make agreements, persuasion of the potential users by the mason and the woreda energy experts and the kebele agriculture extension workers persuade potential users and bring them to the BCE to make an agreement.

Except for one of the BCEs, that constructed 100 digesters since 2009, biogas construction is not a full time business; rather the masons under the BCEs participate in other economic activities, other construction and agricultural activities, to supplement their livelihood. During active biogas digester construction period, all of the surveyed BCEs hire 1 to 3 additional support masons and 2 to 8 daily labourers to run the construction business. Concerning the construction contract, all the representatives of surveyed BCEs said that they did not have the experience of taking the overall construction contract, which include not only the biogas construction but also the materials supply. Constraints for being involved only in construction contract were shortage of finance (4 BCEs), lack of business skill (3 BCEs) and the attitude that my BCE's responsibility is only to construct biogas digesters (2 BCEs). In relation to shortage of finance, 4 out of 5 BCEs knew that their financial problems could be solved by the credit availed by micro-finance institutions. However, fear of credit interest rates (2 BCEs), lack of knowledge about the procedures (2 BCEs) and how to process and lack of requested collaterals to access credit (1 BCE) were some of the reasons. Regarding BCEs' training, all of the surveyed BCEs got training on business skill development, which was organized by the regional MEA, regional Trade and Industry Bureau and SNV. According to the respondents, though the training conducted so far was very essential in filling their gap in relation to business skill, there should be regular and continuous support to lift them to the required capacity.

The quantitative data presented above also supported by the qualitative findings from FGD. One of the participants of the FGD remarked the following.

"The role of private sector in periods before NBPE was different from the current situation. Formerly, the construction of biogas digester had been performed by the government's expert, hired masons and daily labourers, who were only active till the completion of the construction. However, the private sector has taken most of the government's role currently. Since the implementation of NBPE, there is gradual improvement in the involvement of the private sector, especially BCEs/masons. From the active involvement of the biogas sector, they had benefited from the business earnings) and had created job opportunity for others. Some BCEs have improved their livelihoods and their families, some built their houses with improved construction materials (stone and cement) and some had hired support masons and

labourers in permanent basis. Even if their role has increased gradually in the biogas sector, their participation was mostly in construction and they had contributed little in manufacturing and supplying construction materials and biogas appliances."

In general, the role played by the private sector looks like what was reported in the 2013 annual plan of the MEA/RBPCU. According to the MEA/RBPCU (2013), private sector has not played its intended role in participation of the comprehensive biogas program activities though the role played by the private sector was identified as a driving force for mass dissemination of biogas technology.

4.7.2. Microfinance Institutions and Bio-digester Dissemination

Of the five micro finance institutions operating in the region, currently only two MFIs are giving credit service to biogas users. These two MFIs are OMO MFI and Mekilt MFI, in which the first is operating in all woredas of the region whereas the second is only operating in few woredas of the region. Accordingly 12 key informant interviews were conducted via structured relevant questions to heads and senior experts of the five MFIs institutions and their branches.

When the lending methodologies being used are taken into considerations, all of the surveyed MFIs exercise both, group lending and individual lending. Except for Vision Fund (former Wisidom) MFI and its branches, all categories of clients had been served by MFIs. These categories include clients from urban, semi-urban, rural and micro enterprises. Regarding the interest rate charged, all of the surveyed MFIs charge different interest rate based on the purpose of the credit being borrowed and the source of the credit. Importantly, the interest rate for agricultural activities credit (18 %) is higher than other income generating activities

(15%-16%), as emphasized by Sidama and Agar MFIs. According to representative of regional Omo MFI, the interest rate was lower than the normal operation if the loan source is governmental or non-governmental organizations injecting loan to special programmes; 10 % flat interest rate for injected loan and 15 % flat interest rate for normal operation.

Willingness and experiences regarding loan to biogas users were also focused during interviewing the key informants. As discussed above, Omo and Mekilit MFIs were the only credit providers to biogas users and Mekilt currently operates in only one biogas program woreda (Meskan) whereas Omo operates in all of the surveyed four woredas. Biogas loan was in operation since 2010 by Omo MFI and since 2011 by Mekilit MFI and the initiative was made by the collaborative effort of regional MEA and SNV in both cases. Concerning loan ceiling size, Omo MFI applies ETB 6,000 and Mekilit applies ETB 7,000 for biogas clients.

Both MFIs were asked about whether they had faced shortage of loan to biogas users during their operations and the finding was that this situation is only common in the case of Omo MFI. Representatives of Omo MFI and its branches had stated that their institutions sometimes face loan shortage when the net mobilized saving declines because of low repayment status and other reasons. According to loan disbursement and repayment report of OMFI, the loan repayment status for biogas clients was only about 29% as of June, 2014. Though various reasons are responsible to the poor repayment status, as added by the representative of OMFI head office, the users' wrong attitude concerning loan and non-functionality of bio-digesters are recognized as the major causes of the problem.

Another important point raised was the way in which service is delivered to clients. Mekilt and other MFIs render all the service to its clients using woreda based field officers, whereas, Omo MFI and its branches render all the services to its clients via woreda based field officers and kebele level agents. Except one service, loan disbursement to biogas users, all the services rendered at woreda level was also rendered at kebele level for OMFI's clients. These services include awareness creation on credit saving and repayment, organizing beneficiaries into groups and repayment collection.

It has been said that three MFIs, namely, Vision Fund (former Wisdom), Sidama and Agar MFIs, and their branches were not participating in facilitating loan to biogas clients. The findings of the survey have confirmed that these three MFIs have prior information about biogas loan, which is availed to clients by Omo and Mekilt MFIs. Though these organizations have heard of the extension of credit service to biogas users, financing of biogas technology is hardly considered in their future plan (portfolio) unless the challenges facing their institutions are solved. Shortage of the required capacities in terms of human and financial resources and limited support from woreda administration in creating awareness during credit repayment are the commonly mentioned challenges that these institutions were fear of.

The findings of the qualitative tool, FGD, also supplements what is really there in the ground. As emphasized by one of the participants,

"Biogas loan is crucial for the success of biogas digester installation and it takes the lion share of relative success since the implementation of NBPE. However, there are two bottlenecks that have inhibited the contribution of biogas loan for mass dissemination. The first is that the existing service delivered by Omo and Mekilit MFIs is very bureaucratic and secondly, there are no alternative sources of loan from various MFIs for biogas users."

4.8. Commitment of Government (GoE)

One of the success factors in domestic biogas adoption is governments' commitment in designing and implementing programs and strategies that suits its own country context. Taking this into consideration, thirty five government organizational leaders/senior experts representing different sectors of development were interviewed so as to assess their roles and contributions towards mass adoption of biogas technology. The regional, zonal and woreda administrative structures were represented by seven, four and twenty four (six per woreda) public organizations, respectively. Nine organizations, one regional MEA, four zonal Water, Mines and Energy Departments and four Woreda Water, Mines and Energy offices, are mandated to lead, coordinate and implement the alternative and renewable energy sector development. The remaining 26 organizations have the role of stakeholders in relation to the development of the biogas sector.

The findings of the survey had revealed that biogas digester was installed in the four sampled woredas and also in the region before the implementation of National Biogas Program of Ethiopia (NBPE) in 2008. However, as emphasized by the representatives of the nine bureaus of energy, the domestic biogas dissemination rate is very slow before the implementation of NBPE. Limited awareness of the society, financial shortage, limited institutional capacity (including knowledge, skill and sufficient staff), inappropriate dissemination strategies and design selection, and limited stakeholders' integrations are the inhibiting factors that had contributed for lower disseminations rate.

In relation to planning and budgeting of the dissemination effort, the surveyed energy bureaus have strategic plan to disseminate the biogas technology in the region as well as in the surveyed woredas. Moreover, these organizations have allocated matching fund budget for promoting and disseminating the technology in the region and in their respective woredas though the previous years' annual matching fund allocations at regional level by MEA is very big and totally not comparable with woreda WME offices' allocations. However, the results achieved in previous years by these organizations are not in line with the target placed in the strategic plan and the inhibiting factors mentioned above also apply here.

In addition to this, the qualitative findings of FGD had also revealed that there was high commitment on the side of the government to promote and disseminate the domestic biogas technology. During the discussion it was emphasized that supporting the dissemination effort through policy is in place and the allocation of budget for the biogas promotion and adoption is gradually increasing at all administrative levels, region, zone and woreda. The dissemination of the biogas technology is included in the GTP and recognized by the government as one of the development tools to achieve MDG. However, as added by the participants, there was limited attention and priority by some political officials, especially at woreda level, for the renewable energy sector because the departments responsible for the development of the energy sector were undermined by the water departments under the bureau of Water, Mines and Energy and with it the required resources.

In addition, the political will and commitment in supporting the dissemination effort declines as one goes from federal to woreda level. Moreover, one of the participants of FGD explained the situation as follows:

‘'It is known that steering committees were established in 20 woredas of the ongoing NBPE to lead the program activities, however, these committees were only active in few woredas and hence, their support for the achievement of the production target set in the annual plan.

Rather, most of the members of the steering committees, including heads of the woreda WME offices are busy with other political assignments.’’

The survey also sought to find out the stakeholders’ role played by governmental organizations in the biogas sector. All of the twenty six surveyed stakeholder organizations were aware of the implementation of the NBPE and the responsible organizations in charge of the overall program implementation though eight out of twenty six organizations have never participated in a /workshop regarding biogas technology.

Regarding roles played by the surveyed stakeholder governmental organizations, the survey findings had revealed that currently ten organizations have played insignificant roles in supporting the technology dissemination. The four regional organizations, namely, Bureau of Agriculture, Bureau of Health, Bureau of Women and Children Affairs and Bureau of TVET, were among the ten organizations contributing insignificantly. The remaining sixteen organizations have contributed to the development of biogas technology in areas intersecting with their organizational goals. These include awareness creation and promotional activities, training of biogas users in slurry applications and composting, and capacitating and licensing of biogas masons.

None of the surveyed governmental stakeholder organizations have included biogas technology and dissemination as one of their major activities in the annual plans and designed an evaluation system helpful in evaluating responsible experts. According to representatives of the Bureaus of Women and Children Affairs, biogas technology promotion is incorporated under promotion of appropriate technologies to the rural women though the efforts had been insignificant and was done in disaggregated manner.

4.9. Participation of other partners and stakeholders

An organization with the objectives of peoples' development agenda highly needs active participation of partners and stake -holders. These partners and stakeholders could support in areas where a gap is observed by the leading organization or in areas where collaborative effort is needed. From the point of domestic biogas technology dissemination, areas like promotion, capacity building, research and development need support from partners and stakeholders. Accordingly, 12 key informant interviews were conducted with representatives of five TVETs, three universities and four non-governmental organizations (NGOs).

Regarding the implementation of biogas technology dissemination, all of the surveyed institutions and organizations have prior information though only one TVET, based in Hawassa, got the chance of participation in a workshop concerning biogas technology. As emphasized by the representative respondents, promotion, capacity building as well as research and development were areas that intersect with mass adoption of biogas technology. Except Arba Minch university, which built a 10 m^3 biogas plant for teaching and researching purpose, none of the surveyed institutions and organizations have made efforts either privately or in collaboration with the bureaus of energy. The main reasons mentioned were lack of initiatives in commencing collaborative effort, lack of support in getting detail information about technical knowledge and dissemination strategy and shortage of budget.

The result of the qualitative tool, FGD, also shows that the participation of partners and stakeholders was very weak in supporting the dissemination effort. One of the participants of the FGD remarks the situation as follows.

"Partners like Institute for Sustainable Development (ISD) are supporting the dissemination effort by promoting the biogas slurry and by giving training on slurry application and composting for agricultural experts and biogas users. However, their support was not sufficient".

According to the regional MEA, the dissemination of domestic biogas technology was under the NBPE, which was the collaborative effort of GoE, Hivos and SNV. Currently, no other NGOs/programs in SNNPR are supporting the dissemination effort in the form of promotion, construction and capacity development.

Chapter 5 - Conclusions and Recommendations

5.1. Conclusions on Prospects

As presented in chapter two, the biogas sector has plenty of prospects that could boost the domestic biogas production. The supportive international context for the renewable energies, the commitment of the government of Ethiopia (GoE) in supporting the development of the energy sector, the huge biogas technical potential of the region, the development of the micro finance sector and the development of infrastructure are the major prospects that would enable the biogas sector to grow to the required level.

The enabling situations created at international level for the development of renewable energy sources and technologies have supported the biogas sector in the country, particularly in SNNPR. In this regard the NBPE currently under implementation can be taken as a good example for the international commitment in supporting the renewable energy sector as a whole and biogas in particular. In this regard, the NBPE can be mentioned here among the recent and on-going projects projects/initiatives.

It is well known that governments' commitment is very essential in supporting not only biogas sectors but also any other development activities. In order to achieve the desired national goals of the energy sector, the commitment of the Ethiopian government plays a vital role in meeting the development issue of the energy sector.

The findings of the survey show that the GoE is committed in developing and disseminating the renewable energy technologies in general and biogas technology in particular. Its commitment is manifested by the formulation of policy, inclusion of the biogas sector in the overall integrated development agenda, in GTP, and allocation of the required budget.

Generally, the tremendous contributions made by the GoE show that the government's commitment in supporting the mass dissemination of biogas technology would help to boost the production.

Ethiopia has huge technical potential for mass adoption of domestic biogas technology. Technical resource considerations include the availability of a constant supply of manure, the availability of water with which to dilute the manure, the suitability of the ambient temperature, and the availability of sufficient space for effluent disposal and usage. Thus, SNNPRS has huge potential for adopting domestic biogas technology on mass basis.

With regard to quantity and total outreach, the microfinance sector is growing gradually to reach more people across the globe. Similar scenario is also observed in Ethiopia since the enactment of the first proclamation in 1994 for regulating the micro finance sector. The availability these MFIs could be taken as an opportunity and their future involvement in the biogas sector will enhance the acceleration of domestic biogas digester deployment in SNNPR as users could get alternatives fitting their needs. The need for higher investment cost in installing bio digesters has been the major obstacles that have inhibited the mass deployment of the technology. In this regard the micro finance sector has a vital role in meeting the financial shortage of the people who are in need of the technology. Although credit could increase accessibility to biogas technology for the farmers, there remain many challenges in accessing it. Availability of credit for renewable energy technologies is still limited and many of the

MFIs are reluctant to avail loan to biogas users though the micro-finance sector is well developed in Ethiopia.

Most of the people of Ethiopia are still heavily dependent on traditional energy sources like fuel wood, agricultural bi-product and animal waste. Forest and Fuel wood resources are under severe pressure of depletion. Declining soil fertility, reducing crop yields and environmental problem are other results. Preference of other renewable energy technologies, like solar, and the on-grid electrification are the major reasons reflected by those who are not interested in biogas technology. The multifaceted benefits of the biogas technology have not understood well by all sections of the rural people.

In market-oriented economy the roles played by private sectors are frequently mentioned as a backbone and a fuel engine for the system. Similarly, the biogas sector needs the role of the private sector to create sustainable biogas dissemination program.. However, there have been limited involvements of the private sector in promotion, marketing, supplying and manufacturing biogas appliances that can be attributed to low entrepreneurial attitude, lack of skill and financial capacity.

The sustainability of biogas sector needs multi-stakeholder approach, which requires the active participation and support of governmental organizations, non-governmental organizations and community based organizations. Though biogas technology and the benefits it gives to the society is well understood by representatives of the surveyed stakeholder and partner organizations, so far their support and participation in biogas technology dissemination have been very limited.

In general, limited integration among stakeholders and partners in supporting the domestic biogas technology has hampered the overall dissemination process.

5.2. Recommendations

With regard to the need for higher investment cost and associated financial shortage, strategies and systems that would help in tackling the problem have to be in place. In order to lessen the challenges of high front cost faced by potential biogas users, the following three recommendations are made. These include strengthening of the ‘contribution to construction’ program, generation of revenues through carbon credits and strengthening of the involvement of MFIs both in quantity and capacity.

The ‘contribution to construction’/subsidy structure under implementation by the NBPE is one of the major success factors for the recently relative higher dissemination rate. Strengthening of the current ‘contribution to construction’/subsidy structure will attract more potential as well as small and lower-income farmers so that the regional biogas potential will be tapped. Sustaining the ‘contribution to construction’ structure would be crucial as this structure have contributed a lot for the successfulness of the Nepal’s domestic biogas dissemination.

Secondly, besides ‘contribution to construction’ structure, revenues have to be generated through mobilization of carbon credits through certified emission reductions (CERs) or verified emission reductions (VERs). This effort, therefore, could contribute to the financing of the contribution to construction cost and future up-scaling of and sustainability of the domestic biogas digester dissemination.

Thirdly, strengthening the participation of the existing MFIs and attracting of new MFIs to the biogas sector will open opportunity for the rural people to have lending alternatives. Accordingly, the regional MEA has to work in collaboration with these institutions, especially with the Omo MFI, in order to tackle the periodic financial shortage. In Ethiopia, World Bank has arranged credit for the development and dissemination of renewable technologies and the Development Bank of Ethiopia (DBE) is in charge of approving eligible MFIs and availing the credit. Therefore, accessing the credit arranged by the WB not only solves periodic credit shortage problem of the Omo MFI but also other eligible MFIs operating in the region. In addition to this, micro-financing institutions need to have access to funds at suitable costs to lend to the biogas sector. One of the reasons for high interest rates for borrowers is the high costs to the micro-financing institutions of accessing their own funds. Therefore, it is essential to establish a revolving wholesale biogas credit fund to provide wholesale loans to micro-financers at low interest rates. These micro-financers can then lend to households to finance biogas plant construction at a reasonable rate.

Besides, the participation of community based cash crop cooperatives has to be strengthened because the micro financing institutions charge high interest rates with short and inflexible repayment periods which keep biogas plants beyond the reach of many poor farming households. In SNNPR, the participation of Sidama Coffee Cooperatives in seven woredas of the NBPE has helped biogas users to access credit with better credit ceiling amount, ETB 10,000, and softer interest rate, 10%. In 2013, the coffee cooperatives have financed 220 biogas plants, out of 638 plants, through Omo MFIs. The provision of loan with relatively better interest rate and credit ceiling has made the service preferable by biogas clients than other MFIs' services, which are currently availing loan with 15 to 16 % interest rate and credit ceiling of ETB 6,000 to ETB 7,000. Community based cooperatives would be better placed to provide loans on softer terms with lower interest rates, longer repayment periods and flexible repayment terms to fit the seasonality of farmer incomes. Cooperatives can operate at smaller rates than commercial micro-financing institution since they know their prospective clients and their transaction costs are lower. Successful implementation of credit scheme through cooperatives will prove that biogas can be an attractive loan product and will likely attract commercial micro-financing institutions into this sector, with increased awareness and capacity. Lower interest rates established by cooperatives will also force the larger micro-financers to offer competitive rates. Moreover, arranging capacity building and awareness creation workshops will be important because micro-finance institutions lack capability and confidence in financing biogas as an attractive loan product.

The participating MFIs, especially the Omo MFI, have also faced a new and emerging challenge to stay in the biogas sector. This challenge is the poor credit repayment status, which is only 29% for OMFI's biogas clients, and most of the clients are not repaying their loan based on the agreed up on time schedule. Therefore, it would be better to implement systems prompting proper orientation of users during loan disbursement, sustaining digester functionality and systems mobilizing community-based organizations (CBOs) in creating awareness to MFIs' clients.

Another area of recommendation will focus on the peoples' awareness regarding biogas technology and its uses. The research results show that 12 % of the surveyed households were not interested in the technology even though they have well informed about its long term benefits. Making people aware does not necessarily lead to the adoption of a technology. They should be provided with more information on the technology to inspire them to adopt it. This situation signals the need for tremendous efforts in making people aware of the benefits and related issues.

The most important element of the promotion strategy is to have a satisfied customer telling friends, relatives and neighbors about the benefits of a biogas plant. As discussed above 58% of the surveyed households got information about biogas from their beneficiary neighbors and this shows that further technology dissemination mainly relies on the quality of the service and the type of the information passed by these neighbors.

Working on promotional approaches which are not conventional would have a potential of attracting prospective farmers and help them better understand the benefits of the technology. At the interest building stage, individual contacts, group discussion, study tours, audio-visuals and demonstrations could be more effective than mass media

Thirdly, this research recommends on issues pertaining the private sector in the biogas sector. To ensure their active participation of the private sector, especially the BCEs/masons, in the biogas sector, due attention has to given in filling their gaps.

As part of the remedial intervention, the capacity of the various private sectors; including constructors, manufacturers and suppliers, has to be built so that their involvement will be sustained. Arranging and conducting regular technical training programs to manufacturers selected from regional towns on biogas appliances designing and productions will smooth the supply, which is only found in the regional capital. In addition to this, BCEs have to be encouraged and supported to actively engage not only in construction but also in manufacturing and supplying biogas appliances. With regard to training of BCEs, regular and continuous business development skill (BDS) training has to be in place in order to raise their awareness and entrepreneurial skill. Linking these BCEs with MFIs will solve their financial shortage, which has inhibited them from supplying and manufacturing the biogas appliances at local level. Above all, creation of sufficient demand for BCEs through various mechanisms, including their active involvement in demand collection, will help them to stay in the business because they only stay in the biogas sector if the business is profitable.

. A large scale implementation of biogas programme is difficult without strong political commitment from the government. The government of Ethiopia has showed its political commitment in enhancing the biogas sector especially since 2008. Formulation of energy policy and formulations of national biogas program and implementation strategies as well as allocation of finance for implementation of NBPE are areas in which the government has shown its commitment.

Though the current energy policy has created conducive environment for the development of the energy sector since 1994, it lacks periodic update considering the ever dynamic development of the sector at international and national level. In addition to this, the development of the biogas sector should be included in the category of the infrastructure development, which comprises road, telecommunications, water, electricity and health infrastructures. The inclusion of biogas development as one of the rural development infrastructures would attract huge government investment to dissemination of domestic biogas technology as a ‘contribution to construction’ to biogas users.

The participation and cooperation of relevant stakeholders would stimulate the biogas households to make full use of their installation. In this regard, stakeholders working in areas of agriculture, health, women and children have to promote the multi benefits of biogas technology in integrative way. An approach with strategies of enhancing the active participation of private sector and construction entities in the biogas sector would help to retain the construction and maintenance knowledge and skill at local level. Another important point that has to be considered during development of best dissemination approaches and strategies is the gender issue. The biogas sector development has to address the issue of gender since women are the victims of the energy crisis and socio cultural influences.

Educational institutions' contribution in capacity building, research and development could also be essential in creating strong biogas sector. In this regard, TVETs are well placed in the region to develop curriculum to biogas courses and thus, they can serve as an institutions where experts, technicians and local masons or artisans get the required knowledge and skills. Additionally, universities can serve as a center of biogas researching, especially in improving the already developed inefficient biogas stove that can bake 'injera', a traditional flatbread national dish in Ethiopia made of 'teff' flour and its prototype production. Moreover, these universities could contribute in developing and adapting biogas digester models requiring low installation investment and models that suit areas with water shortage problem.

References:

ADB (July, 2006), Report on the ADB FINESSE *Training Course on Renewable Energy and Energy Efficiency for Poverty Reduction*, Nairobi, Kenya.

AEMFI (2010) Ethiopian Micro Finance Institutions Performance Analysis Report, January, 2010. Bulletin 6 Addis Ababa: AEMFI

Adams, J., Khan, Hafiz T.A., Raeside, Robert & White, David. (2007). Research Methods for Graduate Business and Social Science Students, USA: Sage Publications Inc.

Alexander Dijkstra, 2012; The private biogas sector in Tanzania: The companies are coming

Al Seadi T. et al. (2008). Biogas Handbook. Biogas for Eastern Europe. University of Southern Denmark. ISBN 978-87-992962-0-0

Amalia G., Christian R.L., Christian Z., Stefan D. and Yvonne V. (2014); Anaerobic Digestion of Biowaste in Developing Countries. Practical Information and Case Studies for Swiss Agency for Development and Cooperation (SDC)

Amera, T. (2010) Review of the urban environment in Ethiopia. In Edwards, S, (2010). Ethiopian Environment Review, 1, 61-78.

Amigun, B., von Blottnitz, H. (2007) Investigation of Scale Economies for African Biogas Installation. *Energy Conservation and Management*, 48 (12), pp. 3090-3094.

Amigun B., Sigamoney R., von Blottnitz H. Commercialization of biofuel industry in Africa: a review. Renewable and sustainable energy reviews, 2007, doi:10.1016/j.rser.2006.10.019.

Arnold, M., Köhlin, G., Persson, R., Shepherd, G. (2003) Fuelwood revisited: "what has changed in the last decade?" CIFOR Occasional Paper No. 39. Center for International Forestry Research, Jakarta

Asmelash (2003). The Impact of Microfinince in Ethiopia: the case of DECSI in Gonat – Afeshum Woreda of Eastern Tigray. Master Thesis, Addis Ababa University: Addis Ababa, Ethiopia.

Bamlaku (2006). Microfinance and Poverty Reduction in Ethiopia. A paper prepared under the Intern ship Program of IDRC, ESARO, Nairobi, Kenya.

Belward, A et al. (2011): Renewable energies in Africa, Current knowledge. Retrieved 3 July 2012, online available at [http://publications.jrc.ec.europa.eu/repository/bitstream/pdf

Benjamin J. (2004), *Renewable Energy and Development*, Brochure to accompany the Mobile Exhibition on Renewable Energy in Ethiopia, Addis Ababa.

Bhat,P.R., Chanakya H.N. and Ravindranath, N.H. (2001). Biogas plant dissemination: success story of Sirsi, India. Energy for Sustainable Development.5 (1):39-46

Bhattacharyya S (2006). Renewable energies and the poor: niche or nexus? Energy Policy, No. 34.

Birehane E., Tilahun, M. & Tewolde-Berhan, S. (2005) Assessment on Vulnerability of Women to man Made and Natural Calamities in Tigray. Mekelle, Mekelle University.

Biruk T. W. (2010): The Potential and Challenges of MFIs to Enable Uptake of Household Biogas Technology in Ethiopia.

Boyle G, Deepchand K, Hua L and bre La Rovere E (2006). Renewable Energy Technologies in Developing Countries: Lessons from Mauritius, China and Brazil. Yokohama: UNU-IAS.

Bureau of Finance and Economic Development (BoFED) (2010/11); SNNPR BoFED: Annual Statistical Abstract 2003 E.C (2010/2011). Hawassa, Ethiopia.

Bureau of Finance and Economic Development (BoFED) (2011/12); SNNPR BoFED: Annual Statistical Abstract 2004 E.C (2011/2012). Hawassa, Ethiopia.

Bugaje, I. M.: Renewable Energy for Sustainable Development. In: Africa in Renewable energy and Sustainable Reviews, 10(6): 603-612 (2002).

CESEN (1986) CESEN-ANSALDO/FINMECCANICA group. IN REPORT, M. A. T. (Ed.) Addis Ababa, Ministry of Mines and Energy.

Clean Start (2012). Clean Start Detailed Business Plan – Nepal, 2012; Clean Start global programme document.

CSA (1999) Report on the 1998 welfare monitoring survey. Addis Ababa, Ethiopia, Central Statistics Authority.

CSA (2007) Ethiopian Central Statistical Agency (2007), Ethiopian Sensus Statistics.

Dereje K., Yenenesh T. and Jemal Y.(2013); Constraints of Rural Women to Utilize Microfinance Institutions: the case of Members of Microfinance Institutions in Rural Districts of Dire Dawa Administration, Ethiopia. ISTE, Developing Country Studies

Desai, Manish A; Mehta, Sumi; Smith, “Indoor Smoke From Solid Fuels: Assessing the Environmental Burden of Disease at the National and Local Levels” World Health Organization

Deublein D. and Steinhauser A. (2011). Biogas from waste and renewable resources: an introduction, Wiley -VCH Verlag GmbH & Co. KGaA.

Dhakal, Nara, September 2008, Financing Domestic Biogas Plants in Nepal, The Netherlands Development Organization (SNV)

Domanski, Jeffrey; Jemelkova; Johnson, et al., "Breathing Easier in Rural China: Analysis of Options for Reducing Indoor Air Pollution from Burning Solid Fuels" Princeton University's Woodrow Wilson School of Public and International Affairs, 2005

Ellen M., Jacob W., Sonali C. and Kristen C.(2007); Using Microfinance to Expand Access to Energy Services. The SEEP NETWORK

ENDA, 2005; Energy Issues in Africa. http://www.enda.sn/energie/plaq-gb.htm#ourwork. (Retrieved on 02 November 2006)

Ejigu, M.: Grasping the Nettle. Our Planet. UNEP, I6(3): 20 (2005).

Eshete G. and Workneh K. (2008). *National Biogas Programme Ethiopia:* Programme Implementation Document. Ethiopia: SNV, 2008

Eshete G, Sonder K, Heedge R. (2006). Report on the feasibility study of a national programme for domestic biogas in Ethiopia. Ethiopia: SNV; 2006.

(EWB) Engineers without Boarders, "The Biogas Digester - A Sustainable Energy Production Technology for Rural Development in Sub-Saharan Countries," Sustainable Development Research Competition, April 5, 2004

Erosion, Technology and Concentration (ETC) Group. Promoting biogas systems in Kenya: a feasibility study in support of Biogas for Better Life – an African initiative. Commissioned by Shell Foundation. Nairobi, Kenya, 2007. Available at http://www.biogasafrica.org/index.php? option=com_docman&task=doc_download&gid=17 (access date: 18/12/09).

Fact sheet N°292 June 2005, Indoor air pollution and health, 2005.

FAO (1995): Chapter 3. Energy demand (supply) and consumption in Africa's agriculture. Retrieved 28 June 2012

FAO (1997), "A System Approach to Biogas Technology" Kathmandu, Food and Agriculture Organization/Consolidated Management Services, 1997. http://www.fao.org/sd/Egdirect/Egre0022.htm

FAO (1999) State of the World‘s Forests 1999. Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/W9950E/W9950E00. htm; Accessed on: 27/06/2011.

Felix t. H. (2005). Domestic Biogas and CDM Financing: Support project to the Biogas Programme for the Animal Husbandry Sector in Vietnam. The Netherlands Development Organization (SNV).

Helms, Brigit. Access for All: Building Inclusive Financial Systems. The World Bank, Thee Consultative Group to Assist the Poor, 2006.

Getaneh (2004). Microfinance Development: Can impact on poverty and food insecurity be improved upon? Paper Submitted to "International Conference on Microfinance Development in Ethiopia." Bahir Dar, Ethiopia.

Gobezie G. (2009) Sustainable Rural Finince: Prospects, Challenges and Implications, International NGO Journal, 4(2), pp. 012-026. February, 2006.

Groves, R.M., Fowler, Jr., Floyd J., Couper, M.P., Lepkowsky, J.M., Singer, E and Tourangeau, R. (2004) Survey Methdology, Wiley Series in Survey Methdology, U.S.A: John Wiley & Sons Inc.,

GTZ and ISAT. Biogas digest. In: Biogas - Costs and Benefits and Programme Implementation, vol. III, http://www.gtz.de/de/dokumente/en-biogas [accessed Date: 14.05.10].

Heegde, F.t., Sonder, K. (2007) Domestic biogas in Africa: a first assessment of the potential andneed (Draft/Discussion Paper). Biogas for Better Life: An African Initiative, May 2007.

Hilman, Subedi, Gilman et al, November 2007, Using Microfinance to Expand Access to Energy Services, Experience in Asia, Latin America and Caribbean, USAID and Citi Foundation

I. Barfuss, J. Müller, M. Zeller, S. Abele, S.G. Gwavuya (2012); Household energy economics in rural Ethiopia: A cost-benefit analysis of biogas energy. ELSEVIER, Renewable Energy.

IFAD's Strategic Framework 2007-2010. http://www.ifad.org/governance/sf/

International Energy Agency (IEA), 2013; World Energy Outlook 2013.

Jean-Luc C. (2006). Micro and Small Enterprises and Micro finance in Africa, the support to dynamic enterprises: an effective weapon for poverty alleviation. in Birritu No. 95, quarterly bulletin of National Bank of Ethiopia, Nov.2005-Jun. 2006.

Japan International Cooperation Agency (JICA) Tokyo International Center (2011); Energy Policy of Ethiopia. Country Paper.

Julie Marks and Oliver Wagg (UNCDF), 2013; Clean Start Connections (Issue1 November 2013), Expanding Market-Based Energy Financing Solutions. A business-led approach to providing clean energy financing for the poor

J.U.Smith (2011), The Potential of Small-Scale Biogas Digesters to Alleviate Poverty and Improve Long Term Sustainability of Ecosystem Services in Sub-Saharan Africa.

Karekezi, S. (2002) Renewables in Africa - meeting the energy needs of the poor. Energy Policy, 30, 1059–1069.

Kossmann W., Pönitz U., Habermehl S., Hoerz T., Krämer P., Klingler B., Kellner C., Wit-tur T., von Klopotek F., Krieg A. and Euler H. (undated). Biogas Digest Volume I – IV. German Agency for Technical Cooperation (GTZ). Eschborn. Germany.

Kristoferson L (1997). Seven energy and development myths - are they still alive? Renewable Energy for Development. 10(2).

Lavinia Warnars, 2013; Bioslurry: A Supreme Fertilizer; A study on bioslurry results and Uses

MARIAM, H. G. (1992) Rural Electrification in Ethiopia: 67-111.

Marree F., Nijboer M., Kellner C. (2007). Report on the feasibility study for a biogas support programme in the northern zones of Tanzania. SNV publication. Nairobi, Kenya, 2007.

Matthew S. Mendis, Wim. J. v. N. (1999) The Nepal Biogas Support Program: Elements for Success in Rural Household Energy Supply, ed. E. a. D. Department, and E. a. E. T. D. Climate, Ministry of Foreign Affairs, pp. 27-29.

MEA/RBPCU, 2013; SNNPR MEA/RBPCU’s Annual report of the NBPE.

MEDAC (1999) Water for Energy. IN REPORTS, C. (Ed.) Ethiopia. Addis Ababa, Ministry of Water Resources.

Ministry of Finance and Economic Development (MoFED) (2002B). Poverty Profile of Ethiopia: Analysis and Comparison of Poverty. Government of the Federal Democratic Republic of Ethiopia: Addis Ababa, Ethiopia.

Mshandete, A.M., Parawira, W. (2009) Biogas technology research in selected sub-Saharan African countries - A review. African Journal of Biotechnology, 8, 116-125.

Mid-Term Review (MTR), November 2011, of the National Biogas Programme Ethiopia Final Report.

Nair, M (2009): Institute for Environmental Security, Renewable Energy for Africa. Retrieved 12 July 2012, online available at [http://www.ideels.uni-bremen.de/Renewable_Energy_for_Africa.pdf]

Najam. A. and Cleveland .C.J.: Energy and Sustainable Development. Pp. 114 -115. In: World Summit Sustainable Development: The Johannesburg Conference. L. Hens. and B. Nath (Eds.). Springer (2006).

Ministry of Water and Energy, Ethiopia (2012); Scaling - Up Renewable Energy Program Ethiopia Investment

Njoroge D.K. Evolution of biogas technology in South Sudan: current and future challenges. Proceedings from biodigester workshop, 2002. Available at http://www.mekarn.org/Procbiod/ kuria.htm.

OECD-Organization for Economic Cooperation and Develeopement (2004); Accelerating Pro-Poor Growth through Support for Private Sector Development: An Analytical Framework

Omo Microfinance Institute (OMFI) of SNNPR (2012): Strategic Plan; Hawassa, Ethiopia

Parawira W (2004). Anaerobic treatment of agricultural residues and wastewater: Application of high-rate reactors. Doctoral thesis. Department of Biotechnology, Lund University, Sweden. http://www.lub.lu.se/luft/diss/tec_848/tec_848_kappa.pdf

Orleans Mfunea and Emmanuel K. Boonb., 2008; Promoting Renewable Energy Technologies for Rural Development in Africa: Experiences of Zambia

Programme Implementation Document, N.B.P. Ethiopia, Editor. 2008. Ethiopia Rural Energy Development and Promotion Center (EREDPC) and SNV: Addis Ababa.

Programme Implementation Document (PID), 2014; National Biodigester Programme Ethiopia phase II (NBPE-II). MWE and SNV: Addis Ababa

Practical Action Org., 2006. “Biogas and liquid befouls.”

Reid D. and Richenda V.L. (2014), COMMENT: Bring sustainable energy to the developing world.

REN21 (2011), Renewable (2011); Global Status Report. Renewable Energy Policy Network for the 21st Century.

Renewable Energy Association (2009) Energy and Environment. At http://www.r-ea. net/info/energy-info (accessed 14 April 2010).

Robert A White (2005), The Role of Biogas in Rural Development and Resource Protection in China: A Case Study of Lijiang Municipality, Yunnan Province, China

Safley, Jr.L.M and Westerman, P.W. (1992) "Performance of a low digester temperature lagoon", Bioresource technology, 41, pp. 167-175.

Saroj Rai (2013); In Clean Start Connections, UNCDF (Issue1 November 2013)

Shadab Fariduddin and Team (2010); Biogas Credit Feasibility Study for Rural Support Program Network: Pakistan Domestic Biogas Programme

SNNPR BoA, 2001; A Strategic Plan for the Sustainable Development, Conservation, and Management of the Woody Biomass Resources

Sundar B. (2005); The Nepal Biogas Support Program: A Successful Model of Public Private Partnership for Rural Household Energy Supply.

Tador and Smith (2009). Economic Developemnt. Tenth Edition Addison Wesley Milan

TDBP. (2009). Biogas technology in Tanzania; Annual report on Biogas technology program in Tanzania, a paper presented on African Biogas Partnership Programme (ABPP) Nairobi 2010.

Tesfaye Belijge (2012); Impact of Microfinance on Rural Household Poverty Reduction. Evidence from Southwest Ethiopia: Addis Ababa, Ethiopia.

United Nations (2009). Millennium Development Goals at http://www.un.org/millenniumgoals/bkgd.shtml

United Nations Conference on Trade and Industry (UNCTD), 2010; Current Studies on Science, Technology and Innovation; Renewable Energy Technologies for Rural Development

UNCTAD (2009). United Nation Commission Trade and Industry Development Report 2009, Geneva: UNCTAD.

United Nation Environment Programme (2007) *Financing Mechanisms and Public/Private Risk Sharing Instruments for Finincing Small Scale Renewable Energy Equipement and Projects*. UNEP, Sepetember, 2007

UNESCAP – United Nation Economic and Social Commission for the Asia and the Pacific (2007) *Recent Developments in Biogas Technology for Poverty Reduction and Sustainable Development*. Beijing 2007:

United Nations Public-Private Alliance for Rural Development (2009). Information. At http://www.un.org/esa/coordination/Alliance/index.htm (accessed 14 April 2010).

van Nes W. J., Nhete T. D. (2007): Biogas for a better life – An African initiative. Renewable Energy World, July – August 2007.

Vien, T.H. (2011) The linkage between land reform and land use changes. A case of Vietnam. Journal of Soil Science and Environmental Management, 2, 88-96.

WB (2013). SNNPR Water Resource Bureau: Annual Report: Hawassa, Ethiopia

World Health Organization. Burden of Disease from Household Air Pollution for 2012 (WHO, 2014).

WHO (2000) The global burden of disease: Update 2004. Geneva, World Health Organisation. World Bank, 1984.

WHO; Indoor Smoke from Solid Fuels; Assessing the Environmental Burden of Disease at national and Local Levels; Series No. 4; 2004.

Wolday Amha (2007). Managing Growth of Microfinance Institutions (MFIs): Balancing Sustainability and Reaching Large Number of Clients in Ethiopia. Occasional Paper No. 18.

Wolday (2002). Product Development in the Ethiopian Microfinance Industry: Challenges and Prospects. AEMFI, Occasional Paper No. 4: Addis Ababa, Ethiopia.

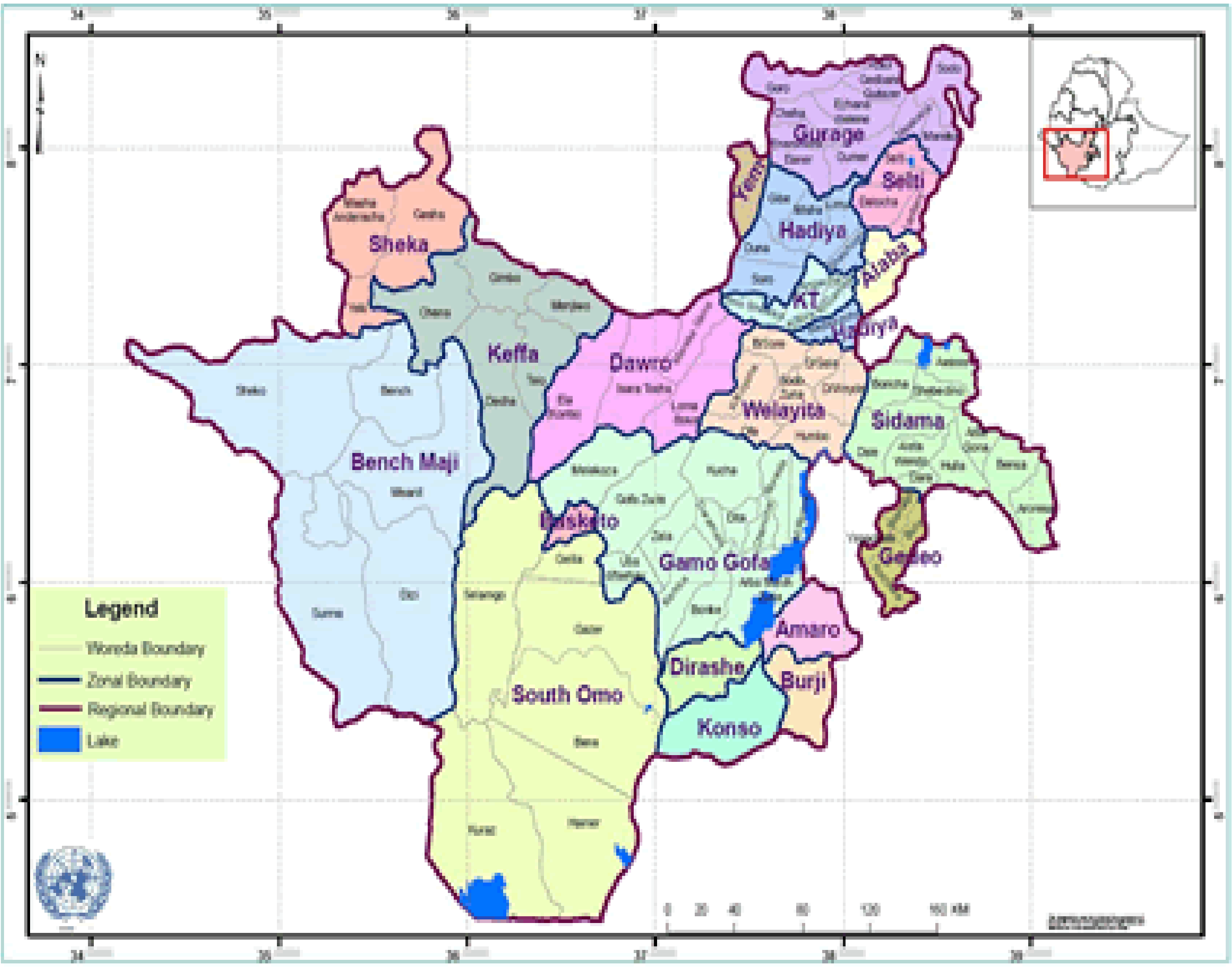
World Bank (2004b). Renewable Energy for Development: the role of the World Bank Group. Washington DC: World Bank. (World Bank, 2006); Energy issue

World Energy Council; the Challenge of Rural Energy Poverty in Developing Countries; 1999- 2005., London. World Bank (2013). Ethiopia Overview http://www.worldbank.org/en/country/ethiopia/overview

World LP Gas Association, LP Gas and Microfinance: A Study into the Applications and Use of Microfinance in LP Gas Access Projects (Paris: World LP Gas Association, 2004).

W. Wolde-Ghiorgis, 2002; Renewable energy for rural development in Ethiopia: the case for new energy policies and institutional reform. ELSEVIER, Energy Policy.

Appendix A: Administrative zones of SNNPR



Map Source: UN, 2010

Appendix B: Omo MFI – Biogas Users Loan disbursement and Borrowers Report; As of June 30, 2014

S.N	Name of Woredas	No. of Beneficiaries	Disbursement	Repayment	Loan Outstanding	Compulsory Saving	Arrears	No of Kebele
1	**Hawassa Branch**							
	Aleta Wondo	220	1,518,000	185,206	1,332,794	193,200	1,068,157	61
	Dale	138	912,000	186,966	725,035	67,200	437,034	36
	Wondo Genet	96	576,000	179,672	396,328	51,700	299,591	13
	Aleta Chuko	106	636,000	65,950	570,050	63,600	506,450	29
	Shebedino	11	110,000		110,000			5
	Dara	76	988,000	10,000	978,000	25,200	952,800	
	Wensho	8	68,000		68,000			
	Hawassa Total	**655**	**4,808,000**	**627,794**	**4,180,207**	**400,900**	**3,264,032**	**144**
2	**Dilla**							
	Wanago	15	90,000	1,100	88,900		88,900	
	Dilla Total	**15**	**90,000**	**1,100**	**88,900**		**88,900**	
3	**A/Minch**							
	A/Minch Zuria	181	1,074,000	323,910	750,090		105,990	
	M/Abata	72	417,000	152,650	264,350	11,620	30,000	
	A/Minch Total	**253**	**1,491,000**	**476,560**	**1,014,440**	**11,620**	**135,990**	
4	**Sodo**							
	Sodo Zuria	89	**603,000**	390,905	212,095	5,005	25,400	
	Boloso Sore							
	Soddo Total	**89**	**603,000**	**390,905**	**212,095**	**5,005**	**25,400**	
5	**Hawassa Ket.**							
	Hawela Tula	18	132,000	11,450	120,550		120,550	
	Hawassa Total	**18**	**132,000**	**11,450**	**120,550**		**120,550**	
6	**Werabe**							
	Silti	24	204,000	56,000	148,000		148,000	
	Werabe Total	**24**	**204,000**	**56,000**	**148,000**		**148,000**	
7	**Welkite**							
	Sodo	171	1,236,000	255,638	980,362		980,362	
	Meskan Abeshege	34	203,000	156,099	46,901		46,901	
	Welkite Total	**205**	**1,439,000**	**411,737**	**1,027,263**		**1,027,263**	
8	**Durame**							
	Doyogena	13	78,000		78,000	6,600		
	Halaba	22	117,700	5,300	112,400	9,630		
	Durame Total	**35**	**195,700**	**5,300**	**190,400**	**16,230**		
9	**Hosaina**							
	Analemo							
	Lemo	11	66,000					
	Hosaina Total	**11**	**66,000**					
	Grand Total	**1,305**	**9,028,700**	**1,980,846**	**6,981,855**	**433,755**	**4,810,135**	**144**

Appendix C: Biogas Plants Completed from 2008 up to September, 2013 in SNNPR

S/N	Woreda	Years						Total
		2008	2009	2010	2011	2012	2013	
1	A/Minch Zuria & Darashei	13	2	42	49	43	64	213
2	Mirab Abaya				12	41	40	93
3	Sodo Zuria				13	40	42	95
4	Boloso sore						29	29
5	Halaba					7	26	33
	A/Minch Cluster total	**13**	**2**	**42**	**74**	**136**	201	468
6	Doyogena					3	7	10
7	Lemo					13	17	30
8	Anilemo						1	1
9	Abeshige					4	5	9
10	Siliti				8	14	15	37
11	Meskan	12	2	46	55	72	67	254
12	Sodo-Guraghe				32	57	97	186
	Meskan Cluster total	**12**	**2**	**46**	**95**	**163**	209	527
13	WondoGenet				35	43	29	107
14	Hawassa-Tula				10	8	12	30
15	Dale			12	51	49	20	132
16	Wonsho						4	4
17	Aletawondo			35	49	58	74	216
18	AletaChuko			8	29	46	21	104
19	Dara						70	70
20	Shebadino						4	4
21	Wonago			4	15	7	5	31
	A/wondo Cluster total			**59**	**189**	**211**	239	698
22	**Other few woredas**					**5**	**31**	**36**
Total		**25**	**4**	**147**	**358**	**510**	**680**	**1724**

Appendix D: Some of the Digesters Installed before the implementation of NBPE in 2008

Report on Existing Status of Biogas Digesters: MEA; June, 2003 (1996 E.C)

S/N	Zone/Sp. woreda	Woreda	Kebele	Village	Constructed by	Year of Construction (E.C)	Type	Size (m^3)	Status
1	Sidama	Awassa Zuria	Jara Gelecha	Jara Gelecha	EREDPC	1986	Fixed	6	NF
2	"	"	Galo Argesa	Kerso Market	"	"	"	"	NF
3	"	"	Dora Bafano	Tenkarecho	S.Synod Mekane yesus	"	"	6	NF
4	"	"	"	Bafano	"	"	"	6	NF
5	"	"	"	"	"	1999/1991	"	6	Nf
6	"	"	Bushulo	Near Bushlo Hospital	BOA/SRTPC	1996/1986	Floatting	8	NF
7	"	"	Entaye	Shutare	BOA/SRTPC	1996/1986	"	8	NF
8	"	Shebedino	Taramesa	Burka	Zone Agri Depa/t	1989	"	5	NF
9	"	Dale	Tula	Bureyo	BOA	1987	"	8	NF
10	"	"	Bera Tadicho	Ealelicho	REMRDA	1986	"	8	
11	"	Aleta Wondo	Korke	Gisa Galano	Zone Boa	1989	"	5	NF
12	"	Bensa	Hache	Galege	BOA	1989	"	4	NF
13	"	Arbegona	Merede	Gatamo	BOA	1991	Floating	4	NF
14	"	Hula	Getame	Benejele	BOA	1991	"	4	NF
15	"	Awassa Z	Town				Fixed	8	FN
16	Gedio	Kochore			BOA	1988	Fixed	8	NF
17	"	Y/Chafe			"	1988	"	8	P/NF
18	"	Bule			"	1989	"	8	P/NF
19	"	Wonago			"	1987	"	8	P/NF
20	"	"				1989	"	8	NF
21	"	"				1989	"	8	NF
22	Amaro	Amaro			BOA	1989	Fixed	8	NF
23	Konso	Konso	Fuchucha	Fuchucha	BOA	1989	Fixed	8	NF
24	"	"	"	"	"	1987	"	8	NF
25	Halaba	Halaba			BOA	1989	Fixed	8	NF
26	Yem	Yem	Deri			1987	Floating	8	NF
27	Hadiya	Badawacho	Mezoria	Bochoso	REMRDA	1995	Fixed	8	NF
28	"	"	1st Amburese	Amburese	BOA	1989	"	8	NF
29	"	"	Amburese	Amburese	BOA	1989	Floating	8	NF
30	"	Soro	Yose Gimbichu		BOA	1987	"	8	NF
31	"		Jajura		BOA	1989	"	8	NF

32	"		PA		BOA	1989	"	8	NF
33	"	Lemo			BOA	1987	"	8	NF
34	"	"	Shokbira		STRPC	1986		8	NF
35	"	"	Ambicho gode			1981	Fixed		NF
36	"	Shashogo	Doesha		BOA	1988	Floating	8	NF
37	"	Misha	Lambuda		REMRDA	1996	"	8	New
38	KT	Angecha	Kerekech o		BOA	1988	Floating	8	NF
39	"	Kachabira	Gemesha		BOA	1989	"	8	NF
40	"	K/gamela	Benara		BOA	1987	Floating	8	NF
41	"	"	Jore		BOA	1988	"	8	NF
42	"	"	Teza Gereba		REMRDA	1996	"	8	NF
43	"	Omo Sheleko	Sigazo		BOA	1988	"	8	NF
44	Wolayta	Sodo zuria	SRTPC	SRTPC	SRTPC	1981	"	8	FN
45	"	"	Dairy	Dairy	SRTPC	1987	"	8	FN
46	**"**	**"**	**Training Center**	**Training Center**	**"**	**1968**	**"**	**8**	**NF**
47	Wolyita	"	Waraza Lashoo	Haba hulate	"	1986	"	8	NF
48	"	"	Waja kero	Ketena 5	BOA	1988	"	4	NF
49	"	"	"	Ketena 3	REMRDA	1995	"	8	FN
50	"	"	Wachega	Ketena 5	BOA	1988	"	8	FN
51	"	"	Waraza Gerera	Majala 6	SRTPC	1986	"	8	FN
52	"	D/Gale	Gacheno	Kentena 1	BOA	1994	"	8	FN
53	"	"	Bibiso Ololo	Ketena 7	BOA	1994	"	8	FN
54	Gamugof a	A/Minch Zuria	Shele	Shele	EREEPC	1994	Fixed	8	NF
55	"	Boroda	Habesa	Gaga Opposite to school	BOA	1991	Floating	4	Incomplete
56	"	Gofa Zuria			BOA	1991	"	4	"
57	D/Omo	Backo gazere	Zomba	Gekaba	BOA	1988	Floating	8	NF
58	"	"	Arkesa	Gartopa	BOA	1987	"	0.05	NF
59	"	Bentse maye	Berale	Heresho	SRTPC	1994	"	8	FN
60	Derashe	Derashe	Geto	Geto	BOA	1987	"	8	NF
61	Gurage	Meskan	Batiligam	Lijano	BOA	1989	Floating	8	FN
62	"	Mareko	Asin Jima	Asino	Self help	1996	"		FN
63	"	Meskan	Jole	Jole	SRTPC	1986	"	8	FN
64	"	Soddo	Lebu			1992	"	8	NF
65	"	Checha	Buchach				"	8	FN
66	"	Ezda	Yesiray				"	8	FN
67	"	Gumer	Wonzier				"	8	FN
68	"	Goro	Fikadu				"	8	FN

69	"	Enamor	Weyra				"	8	NF
70	"	Kokir	Ankedel				"	8	NF
71	Siltie	Dalocha	Burka Dilapa	Galie Maoria	BOA	1988	"	8	NF
72	"	Silti	Datiwoze	Geme	BOA	1988	"	8	NF
73	"	Lanfuro	Tota 01	Tora 01	BOA	1988	"	8	FN
74	"	Silti			REMRDA	1996	"	8	FN

KT: Kamabata Tambaro

REMRDA: Rural Energy and Mines Resources Development Agency

SRTPC: Sodo Rural Technology and Promotion Center

EREDPC: Ethiopian Rural Energy Development and Promotion Center

Appendix E: Questionnaires and FGD

INTERVIEW SCHEDULE FOR VILLAGERS (NON BENEFECIARIES)

Code: --------------------   Date: -------------------

1. Family Members Information

S/N	Family members (Permanent)	Sex	Age	Relation with family members	Education level
1					
2					
3					
4					
5					
6					

2. **Family living situation and status of house**

2.1. What is the major income source of the family in which the family relies on?

1) Crop husbandry
2) Animal husbandry
3) Crop and animal husbandry
4) Income generating activities other than agriculture
5) All

If the answer to question no. 2.1 is code 03, go through question no. 2.2 to 2.5

2.2 The land in use:-

1) Belongs to the family

2) Obtained in rent

3) Both (1 & 2)

2.3 How many hectares ('Temad Bere') of land are you using for agriculture?

1) Less than 0.25 Hr. 2) 0.25 – 0.5 Hr. 3) 0.6 – 0.75 Hr. 4) 0.76 – 1 Hr.

5) Above 1 Hr.

2.4 Which of the following crops are produced in the farm land?

1) Grain 2) Vegetable and root crops (carrot, Onion, Potato & others) 3) Fruits (Avocado, Banana and others) 4) 'Chat' 5) Coffee 6) False banana ('Enset')

2.5 To what purpose do use the above mentioned product of agriculture?

1) For domestic consumption

2) For market

3) Both for household consumption and for market

2.6 What type of construction materials is being used to construct the following parts of the house?

1) Floor of the house: 1) Mud & cow dung 2) Stone & cement 3) Bamboo tree
2) Wall of the house: 1) Mud & wood 2) Stone blocks & cement
3) Roof of the house: 1) Thatched roof 2) Corrugated iron sheet

2.7 How many rooms does the house possess? 1) two 2) three 3) More than three

2.8 What assets are available in the house? (Possible to check more than one)

1) Radio/Tape recorder 2) Television 3) Bicycle 4) Motorcycle 5) Electric stove 6) Car/truck 7) Nothing

3. Domestic Animal size and Manure Management (Go through the following questions if the answer to question no. 2.1 is code 3)

3.1. Which of the following domestic animals are owned by the family? (Possible to check more than one)

1) Cattle 2) Sheep 3) Goat 4) Horse 5) Donkey 6) other, specify: --------

If the answer to question number 3.1 includes code 01, go through questions no. 3.2 to 3.9

3.2. Could you tell me the size of the cattle based on their origin?

3.2.1. Local breed: 1) zero 2) one 3) two 4) three 5) four 6) above four

3.2.2. Hybrids: 1) zero 2) one 3) two 4) three 5) above three

3.2.3. Exotic: 1) zero 2) one 3) two 4) three 5) above three

3.2.4. Total size of cattle: 1) four 2) five to eight 3) above eight

3.3. The dung collection is done:

1) Everyday

2) Once per two days

3) Once per three days

4) Sometimes

3.4. How much dung is collected from their stabled room?

1) 20 – 40 Kg.

2) 40 – 60 Kg.

3) Greater than 60 Kg.

3.5. Where do you store the collected dung?

1) In pit

2) Collecting in a surface ground

3) Throwing into open land

3.6. To what purpose(s) do you use the collected dung?

1) For fertilizing the land

2) For making dung cake

3) Both (1 & 2)

4. Water Sources and Access

4.1. Are there water sources in your area (kebele)?

1) Yes 2) No

If the answer to question number 4.1 is code 01, go through question no. 4.2 to 4.6.

4.2. What types of water sources are available in your area? (Possible to check more than one)

1) River 2) Spring water 3) Communal piped water 4) Private piped water 5) Communal hand dug well 6) Rope pump water 7) Canal water 8) Pond

4.3. How many times per week do you fetch the water for domestic use?

1) Once

2) Twice

3) Three times

4) Every day

4.4. How far does the sources of the water from the residence (dwelling house)?

1) Within 15 minutes distance walk

2) Out of 15 minutes distance walk

4.5. What are the main sources of water for domestic animals?

1) River 2) Spring water 3) Communal piped water 4) Private piped water 5) Communal hand dug well 6) Rope pump water 7) Canal water 8) Pond

4.6. How many times per week do you get the water for domestic animals?

1) Once

2) Twice

3) Three times

4) Every day

5. Demand and Supply of Household Energy

5.1. What type of energy is used for bread and 'injera' baking and cooking/heating?

1) Fuel wood

2) Branches, leaves and twigs

3) Dung cake

4) Charcoal

5) Gasoline

6) Electricity

5.2. What type of energy is being utilized for lighting?

1) Gasoline
2) Electricity
3) Candle
4) Gasoline and electricity
5) All

5.3. How do you get the following biomass energy sources?

S/N	Biomass energy sources	01 By Collecting	02 By purchasing	03 By collecting and purchasing	04 Other
5.2.1	Fuel wood				
5.2.2	Leaves & byproducts of crop				
5.2.3	Dung cake				
5.2.4	Charcoal				

5.4. How many hours are spent to collect fuel wood? --------- hours

5.5. How far is the distance to be covered to collect the fuel wood? -------- Km

5.6. How much money is spent per week to purchase the fuel wood? Birr ---------

5.7. How do you compare this year's and last year's fuel wood price?

1) Increased
2) Decreased

3) No difference

6. Awareness on Biogas Technology

6.1 Have you heard that biogas is being used to meet energy demand?

1) Yes 2) No

6.2 Where did you hear about biogas? (Possible to check more than one)

1) Beneficiary neighbor
2) Biogas masons
3) Extension worker
4) Mass media (radio/television)
5) Woreda energy officers

6.3 What did you hear about uses of biogas from the information source? (Possible to check more than one)

1) It serves lighting
2) It serves cooking
3) The byproduct is a potent organic fertilizer
4) It prevents health problems caused by household smoke
5) It reduces time wastage because of collecting fuel wood and dung making

6.4 Do you have an interest to get the benefits of biogas? (Please explain the uses of biogas to the interviewee and go to question no. 6.10 if the answer is code 2)

1) Yes 2) No

6.5 What hindered you from using biogas technology if you have an interest to own the technology?

1) I heard that the invest cost of the construction is high
2) Other family members (wife and children) refused to possess the technology
3) Neighbor's biogas digester is not functional
4) Currently I have other plan to execute
5) No accessible road to supply the construction materials

If the answer to question number 6.5 is code 01, go through question no. 6.6 to 6.9

6.6 Who told you about the high cost of the technology?

1) Beneficiary neighbor
2) Kebele official
3) Kebele agriculture worker
4) Biogas masons
5) Woreda energy officers

6.7 What is the investment cost for construction based on the information heard? Birr --------

6.8 Do you know that credit facility is in place to construct biogas construction?

1) Yes 2) No

6.9 If you have prior information that MFIs give credit to biogas technology users, why don't you possess the technology?

6.10 What are the reasons behind for being not interested in biogas technology as energy source?

QUESTIONNAIRE FOR MICROFINANCE INSTITUTIONS

I. General Information

1. Name: ---------------------------
2. Address: -------------------------
3. The Name of the organization: --------------------------------
4. Position in your organization: --------------------------------
5. The lending methodology being used by your organization is:
    1. Group lending
    2. Individual lending
    3. Both
    4. Other, please specify:----------------
6. Your organization clients can be categorized under
    1. Urban households
    2. Semi-urban households
    3. Rural households
    4. Micro enterprises
    5. All of the above category
7. When it comes to interest rate charged, the interest rate applied for different type of clients and purposes is:
    1. The same interest rate
    2. A different interest rate
8. If your organization charges the same interest rate, how much is the interest rate? --------

9. If your organization charges different interest rate, what are the reasons to do so? --

10. The interest rate charged by your organization for different category of client and purposes is:

    1. Agriculture: -------- %
    2. Other income generating activities: ------- %
    3. Normal operation: -------- %
    4. Injected fund operation: ----- %

I. Credit and Biogas technology (Experience and Willingness)

1. Does your organization give credit and saving service to biogas technology users?

   1. Yes 2.No

If the answer to question number 1 is code 02, go through question no. 12 to 15.

2. Who initiated the credit and saving service to biogas users?

   1) The institution itself
   2) The regional Mines and Energy Agency
   3) Clients (Biogas users)
   4) Other, specify -------

3. When did your institution start availing of loan to biogas users? ---------

4. Does your organization put loan size ceiling to biogas users?

   1) Yes 2) No

5. If yes, how much is the loan size ceiling applied by your organization? Birr -------------

6. Have your organization faced financial shortage problem during credit disbursement to biogas users?

1) Yes 2) No

7. If yes, what are the reasons?

----

8. Does your organization have sub branch offices at kebele level?

1) Yes 2) No

9. If no, how does your organization give services to beneficiaries at kebele level?

1) Using the field officers of the woreda sub branch office.

2) Using the extension agent at kebele level.

3) Both methods

4) Other: specify --

10. Does the kebele extension agent give all the services rendered at woreda office level? (Ask this question if the answer to question no. 8 includes code 02)

1) Yes 2) No

11. What are the responsibilities shouldered by the extension agent? (Ask this question if the answer to question no. 9 is code 02)

1) Awareness creation on saving and credit repayment
2) Organizing beneficiaries into groups
3) loan disbursement
4) Collecting repayment
5) All the above responsibilities except no. 3

Ask question no. 12 to 15 if the answer to question number 1 is code 02

12. Is your organization aware that some MFIs extended their credit service to biogas technology beneficiaries? If no, please go to question no. 13).

    1) Yes 2) No

13. Is financing biogas technology considered in the future plan (portfolio) of your organization?

    1) Yes 2) No

14. What could possibly be a challenge(s) to your organization?

INTERVIEW SCHEDULE

Code: --------------------   **Date: -----------------------**

1. Name: -----------------------------------
2. Address: --------------------------------
3. Name of the shop: --------------------
4. Do you know that the biogas program working in this woreda/town?

    1) Yes   2) NO

5. Have you ever supplied the biogas construction materials and/or appliances based on demand (biogas users)?

    1) Yes   2) NO

6. If yes, which of the following construction inputs are supplied by your shop for sale?
    1. Only construction materials like PVC pipe, GI (PPR) pipes, paints, iron road, etc
    2. Only biogas appliances like stove and lamp set
    3. Both
7. What hindered you from supplying biogas appliances? (Ask this question if the answer to question no. 6 is code 01)
    1. I don't know where to get the appliances
    2. I know where to get the appliances but the demand is not satisfactory
8. If you know where to get the biogas appliances, could you supply it to the market? (Ask this question if the answer to question no. 7 is code 01)

    1) Yes   2) NO

9. If no, why?

----

10. Do you get all the appliances from one place (town)? (Ask this question if the answer to question no. 6 includes code 02)

    1) Yes 2) No

11. If yes, where? --

12. If no, could you tell me where do you find each of the following appliances?

    ❖ Stove and related from ---------------------- town (s)

    ❖ Lamp set and related from ------------------- town(s)

INTERVIEW SCHEDULE FOR APPLIANCE MANUFACTURERS

Code: --------------------- **Date: -----------------------**

1. Name: ----------------------------
2. Address: -------------------------
3. Name of the organization: -----------------------
4. Have the organization ever manufactured locally produced biogas appliance(s)? (Mention the locally manufactured appliances to the interviewee) (If no, please go to question no.13)

   1) Yes 2) No

5. Where did you get the prototype design of the biogas appliance(s) manufactured in your organization?

   1. From regional/zonal/woreda energy office
   2. From other biogas appliance manufacturer
   3. Other, specify: --

6. Is the organization manufacturing biogas appliance(s) currently? (If no, please go to question no. 11)

   1) Yes 2) No

7. Which of the following appliances are being in production if the organization is manufacturing appliances currently? (Possible to check more than one)

   1. Dome pipe
   2. Biogas stove
   3. Water drain

8. Does anyone from your organization attended training on any of the above mentioned appliance(s) manufacturing?

    1) Yes 2) No

9. Which organization had conducted the training if training was given to your organization's technician? ---

10. Does your organization manufacture the biogas appliances based on the demand (biogas users) request?

    1) Yes 2) No

11. What factors forced the organization to give up the manufacturing if it has stopped production?

    ----

12. If the organization is producing some type of appliances, what could be mentioned as a limiting factor(s) for not manufacturing all types of appliances?

    1. Lack of technical skill
    2. Some input materials are not easily available in the market
    3. Limited financial capability
    4. Others; specify: ---------------------------------------

13. What factors limited the organization from manufacturing biogas appliance(s)?

INTERVIEW SCHEDULE FOR PROSPECTIVE BIOGAS CONSTRUCTION ENTERPRISES

Code: -------------------- **Date: ----------------------**

1. Name: ----------------------------
2. Sex: ------
3. Address: --------------------------
4. Are you married?

   1) Yes 2) NO

5. If married, how many children do you have? -------------
6. Did you take biogas construction training?

   1) Yes 2) No

7. When did you take biogas construction training? ----------
8. Which organization gave you biogas construction training? --------------
9. Had you constructed biogas digesters before the biogas construction training?

   1) Yes 2) No

10. Do you have a license to construct biogas digesters from recognized governmental body?

    1) Yes 2) No

11. Which organization gave you biogas digester construction license? ---------------------
12. How many biogas digesters have you constructed in the previous years? -------------
13. Where do you construct biogas digesters?

    A) Only within the woreda

    B) Within and other woredas

14. Do you have an office to register new biogas demands (users) and hence to commence construction to these users?

    1) Yes 2) No

15. How do you find new biogas users if you don't have an office? (Possible to check more than one)

    1) Users themselves come and contact me personally to make agreement on construction

    2) I make house to house promotion and persuade users to construct biogas digesters

    3) Through extension workers and experts of woreda Energy office

16. Are you working biogas construction as a full time job?

    1) Yes 2) No

17. If no, what other work supports your income? ---

18. Do you hire other support masons and labourers during construction?

    1) Yes 2) NO

19. If yes, how many support masons and labourers do you hire during construction?

    1. Support masons --------------
    2. Daily labourers ----------------

20. Do you take the whole construction contract; including supply of appliances and construction materials, from users?

    1) Yes 2) No

21. What have hindered you from taking the whole contract? (Possible to check more than one)

1) Financial problem

2) Business skill gap

3) An attitude that my responsibility is only to construct biogas digesters

22. Do you know that your financial problem could be solved by getting loan from MFIs? and go to question no. 25 if the answer to the this question is yes)

    1) Yes 2) No

23. What reasons lagged you getting the loan from MFIs? (Possible to check more than one)

    1) Fear of credit interest rate
    2) I don't know how to apply and process the credit request
    3) Fear of the process /bureaucracies
    4) I couldn't fulfill the criterion (like collateral issues) set by the MFIs

24. Have you ever taken training on business skill development? (Ask this question if financial problem is one of the case in question no. 21)

    1) Yes 2) No

25. If yes, which organization gave you the training? When? ---------------------

QUESTIONNAIRE FOR ORGANIZATIONAL LEADERS

1. Name: -------------------------------
2. Name of the organization: --------------------------------
3. Position in your organization: ------------------------------
4. Where do you position the role of your organization in biogas technology dissemination? (If answer is code 02, please go to Q-11)
    1) Mandated to lead, coordinate and implement
    2) Stakeholder's role

If the answer to question number 4 is code 02, go through question no. 11 to 17.

5. Is biogas technology installed in the woreda/region before the coming of National Biogas Program of Ethiopia (NBPE)?
    1) Yes   2) No
6. How do you see the dissemination rate before the implementation of NBPE?
    1) Lower dissemination rate before implementation of NBPE.
    2) Higher dissemination rate before implementation of NBPE
    3) Similar with the dissemination rate before NBPE
7. Which of the following factors contributed to lower dissemination rate before NBPE? (If the answer to question no. 6 is code 01 and possible to check more than one)
    1) Financial shortage
    2) Limited institutional capacity /Knowledge, skill, enough staff/
    3) Limited awareness of the society
    4) Limited stakeholders' integration

8. Do your organization have strategic plan to disseminate the biogas technology in the region/woreda? (If yes, please go to question no. 9 & 10)

   1) Yes 2) No

9. Are the results achieved in the previous year(s) in line with the target put in the strategic plan? (Ask this question if the answer to question no. 8 is code 01)

   1) Yes 2) No

10. Which of the following challenges contributed for lower achievement of the target put in the strategic plan? (Possible to check more than one)

    1) Limited integration of stakeholders
    2) Limited awareness of the people
    3) Budget shortage
    4) Limited institutional capacity /Knowledge, skill, enough staff/

Ask question no. 11 to 17, if the answer to question number 4 is code 02

11. Are you aware of the biogas programme being underway in the region/woreda?

    1) Yes 2) No

12. Can you tell me which organization is playing the coordinating and/or implementing role at regional/woreda level? ---

13. Does your organization ever participate in a meeting/workshop regarding biogas technology?

    1) Yes 2) No

14. Have your organization played any role in supporting the biogas technology dissemination as a stakeholder? (If no, please go to question no.16)

    1) Yes 2) No

15. What roles have your organization played previously in this regard?

----

16. Does your organization include biogas technology promotion and dissemination as one of its activities in its annual plan?

    1) Yes 2) No

17. Is there an evaluation system in your organization to evaluate responsible experts considering biogas dissemination as one of its activities?

    1) Yes 2) No

QUSETIONNARIE FOR STAKEHOLDERS AND PARTNERS

1. Name: --------------------------------------
2. Name of the organization: -------------------------------
3. Position in your organization/institution: ------------------------
4. Are you aware of the biogas technology dissemination is being underway in the region/woreda by regional Mines and Energy Agency?

    1) Yes   2) No

5. Has your organization ever participated in a meeting/workshop regarding biogas technology?
    1) Yes   2) No
6. Which of the following elements of biogas dissemination intersect with the goal of your organization/institution? (Possible to check more than one)
    1) Promoting biogas technology
    2) Research and development
    3) Capacity building
7. Have your organization played any role previously in conducting activities that intersect with the goal of biogas dissemination? (If no, please go to question no. 9)

    Yes   2) No
8. Can you mention activities that have been conducted in this regard?

----

9. What have challenged your organization from providing your contribution as stakeholder?

   ----

10. Is supporting biogas dissemination considered in the future plan (portfolio) of your organization?

    Yes 2) No

FOCUS GROUP DISSCUSSION FOR ENERGY STAFF

Section I: Awareness

1. Is there an indication of biomass fuel crisis and its adverse effect in the region? If yes, do people feel this crisis? Explain
2. Do you feel that the biogas technology is known well by the rural community in the region? Why? Why not?

Section II: Commitment and Willingness

1. Do you believe that the regional government has shown commitment and willingness to disseminate biogas technology as a development tool? Why? Why not?
2. Similarly, do you believe that the woreda governments have shown commitment and willingness to disseminate biogas technology as a development tool? Explain?

Section III: Private Sector Development

1. It is known that the involvement of private sectors in manufacturing and supplying inputs as well as in marketing products is crucial step in development activities. If this is the fact, is there involvement of private sectors in biogas development activities? If yes,
    i. How do you compare their involvement in the previous periods and in the current situation in terms of quantity and extent of involvement?
    ii. What are their areas of involvement currently?

Section IV: Credit and related

1. Does credit service facilitate the mass dissemination of biogas technology? Why? Why not?
2. If your opinion is credit facility is crucial to finance the biogas investment, do you believe that the existing credit and saving institutions' service to biogas users are enough to serve all sections of the community based on their needs? Why? Why not (Facilitator: mention all the regional credit and saving institutions serving the biogas users currently)

Section V: Previous Biogas Programs

1. Since the first biogas installation was made in the region in 1968 E.C, dissemination of biogas technology have implemented in the region by NGOs and GOs. (Mention the different programs.) Which organization(s) and program(s) have been successful? Why? How? Which are not? Why?

Section VI: Partnership and Stakeholders' contribution

1. Stakeholders' contribution and bilateral and multilateral cooperation are crucial in promoting development activities. How do you see stakeholders' contribution in biogas technology dissemination? What could possibly enhance their contribution? How?

Section VII: General

1. What favourable factors are there for mass dissemination of biogas technology? Explain the why of each of the factors.

2. What Challenging factors are there for mass dissemination of biogas technology? Explain the why of each of the factors.
3. In your opinion, what must be done for each of the challenging factors as a way forward?

Studies on Prospects and Challenges of Uptake of Domestic Biogas Technology

(The case of SNNPR, ETHIOPIA)

A PROPOSAL

Submitted to Indira Gandhi National Open University in partial fulfillment of the requirement for the degree in Master of Arts in Rural Development

By

Zerihun Desalegn

January 2014

Addis Ababa, Ethiopia

TABLE OF CONTENTS

LIST OF ABBREVATIONS AND ACRONYMS

BCE	: Biogas Company Enterprise
BLT	: Branches, leaves and twigs
BoFED	: Bureau of Finance and Economic Development
EFAP	: Ethiopian Forestry Action Plan
FAO	: Food and Agriculture Organization
FGD	: Focal Group Discussion
Km	: Kilometer
LIVA	: Livelihood Improvement Volunteers Association
M^3	: Cubic meter
MEA	: Mines and Energy Agency
MFI	: Micro-finance Institutions
MW	: Mega Watt
NBPE	: National Biogas Program Ethiopia
NGO	: Non-Governmental Organization
OMFI	: Omo Micro-finance Institution

SNNPRS	: Sothern Nations, Nationality and People Regional State
SNV	: Netherlands Development Organization
SPSS	: Statistical Package for Social Sciences
Sq. Km	: Square Kilometer
Tcal	: Tera Calories
TJ	: Tera Joule
TVET	: Technical Vocational Education and Training
TWh	: Tera Watt hour

INTRODUCTION

1. Background of the Study

1.1 The Energy Scenario in Ethiopia

Ethiopia is endowed with various energy resources. The gross hydro-energy potential of the country is about 650 TWh per year, of which 25% could be exploited for power production (CESEN, 1986). This enormous potential ranks Ethiopia as one of the world's leading countries in hydro potential. The most promising hydropower development potential is found in the Blue Nile, Omo, and the Wabi Shebelle river basins (MEDaC, 1999). The energy potential of the country so far discovered comprises between 30 and 50 billion m^3 natural gas, more than 1000 MW geothermal power, and several hundred million tons coal and oil shale (Mariam, 1992). The total solar radiation reaching the territory is 2.3 TWh per year while wind energy potential is estimated at 4.8 million Tcal per year (CESEN, 1986). The country's woody biomass energy resources are about 14 million Tcal in standing stock and 0.93 million Tcal in terms of annual yield. The annual agricultural waste available for energy is about 176,000 Tcal per year. Although the country has abundant energy resources, its potential is not yet well developed due to lack of capacity and investment. For example only less than 1% of the total hydropower potential of the country is known to have been utilized so far.

The energy sector in Ethiopia is composed of three main sub-sectors: biomass, petroleum and electricity. Energy consumption is very low, with an estimated total per capita consumption of only about 0.2 tone oil-equivalent.

Woody biomass represents the principal form of cooking and lighting fuel in the country's rural areas, and an increasing fraction of the population is being confronted with the difficult choice between eating its food poorly cooked or travelling long distances to collect fuel for cooking. The scarcity of fuel wood has led to an increased utilization of dung and agricultural residues for cooking, which could otherwise have been used to enhance the nutrient status and texture of the soil and contribute positively to agricultural production. The total amount of energy generated from dung directly burned in household stoves is estimated at 56.3 TJ in the year 1998/99 and was about 8% of the total energy consumption in Ethiopia.

With a rapidly increasing population, cultivation is expanding in the region. Marginal and steep lands are increasingly being brought under cultivation, leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is taking place at the expense of communal lands on which most woody biomass resources are located, leading to a decline in these resources. Regionally, traditional fuels provide 99.8% of the total (rural and urban) domestic energy supply, with 88% derived from woody biomass, 10% from crop residues, 1% from dung and 0.1% from charcoal. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of declining stocks of wood fuel and the increasing opportunity costs in its collection or purchase. (Eshete G. and Workneh K., 2008: 5-6 & 9)

The big share of biomass fuels such as firewood, crop residues and dried dung in the country as well as in the region has obliged the rural mass to entirely depend on traditional fuels for their energy consumption. This use of energy is often coupled with many problems such as deforestation, land degradation, various health and social problems as well as raising the level of greenhouse gas emissions. As a solution to the problem, promotion and dissemination of renewable energy technologies are devised. Among other sources of renewable energy, biogas can be used as a replacement for these fuels and can help solve many of the problems that are associated with biomass fuels.

Rural areas of developing countries like Ethiopia are very dependent on biomass fuels such as firewood and dried dung for their energy consumption. This use of energy is often coupled with many problems such as deforestation, land degradation, various health and social problems as well as giving rise to greenhouse gas emissions. Biogas can be used as a replacement for these fuels and can help solve many of the problems that are associated with biomass fuels.

1.2 The Biogas Technology and Its Uses

The biogas digester is a physical structure that is also commonly referred to as a biogas plant or anaerobic digester. A biogas digester is essentially an underground and airtight pit that a user puts crops, animal manure, human faeces, and water into. Once a suitable bacteria culture has been developed inside the biogas digester, biological waste is mixed with water in a 2:3 ratio and retained for approximately 50-60 days (FAO 1997). It is estimated that 50-70 percent of the raw material fed into the biogas digester is eventually converted to usable biogas, resulting in an efficiency utilization rate 5 to 7 times greater than traditional burning of biomass energy (EWB, 2004).

Since biogas digester systems provide a reliable renewable energy resource that can be used for cooking, heating, lighting, and powering diesel engines, amenities such as reading light, heat for schools, and cheap fuel for machinery becomes available. Access to biogas also significantly reduces the need for conventional energy sources such as fuel wood, which degrades forest resources and require hours of strenuous labor to collect. Moreover, the anaerobic digestion process does not convert all of the organic material in the process into biogas. Material that is not converted is known as sludge, and is a potent organic fertilizer that can significantly enhance a farm's productivity (compared to conventional application of animal and human wastes). Biogas digesters produce high-grade fertilizer, which has been shown to be both safer and more productive than the original manure.

In addition to providing cheap fuel, improving farm productivity, and increasing household income, the use of biogas digester systems can significantly increase a rural farmer's environment and health conditions. Major environmental and health benefits accrued from biogas digester include reductions in indoor air pollution, water contamination, and deforestation. (Robert A White, 2008)

1.3 The Prospects and Challenges of the Uptake of Biogas Technology

As against the challenges facing the dissemination of the biogas technology in the region, prospects identified before and during the actual implementation of the different biogas development programmes could play remarkable role in mass dissemination of the domestic biogas digesters in the region. The renewed interest for renewable energy technologies at the international level, favourable energy policy of the country, the technical potential of the region, decentralized government structures, availability of fund to subsidize the construction investment and availability of various micro credit institutions shall help the development of the biogas sector as required.

Although the economic, environmental, and health benefits that an Ethiopian farmer can accrue from adopting a biogas digester system are clear, there remains several barriers that prevent mass biogas digester dissemination and adoption. Issues like high construction investment, lack of awareness among rural households about the technology's long term benefit, the under developed nature of the biogas market, low level of private sector development, poor supply networks, increasing number of non operational biogas plants and turn over and dropouts of skilled labour forces would inhibit the large scale deployment of the biogas technology in the country in general and in the region in particular.

2. Statement of the problem

Ethiopia is water -richest country in East Africa. Estimations of the forest cover accounts to as much as 40% of the country around 1900. Today, less than 3% of the natural forests remain intact. Available statistics indicate that the share of biomass in the global energy consumption has remained roughly the same over the last 30 years. Biomass energy accounted for an estimated 14% and 11% of the world's final energy consumption in 2000 and 2001, respectively. In Sub-Saharan African, about 50% of all primary energy comes from biomass. In Ethiopia, however, dependency from biomass amounts to 95% (Benjamin J., 2004). The situation in SNNPR is much worse than the country's profile. Regionally, traditional fuels provide 99.8% of the total (rural and urban) domestic energy supply, with 88% derived from woody biomass, 10% from crop residues, 1% from dung and 0.1% from charcoal. However these regional figures conceal considerable local variations in both supply and consumption. In addition, there are temporal changes in these patterns in the face of declining stocks of wood fuel and the increasing opportunity costs in its collection or purchase (Eshete G. and Workneh K., 2008)

The traditional biomass (more precisely fire wood), essential in meeting the local energy demand in many regions of the developing country and serving about 2.4 billion people in developing countries as a primary source of energy, already has become a scarce (and expensive) commodity, forcing the fuel wood carriers, mostly woman and children, to go for longer and longer distances. Additionally, the over utilization of the biomass for energy leads to a reduction in agricultural productivity as a result of using dung and crop residue as fuel instead of using these as soil nutrients. Due to the use of dung as a source of domestic energy it is estimated that 10% of the annual grain production is lost in Tigray region (Birhane *et al.*, 2005). The total demand for fuel wood in Ethiopia cannot be met by the sustainable exploitation of forest resources, village wood lots and fuel wood plants. Overall, the over-utilization of biomass resources leads to soil erosion, loss of arable land, loss of land productivity, decreasing yields, loss of water retention capacity of the soil, siltation of dams and reservoirs, a general land degradation and finally to desertification.

At present, the demand in Ethiopia for fuel wood is around 58 million m^3 per year, while sustainable supply lies at only about 11 million m^3. Sustainable supply for fuel wood refers to the amount of wood in the form of branches, leaves and twigs (BLT) taken out of the forest, without damaging the structure of the trees. Or, in other words, at the end of one year, after fire wood has been removed constantly from the forest, the capacity of the forest is the same as at the beginning of the year. By utilizing appropriate calculation methods, one can estimate the sustainable yield of fuel wood in Ethiopia – as was done by the Ethiopian Forestry Action Plan (EFAP) in 1996. They calculated the annual deficit to be about 47 million m^3 in the year 2000 and more than 58 million m^3 in 2005 (Benjamin J., 2004).

The associated harmful environmental, health and social effects with the use of traditional biomass and fossil fuel has enhanced the growing interest in the search for alternate cleaner source of energy globally. Among other forms of clean source of energy, biogas energy can be mentioned as a source of energy for the people of Ethiopia in general and in SNNPR in particular.

Biogas generation has simply been seen as a by-product of anaerobic digestion of organic waste. Having proven to be a practicable and promising technology, it has been very successful and a very reliable and clean source of energy when proper management programmes are pursued. There are vast biomass resources including organic waste in Ethiopia that have the potential to use as feedstock for biogas production and to reduce the over reliance of wood fuel and fossil fuel, and to help reduce the greenhouse gas emissions which may be affecting climate change.

In Africa particularly in Ethiopia, biogas technology dissemination has been relatively unsuccessful though the technology has proven to be very essential to improve the livelihood of the rural people. This is attributed to failure of government to support biogas technology through a focused energy policy, especially before the National Energy Policy of 1994, poor design and construction of digesters, wrong operation and lack of maintenance by users. In addition, poor dissemination strategies, high investment cost of the technology, lack of project monitoring and follow ups by promoters and implementers, and poor ownership responsibility by users have also lead to the dissemination challenges.

According to Eshete G. and Workneh K. (2008), SNNPR state would have the technical potential of constructing about 152,000 household biogas plant installations. However, only 104 biogas plants have so far been established by governmental bodies and different NGOs since the first biogas installation in Woliyta Soddo in 1968 E.C. for the purpose of education in Agricultural College's compound. Between 2008 and 2013, 1949 biogas digesters have been constructed in the region (SNNPR MEA, 2013). From the 1949 digesters, 1724 biogas digesters were constructed by the ongoing NBPE and 225 digesters by NGO called Livelihood Improvement Volunteers Association (LIVA) which has been working in Halaba woreda. Up to the end of 2013, therefore, 2053 biogas digesters were installed in the region.

The proposed research is envisaged to investigate the prospects for mass dissemination of this important technology and the problems that hinder its development in the region.

3. Research Objectives

3.1. General Objectives

The overall objective of this study is to assess the prospects for mass dissemination of domestic biogas technology, to identify the challenges in the regional context and to make possible recommendations for mass dissemination of biogas technology.

3.2. Specific Objectives and Questions

To assess the prospects for mass dissemination of the technology at the regional level.

What are the prospects for mass dissemination of the technology at the regional level?

To assess the challenges that hinder mass dissemination of the biogas technology.

Are there challenges that hinder mass dissemination of the technology?

To make possible recommendations for mass dissemination of biogas technology in the region.

What could be recommended for successful adoption of biogas technology in SNNPR?

4. Literature Review

Reliance on traditional biomass energy is particularly high in sub-Saharan Africa, accounting for up to 95% of the total energy consumption in some countries. The very high figure (81.8%) registered for combustible renewable and waste energies consumption is a reflection of heavy reliance on biomass energy, which is used primarily at household level (ADB, 2006).

The woody biomass demand survey in Ethiopia shows that the biomass fuels provide more than 90% of the total energy supply of the country with 77.9% being derived from woody biomass, 7.3% from crop residue and 7.5% from dung (Plas et al, 2004).

Domestic energy in rural Ethiopia has a heavy reliance on biomass fuels, a relatively high domestic energy consumption (>700kg/cap/annum), and uses low levels of renewable energy or energy efficiency technologies, so the energy demand in most areas significantly exceeds supply. There is a significant energy deficiency in rural Ethiopia with an increasing cost for household energy. This results in pressure on existing resources; deforestation/

desertification, internal migration to resourceful areas, loss of biodiversity, degradation of soils (large eroded areas with gullies, and reduction of soil fertility), reduction of agricultural productivity (both for cropping as well as livestock), increased health cost due to the effects of indoor air pollution, and increasing household workloads (Eshete et al, 2004).

Small-scale biogas digesters have great potential to contribute to sustainable development by providing a wide variety of socioeconomic benefits (Mshandete and Parawira, 2009), including diversification of energy supply, enhanced regional and rural development opportunities, and creation of a domestic industry and employment opportunities (Rio and Burguillo, 2008). Potential environmental benefits include reduction of local pollutants, reduced deforestation due to logging for fuel, and increased sequestration of carbon (C) in soils amended with the digested organic waste (Lantz et al, 2007).

Ethiopia has the largest livestock population in Africa. A survey in 2003 counted 35 million cattle, 25 million sheep, and 18 million goats. Livestock is an integral part of nearly all the mixed type highland farming systems and principal store of farmers' wealth. Agriculture employs 80 percent of the population and accounts for almost 50 percent of the Gross Domestic Product (GDP). Smallholder farmers, generally with less than 1 hectare of land account for about 95 percent of the agricultural output. In times of good weather, roughly 75–80 percent of the annual output is consumed at the household level (World Bank, 2006). Despite being blessed with livestock, for many years Ethiopia couldn't enjoy the social, economic and environmental benefit through the use of cow dung as a clean source of energy (biogas); rather, the dung in the form of dung cake is burned directly which otherwise could have been used as a feed stock for biogas generation where the sludge can be used as an organic fertilizer (Biruk, 2010).

In a review of socio-economic factors affecting adoption of biogas digesters in 5 countries in Sub-Saharan Africa; Kenya, Nigeria, Uganda, Tanzania and Sudan, most factors affecting adoption were associated with costs and ability to pay; family income, size of farm, construction costs, costs of traditional fuels and availability of credit facilities. Other factors were associated with availability of feedstock; number of dairy cattle, average cost of a dairy cow, and land and water availability. Education, awareness, and type (e.g. age and sex) of household head were also factors affecting adoption. There is a need to address country specific requirements for widespread adoption of biogas digesters to be achieved. Costs and subsidies for purchase are important issues that could have a strong impact on adoption. Cheaper materials are needed for construction, and credit facilities are required. Reduction of retention time from 60 to 30 days reduces by half the size of the plant needed, with a significant reduction in construction cost. Awareness of the value of biogas digesters needs to be addressed, using different methods of dissemination, such as electronic and printed media, workshops, field days, demonstrations, and farmer to farmer contacts (J.U.Smith, 2011).

5. Methodology

5.1. Background of the Study Area

Covering a total area of 109,015 square kilometers with a share of 10% of the country, Southern Nations, Nationalities and People's Region (SNNPR), located in the southern and south-western part of Ethiopia, roughly lies between 4˚.43 – 8˚.58 north, latitude and 34˚.88 – 39˚.14 east longitude. The region is bordered with Kenya in South, the Sudan in the southwest, Gambella region in the northwest and surrounded by Oromia region in the northwest, north and on the east. (SNNPRS BoFED, 2010).

The population size of the region is 16,333,622 (CENSUS, 2002) accounting to nearly 20% of the country's total population. Rural population growth rates for the period 1995-2000 were projected to be 2.98% per annum and urban rates 5.22%. Some 93% of the population lives in the rural areas (Eshete G. and Workneh K., 2008). The average population densities of the region became 149.8 persons per sq.km, which makes the region one of the most populous parts of the country.

The region comprises a multination population of about 56 ethnic groups with their own distinct geographical location, languages, cultures, and social identities. These varied ethnic groups are classified in to the Omotic, Cushitic, Nilo-Saharan and Semitic super language families. Among which, the Omotic and Cushitic are the most populous and diversified ones with the largest area coverage in the region. Based on ethic and linguistic identities the region is at present divided into 14 zones-sub-divided in to 126 woredas and 8 special woredas. According to the zonal reports of 2002 E.C, the region is composed of 3733 rural kebeles. Regarding urban areas there are 22 town administrations and 171 certified towns with municipality city status, having a total of 299 urban kebeles (SNNPRS BoFED, 2010)

5.2. Universe of the Study

The Southern Nations, Nationalities and People's Region shall be the universe of this descriptive research. All woredas of the region are not included in the study rather only few woredas having biogas digesters already and included in the on-going National Biogas Program of Ethiopia (NBPE) shall be the focus of this survey. Out of the 20 biogas program woredas included up to December 31st, 2013 in the on-going NBPE, 4 woredas will be selected for this study. These woredas are Arba Minch zuria, Meskan, Aleta Wondo and Soddo zuria. In the survey, non beneficiaries of domestic biogas technology, biogas masons and companies, construction materials and appliance suppliers, manufacturers of appliances, partners from public sectors, MFIs, universities and Non Governmental Organizations from the selected four woredas shall be contacted to collect first hand and second hand information.

The above mentioned four woredas represent four zonal administrations of SNNPR. Accordingly, Arba Minch zuria belongs to Gamo Gofa zone, Meskan woreda is from Gurage zone, the woreda Aleta Wondo belongs to Sidama zone, and Soddo zuria belongs to Woliyta zone. Additionally, financial and time constraints are considered in the selection of the woredas and hence woredas in the range of 300km from the regional capital city, Hawassa, have been given priority.

5.3. Sampling and Sampling Size

Both probability and non probability sampling technique will be employed in order to get the required reliable data for the survey and to achieve the objectives of the study. Systematic sampling technique will be employed from probability sampling and purposive sampling techniques.

The purposive sampling will be used to select the woredas which are included in the NBPE of SNNPR. Accordingly, four woredas and their respective capitals and Hawassa city, the capital of SNNPR, which are essential in meeting information related to the prospects and challenges in disseminating domestic biogas technology in SNNPR will be selected. Moreover, leaders and experts of coordinating and implementing offices (from regional level to woreda level) shall be included to get their valuable opinion in the dissemination of domestic biogas technology in the region.

The four woredas are selected based on their high potential for dissemination of biogas in mass base and their high relative contribution to the overall plan achievement of the on-going NBPE in SNNPR since 2008**.** The high technical potential for domestic biogas dissemination of these four woredas is confirmed by a report on feasibility study of a national programme for domestic biogas in Ethiopia, baseline surveys and field level scanning for woreda selection. The south NBPE has installed a total of 1724 biogas digesters in twenty woredas as on December, 2013. From these total digesters, these woredas take a share of 766 digesters. Arba Minch zuria and Meskan woredas have joined the NBPE since 2008 and have shared a total of 467 digesters (Arba Minch zuria woreda contributed 213 digesters and Meskan woreda contributed 254 digesters). Aleta Wondo woreda, which joined the NBPE in November, 2010 has implemented 216 biogas installations. 83 digesters have been installed in Soddo zuria woreda, which joined the NBPE in 2011. Before the launching of the NBPE in Ethiopia particularly in SNNPR, biogas installation was practiced in 48 woredas of the region by the Ministry of Agriculture and Rural Development, Rural Energy Development and Promotion Center, and NGOs as a Pilot project and demonstration.

The systematic sampling technique will be employed to select the non- beneficiaries of domestic biogas in each of the four woredas and this will assure the inclusion of the different perspectives and values reflected by these distinct groups on possessing the biogas technology as a mechanism in improving their livelihood. Non beneficiary selection through systematic sampling shall not be made from all kebeles existing in each of the mentioned four woredas; rather, those kebeles possessing biogas plants up to the end of 2013 will be targeted. Moreover, these non beneficiaries will be neighbors of existing biogas users and should meet the technical criterion set for biogas users. Accordingly, A/Minch zuria, Meskan, Aleta Wondo and Soddo zuria shall be represented by 9, 20, 15 and 21 kebeles, respectively.

The sample size of non beneficiaries per selected woreda shall be based on the proportion of the biogas plants installed in each woreda until the end of 2013. Accordingly, the non beneficiaries selected from A/Minch zuria, Meskan, Aleta Wondo and Soddo zuria woreda for the study purpose are 32, 38, 32 and 13 respectively. In all, a total of 123 non beneficiary households shall be selected from the selected four woredas for this particular study.

Additionally, purposive sampling technique will be used to select key informants to address issues related to government's commitment in supporting the biogas sector, private sector development, financing biogas construction investment and partnership and stakeholder's participation.

A total of 35 organizational leaders/senior experts of different public sector organizations, which are directly or indirectly related with the dissemination of biogas technology, shall be included purposively in the study. These public organizations are from both regional level and woreda level and they are established to address development issues of energy, agriculture, women and children, health, trade and industry and rural youth employment offices. In addition to these organizations regional administration bureau and the four woreda administration offices shall be included purposively.

Suppliers of construction materials and biogas appliances, biogas construction enterprises as well as biogas appliance manufacturers are private sectors that shall be included purposively in this study. A total of 21 key informants representing 10 biogas construction materials and appliances supplying institutions, 6 potential biogas appliance manufacturing enterprises and

5 prospective biogas construction enterprises (BCE) will be interviewed purposively. The study shall include 2 suppliers and 2 manufacturers per woreda. Similarly, 2 suppliers and 2 manufacturers from Hawassa city administration shall also be included. The BCE composition shalll be 1 BCE per woreda and 1 BCE from Hawassa city.

With respect to financing of the biogas plant construction, 12 key informants from different micro-finance institutions and cooperatives will be contacted purposively to collect data related to willingness and experiences in financing the biogas technology dissemination. These informants will be included from 5 Omo Microfinance Institutions (regional OMFI office and 4 OMFI branch offices located in the 4 woredas), from 4 WISDOM Microfinance Institutions (4 WISDOM MFI offices located in the 4 woredas), from Sidama Microfinance Institutions, from Agar and Mekilit Credit and Saving Institution based in Butajera town, capital of Meskan woreda.

Partnership and stakeholder's participation are keys to meet issues related to promotion, capacity building, research and development. Purposive survey shall be made by involving 12 key informants from selected organizations working on these particular areas. The informants shall be selected purposively from 5 TVETs based in the capital of the selected woredas and in Hawassa city, 3 universities (Arba Minch University, Woliyta Soddo University and Hawassa University) and 4 NGOs based in the selected woredas and working in development areas directly or indirectly related to the benefits of biogas technology.

Individuals who are knowledgeable and experienced in coordination and implementation of the biogas technology development shall also be part in this study and 1 focal group discussion (FGD) shall be made. The FGD shall include a total of 5 individuals currently working in the regional Mines and Energy Agency- Biogas Program Coordination Unit and SNV Ethiopia as coordinator, experts/officers and technical advisor.

5.4. Data Collection: Tools and Procedures

Depending up on the nature of the topic to be researched different types of data collection tools can be used in social research. In this particular research a combination of tools shall be employed to get the required data and information.

The main tool of data collection shall be the interview schedule which shall be used to collect data from non beneficiary households and private sectors. The interview schedules shall contain mostly close-ended questions, though some open-ended questions shall also be included. To ease communication with rural households and some private sectors, the interview schedule shall be translated into Amharic, the National official language of Ethiopia. The data collection tool will be pre-tested in selected households, microfinance institutions and private sectors prior to the main survey and the pre-test shall be conducted in kebeles outside the sampling frame.

Questionnaires, both close-ended and open-ended, shall be another important tool to be administered to collect data from leaders/senior experts of public sector organizations, microfinance institutions and stakeholders.

In addition to interview schedule and questionnaires, focal group discussion shall be used as data collection tool to meet the opinions, attitudes and perception of well experienced staff of the regional energy sector or regional biogas program coordination unit.

Moreover, a substantial level of information will be obtained from secondary sources, such as unpublished reports, journals, literatures and prior studies on mass dissemination of biogas technology. These would be used as a means of triangulating the quantitative findings of the survey and to adopt welcoming experiences outside Ethiopia.

6. Methods of Data Analysis

The data collected using the above mentioned tools shall be analyzed with the aid of appropriate methods of analysis. The data collected through interview schedules and questionnaires shall be coded, scrutinized, verified, edited and arranged serially. Then, Statistical Package for Social Sciences (SPSS) shall be employed to present results of the survey.

Besides, the qualitative data gathered via focus group discussion shall be copied and organized regardless of the basic research questions to discuss in comparison with the quantitative data obtained through the scheduled interviews and questionnaires.

7. Chapterization

The proposed research shall contain a total of five chapters. The first chapter shall be an introduction to the subject matter of the study under investigation. Within the main topic, background and rationale, the energy scenario in Ethiopia, biogas technology, research problem, research focus and limitations and research objectives shall be described.

The prospects and challenges of the uptake of biogas technology shall be the main topic in the second chapter. The main issues covered in this topic shall be in depth background information about the factors in favour of and against mass dissemination of biogas technology in the region.

The third chapter shall deal with the role of micro finance institutions and private sectors in boosting biogas dissemination. Review of literatures shall be made and appreciable experiences from countries with good track record in integrating micro finance and private sector in the biogas dissemination program shall be considered.

The fourth chapter shall be research methodology. Research strategy, data collection, analytical framework and limitation and potential problems to be faced in the course of the study shall be covered.

Chapter five shall reveal the findings of the survey. This chapter discusses the main findings, analyze the data collected from primary and secondary sources, synthesize the empirical findings and make possible recommendations for mass adoption of biogas technology.

8. Budget Estimate

Budget shall be required to the research activities mentioned below in the table. Accordingly, a total of birr 29,360 is estimated to conduct the proposed research.

S/N	Items/Research Activities	Budget /Birr/	Remark
1	Data Collection/1 Investigator	5,200	200 birr per day for 26 days
2	Data Collection/8 Woreda assistant	16,800	100 birr per day for 21 days
3	Stationeries, typing & binding	5,000	
4	Refreshments/FGD/	300	
5	Transportation /Motorcycle rent for assistants	2,100	100 birr per day for 21 days
	Total	**29,400**	

9. Reference

ADB (July, 2006), Report on the ADB FINESSE *Training Course on Renewable Energy and Energy Efficiency for Poverty Reduction*, Nairobi, Kenya. AFREPRRN/FWD.

Benjamin J. (2004), *Renewable Energy and Development*, Brochure to accompany the Mobile Exhibition on Renewable Energy in Ethiopia, Addis Ababa.

BIRHANE, E., TILAHUN, M. & TEWOLDE-BERHAN, S. (2005) Assessment on Vulnerability of Women to man Made and Natural Calamities in Tigray. Mekelle, Mekelle University.

CENSUS (2002), CENTERAL STASTICAL AGENCY (CSA), Addis Ababa

Desai, Manish A; Mehta, Sumi; Smith, “Indoor Smoke From Solid Fuels: Assessing the Environmental Burden of Disease at the National and Local Levels” World Health Organization (WHO), 2004

ESHETE, G., KABO, M., WIJNHOUD, J. D. & SIMS, R. (2004) Identification Study on Renewable Energy and Energy Efficiency in Southern Nations and Nationalities Peoples Regional State and Ethiopia.

Eshete G. and Workneh K. (2008), *National Biogas Programme Ethiopia:* Programme Implementation Document

(EWB) Engineers without Boarders, “The Biogas Digester— A Sustainable Energy Production Technology for Rural Development in Sub-Saharan Countries,” Sustainable Development Research Competition, April 5, 2004

FAO (Food and Drug Administration of the United Nations), "A System Approach to Biogas Technology" Kathmandu, Food and Agriculture Organization/Consolidated Management Services, 1997. http://www.fao.org/sd/Egdirect/Egre0022.htm

J.U.Smith (2011), The Potential of Small-Scale Biogas Digesters to Alleviate Poverty and Improve Long Term Sustainability of Ecosystem Services in Sub-Saharan Africa.

Lantz, M., Mattias, S., Bjornsson, L., Borjesson, L. (2007): The prospects for an expansion of biogas systems in Sweden —incentives, barriers and potentials. Energy Policy, 35, 1830–1843.

MARIAM, H. G. (1992) Rural Electrification in Ethiopia: 67-111.

MEDAC (1999) Water for Energy. IN REPORTS, C. (Ed.) Ethiopia. Addis Ababa, Ministry of Water Resources

Mshandete, A.M., Parawira, W. (2009) Biogas technology research in selected sub-Saharan African countries - A review. African Journal of Biotechnology, 8, 116-125.

Plas, R.J, Openshaw, K., Madon, G., Visser, P.Hood, A.., Siemons R.M.et al (2004), Ethiopia Rural Biomass Strategy Final Report. Biomass Technology Group (BTG)

Rio, P., Burguillo, M. (2008) Assessing the impact of renewable energy deployment on local sustainability: Towards a theoretical framework. Renewable and Sustainable Energy Reviews, 12, 1325–1344.

Robert A White (2005), The Role of Biogas in Rural Development and Resource Protection in China: A Case Study of Lijiang Municipality, Yunnan Province, China

Rugby, “Biogas and Liquid Biofuels.” Intermediate Technology Development Group, 2004.

SNNPRS Bureau of Finance and Economic Development, Regional Stastical Abstract, 2002 E.C (2009-10).

SNNPRS Mines and Energy Agency (MEA)/Regional Biogas Program Coordination Unit (RBPCU), 2012 Annual Report

Curriculum Vitae

Personal Date:

Name:	Mengistu Hulluka Deyas (Dr.)
Academic Rank:	Associate Professor Haramaya University of Agriculture, Ethiopia
Date of Birth:	March 27, 1941
Place of Birth:	Addis Ababa, Ethiopia
Nationality:	Ethiopian
Marital Status:	Married, three children
Language:	English, Amharic, Guraghgna, Italian (Fair)
Address:	**Office:**

St. Mary's University College
P.O.Box 1211
Addis Ababa
Ethiopia Tel: 0115524566 E-mail: ethiopique1@live.com

Residence: P.O.Box 1208
Debre Zeit
Ethiopia
Tel: Mobile 00251912294041
Res. 00251114370991

Educational Background:

Ph.D.	-	University of Nebraska, USA, 1972
M.Sc.	-	University of Minnesota, USA, 1966
B.Sc.	-	Haile Selassie University, Ethiopia, 1963

Administrative Experience

May 2010 -	Dean, School of Graduate Studies, St. Mary's University College
April 2006 – 2009	Ambassador Extraordinary and Plenipotentiary of the Federal Democratic Republic of Ethiopia to the Hellenic Republic

2002 – 2006	Ambassador Extraordinary and Plenipotentiary of the Federal Democratic Republic of Ethiopia to Italy
1998 – 2001	Minister, Ministry of Agriculture
1993 – 1998	Academic Vice President, Haramaya University of Agriculture
1988 – 1993	Head, Crop Protection Program, Debre Zeit Agricultural Research Center
1981 – 1985	Dean, College of Agriculture, Addis Ababa University
1978 – 1981	Assistant Dean for Academic Affairs, College of Agriculture, Addis Ababa University

Professional Experience

1993 -	Associate Professor
1988 – 1993	Assistant Professor, Senior Research Scientist, Debre Zeit Agricultural Research Center, Haramaya University of Agriculture
1986 – 1987	Sabbatical leave in USA, Texas, A & M University and Bonn University
1978 – 1981	Assistant Dean for Academic Affairs, College of Agriculture Addis Ababa University, Haramaya, Ethiopia
1972 – 1978	Assistant Professor, Department of Plant Sciences, Addis Ababa University, and Head of Crop Protection Section

Course Instruction

Post Graduate:	Advanced Plant Pathology, Survey of Crop Diseases, Storage Diseases,
Undergraduate:	Anatomy and Morphology, Plant Pathology, Crop Protection, Mycology, Forest Pathology, Forest Protection

Technical Advisory Activities

2000 – 2002	Chairman, Board of Trustees, South University, Ethiopia At Ministerial Capacity, served as chairman and member of committees of different organizations: National Seed Industry Agency; Environment Protection Agency; Institute for Bio-diversity and Conservation Research; Ethiopian Agricultural Research Organization; Civil Service College; etc.
1995 – 2000	Member, Board to Trustees, Southern Higher Education Institutions, Ethiopia

1993 – 1994	Chairman, Committee for assessing the structural functional relationship of Departments and Administrative Units at Haramaya University of Agriculture
1992 – 1993	Chairman, Committee for preparing a working paper on consolidating agricultural institutions under one umbrella
1990 – 1991	Member, Committee for upgrading Hawassa Junior College of Agriculture from a diploma program to a degree program
1988 – 1993	Member, Research and Extension Liaison Committee, East Shoa Region, Ethiopia
1988 – 1990	Chairman, Research and Publication Committee, Debre Zeit Agricultural Research Center
1983 – 1985	Member, Task-force for Upgrading the College of Agriculture at Haramaya, Ethiopia to a full-fledged University
1974 – 1976	Coordinator, Forestry and Crop Disease Management Activities in the National Campaign for Cooperation and Development

International Experience

1997	USA	Working visit at Langston University Oklahoma
1995	Ghana	Workshop on Extension Education to Mid-career front-line extension agents
1994	USA	Working visit to various Universities
1993	Egypt	Instructor in Sub-regional Training Course on Cereal Disease Methodology
1992	Sudan	Nile Valley Regional Program on Cool Season Legumes and Cereals, Regional Coordination Meeting
1991	Kenya	The 7th Regional Wheat Workshop for Eastern, Central and Southern Africa
1990	Israel	Educational Visit and Research Program Arrangement at Tel Aviv University
1988	Zimbabwe	Second Global Review of Sorghum and Millet Pathology
1988	USA	Working visit to Cereal Rust Laboratory, St. Paul, Minnesota
1988	Mexico	Scientific Tour in CIMMYT
1987	Germany	Bonn University – Cooperative Research Program
1986	USA	Sabbatical Leave (10 months)
1985	Kenya	Seminar on Population Aspects in Curriculum Development
1984	Cameroon	Seminar on Food and Nutrition Program
1984	Italy	Working visit to FAO Headquarters
1984	Bulgaria	Educational tour to Universities and Research Centers
1984	France	Educational tour to Universities and Research Centers
1983	Britain	Educational tour to Universities and Research Institutions

1979	Germany	Tour to Educational and Research Institutions
1978	India	International Workshop on Sorghum Diseases, ICRISAT
1974	Italy	Training on the Use of Atomic Energy to Plant Breeding for Disease Resistance
1969	Malawi	Conference on Crop Improvement
1969	Zambia	Conference on Crop Improvement

Awards and Grants

1994 Grant by the University of Haifa (Institute of Evolution, Israel, in Cooperation with GIFRID Project 157, INT 60 – 94) Study on Wild Barely (Hordeum Sponatanum).

1991 FAO Research Grant (Project No. ETH/88/010). Baseline Survey of Forest Diseases in Ethiopia.

1987 AUA Research Grant – Studies on Wheat and Tef Diseases.

1986 Fulbright Visiting Scholar Award, Texas A & M University.

1972 AAU Research Grant – Studies on Sorghum Diseases in Ethiopia.

1969 Rockefeller Foundation Fellowship, University of Nebraska, USA.

1964 US AID Scholarship, University of Minnesota, USA.

Post – Graduate Students Thesis Research Advisor-ship

Guidance and supervision was rendered to 30 M.Sc. students on thesis research work as principal advisor and co-advisor. The titles of the theses are as follows:

1. Mycoflora associated with grain sorghum in pits and the role of four different species of fungi on the quality of sorghum grains in Haramaya district, Hararghe, Ethiopia (1983).

2. The relative susceptibilities of some potato (*Solanum tuberosum L.*) cultivars to late blight (*Phytophthora infestans*) (Mont) de Bary and screening of fungicides for control of the disease (1984).

3. Distribution and prevalence of physiologic races of *Puccinia graminis tritici* in some parts of Ethiopia and reaction of wheat cultivars to these races (1984).

4. Identification and characterization of *Coffea Arabica* L in Habro, Hararghe, Ethiopia (1985).

5. The occurrence and distribution of races of Hemileia vastrarix B. and Br. And of physiologic Resistance Group of *Coffea arabica* L. in Ethiopia. (1985).

6. Prevalence and distribution of bacterial wilt (*Pseudomonas solanacearum*) in some major potato growino regions of Ethiopia and reactions of some cultivars to the diseases. (1986).

7. A study of varietal resistance in pepper (*Capsicum spp*) against some isolates of pot viruses distributed in Ethiopia (1987).

8. Evaluation of sorghum (*Sorghum bicolor*) lines for resistance to leaf anthracnose and characterization of *Collectrichum graminicola* isolates (1988).

9. Characterization of *Ustilago scitaminea* SYD isolates and evaluation of sugarcance (*Saccharum officinarum* L.) varieties for resistance to smut (1991).

10. The biology, significance and control of maize weevil, *Sitophilus zeamais* MOTSCH. (Coleoptes: Curculindae) on stored maize.

11. The biology and control of the Adzuki bean beetle (*Callosobruchus chinesis* L.) (COLEOPTERA: BRUCHIDAE) on chickpea (*Cicer arietinum* L. (1991).

12. Laboratory and field evaluation of Bacillus thuringiesis BERLINER VAR. kurstaki on African Bollworm, *Helicoverpa armigera* (HUBNER) (1992).

13. Prevalence of sugar cane smut (*Ustilago scitaminea* SYD) at Wonji/Shoa Sugar estate & evaluation of hot water and fungicidal treatments as control measures (1992).

14. Studies on barely scald (*Rhynchosporium secalis* (Oud.) Davis and evaluation of barley lines for resistance to the disease in Ethiopia (1993).

15. Phenology and management of the mazie stalk borer *Busseola fusca* (Fuller) Lepidotera: (Noctudae) on sorghum in Eastern Ethiopia (1993).

16. Investigation of damping – off disease of coffee (*Coffee Arabica* L.) in Sidamo, Ethiopia (1993).

17. Studies on the epidemiology of chocolate spot (Botrytis fabae sard.) of faba bean (*Vicia faba* L.) (1993).

18. Studies on the mycoflora and aflatoxin of ground nut seed in Eastern Ethiopia (1994).

19. Studies on leaf Blight (*Exserophilum turcicum* (poss) Leonard and Suggs) and evaluation of maize germplasm for resistence to the disease in Ethiopia (1994).

20. Studies on the economic importance and control of bean bruchids in haricot bean, *Phaseolus vulagaris* L. in Eastern and Southern Shewa (1994).

21. Survey of weed flora and evaluation of some foliage applied herbicides in the sugar cane (*Saccharum officinarum* L. plantations of Wonji, Shoa, and Metahara Sugar Easttes (1994).

22. Distribution of head smudge disease of tef (*Eragrostis* tef) and variability of the pathogen (*Drechstera* spp.) in Wollega, ETHIOPIA (1994).

23. Effects of grass weed on selected crop and weed vegetative parameters and yield components (1996).

24. Variation in isolates of *Xanthomonas campestris pr. holcicola* (Bacterial Streak of Sorghum) 1996).

25. The effect of Bean *(Phaseolus vulgaris)* cultivar mixtures on development of bean rust and common bacterial blight (1997).

26. Distribution of root-knot nematodes (*Meloidogyne spp*.) in some vegetable farms in Hararghe, Eastern Ethiopia (1997).

27. Characterization of *Gibberella xylarioides* Heim and saccas, (Fusarium wilt) of coffee (*Coffee Arabica* L.) (1997).

28. Determination of critical period of weed control and the effect of mixed weed population on maize (Zea mays L.), yield and yield components.

29. Influence of micro – environment in the development of stem rust (*Puccinia graminis f. sp. Tririci*) epidemics on durum wheat (*Tiricum turgidum* L. car. Durum) at Debre Zeit.

30. Incidence of tracheomycosis, *Gibberella xylarioides (Fusarium xylarioides)*, on Arabica coffee in Ethiopia.

Publications

Theses

1. Mengistu Hulluka. 1996. Reaction of oat varieties to races of *Puccinia graminis pers. F. Sp. Avenae* (stem rust). M.Sc. Thesis)

2. Mengistu Hulluka. 1972. Population trends of bean wilt bacterium *(Corynebactrerium flaccumfaciens*) in three bean cultivars. (Ph.D. Thesis)

Scientific Journal Articles (Peer reviewed)

1. **Hulluka, M.** and Robert, B.J. 1966. Reaction of a select group of oats to races 6AF and 6AFH of oat stem rust and a new source of resistance to stem rust. Plan Dis. Reptr. 50(9): 631 – 633.

2. **Hulluka, M.** Schuster, M/L./ weighing, J.L., and coyne, D.P. 1978. Population trends of *Corynebacterium flaccumfaciens* strains in leaves of phaseolus species. Fitopatologia Brasileira 3:13 – 26.

3. Schuster, M.L., Coyne, D.P. and **Hulluka, Mengistu** 1978. Characterization of bean bacterial diseases and implications in control by breeding for resistance. Fitopatologia Brasileira 3:149 – 161.

4. **Hulluka, M.** 1984. Sorghum disease at some locations in Ethiopia. Ethiopian Journ. Of Agriculture Sci. 4(1): 45 – 53.

5. **Hulluka, M.** 1984. Fungi recovered from seeds of sorghum (sorghum bicolor L. moench) and studies on seed treatment. African Jour. Of Agric. Sci. 9: 1 + 2): 125 – 129.

6. Andnew, Yeshi and **Hulluka, M**. 1986. Reaction of selected sorghum varieties to bacterial streak and characterization of isolates of *Xanthohomonas campestris pv. Holcicola* (Elliott) Starr and Burk. Ethiopian Journ. Of Agr. Sci. 7(2): 99 – 107.

7. Wondimu, M and **Hulluka, M.** 1987. Distribution of races of *Hemeilia vastarix* B. & Br and physiologic resistance groups of coffea Arabica L. in Ethiopia. Ethiopian Journ. Of Agr. Sci. 9(1): 25 – 37.

8. Biratu, T and **Hulluka, M.** 1988. Studies on Colletorichum species associated with coffee berry disease. Ethiopian Journ. Agri. Sci. 11(1): 1 – 6.

9. Biratu, T., **Hulluka, M.** and Hindorf, H. 1990. In vitro evaluation of fungicides against *Colletorichum coffeanum* Noack, incitant of coffee berry disease. Med. Fac. Landbouww. Rijksuniv. Gent. 55(31): 975 – 982.

10. **Hulluka, M.** and Fredericsen, R.A 1992. Sources of resistance to downy mildew (*Peronosclerospora sorghi*) in Ethiopian sorghum. East Africa Agric, And For. Jour. 57(2)

11. **Hulluka, M.** and Ahmed, S. 1993. Occurrence of garlic bulb rot, in Ethiopia. FAO Plant Protection Bulletin 41 (2): 124.

12. Ayalew, A., Abate., **Hulluka, M.** 1995. Mycoflora, aflatoxins, and resistance of groundnut cultivars from Eastern Ethiopia. SINET: Ethiopia. J. Sci. 18(1): 117 – 131.

13. Tadesse, S. Ahmed and **M. Hulluka**, 1996. The effects of minimum tillage on weeds and yield of durum wheat in central Ethiopia. Crop Agric. (Trinidad) 73 (No. 3) 242 – 244.

14. A. Tefferi, **M. Hulluka**, and H.G. Welz. 1996. Assessment of damage and grain yield loss in maize caused by northern leaf blight in western Ethiopia. Jour. Of plant diseases and protection 103 (4): 353 – 363.

15. Taye Tessema, D.G. Tanner and **M. Hulluka**, 1996. Grass weed competition with bread wheat in Ethiopia: I. Effects on selected crop and weed vegetative parameters and yield components. African crop sci. Jour. 4(4): 399 – 409.

16. Girma, A. and **Mengistu, H.** 2000. Cultural characteristics and pathogenicity of *Gibberella xylarioides* isolates on coffee. Pest Mgt. Journal of Ethiopia 4: 11 – 18.

17. Girma A., **Mengistu, H.** and Hindorf, H. 2001. Incidence of tracheomycosis, *Gibberella xylarioides* (fusarium xylarioides) on Arabica coffee in Ethiopia. Journal of Plant Diseases and Protection. 108(2): 136 – 142.

1. Hulluka, M. 1977. Important sorghum diseases in Ethiopia. In: proceedings of the workshop on sorghum improvement in Ethiopia, 27 – 29 Oct., 1977. Nazareth, Ethiopia.

2. Hulluka, M. and Brhane, G.K. 1978. Diseases of sorghum in Ethiopia. In: proceedings of the international workshop on sorghum diseases, 11 – 15 Dec., 1978. ICRISAT, Hyderabad, India.

3. Hulluka, M. and R.A Frederiksen. 1987. Disease resistance and sorghum culture in Ethiopia. In: proceedings of Fifteenth Beinnial Grain Sorghum Research and Utilization Conference, 15 – 17 Feb., 1987, Lubbock, Texas.

4. Biratu, T. W. and Mengistu Hulluka. 1990. Identification of Colletotrichum spp. From coffea Arabica in Ethiopia. Anniversary meeting on "*Colletotichum*: Its Biology, Ecology, Pathology and control". British society of plant pathology, Univ. of Bath, 12 – 14 December, 1990.

5. Mengistu Hulluka. 1988, Evaluation of sorghum germplasm for downy mildew (Peronosclerospora sorghi) resistance, In: proceedings of the 13th conference of Ethiopian phytopathological committee, 11 – 12, March 1988, Addis Ababa, Ethiopia.

6. Yeshi Andnew and Mengistu Hulluka. 1988. Incidence of bacterial stripe and black disease of wheat at Debre Zeit. In: proceedings of the 13th conference of Ethiopian phytopath committee, 11 – 12, March 1988, Addis Ababa, Ethiopia.

7. Yeshi Andnew and Mengistu Hulluka. 1988. Incidence of Sclerotium wilt (*S. rolfsii*) on durum wheat at Debre Zeit. In: proceedings of the 13th conference of Ethiopian phytopath Committee, 11 – 12, March, 1988, Addis Ababa, Ethiopia.

8. Mengistu Hulluka and Esele, J.P.E. 1988. Sorghum diseases in East Africa. In: proceedings of the second International Workshop on Sorghum and Millet Disease, 7 – 11 March, 1988, Harare, Zimbabwe.

9. Mengistu Hulluka. 1988. Research approach and monitoring crop disease management practices in Ethiopia. In: proceedings of 20th National Crop Improvement Conference, (NCIC), 28 – 30 March 1988, Addis Ababa, Ethiopia.

10. Mengistu Hulluka, 1989. Relation of Weather variables to crop disease outbreak. In: proceedings of Twenty-first National Crop Improvement Conference (NCIC), 10 – 12 April 1989, Addis Ababa, Ethiopia.

11. Mengistu Hulluka, G. Woldeab, Y. Andnew, R. Desta, and A. Badebe. 1991 Wheat pathology research in Ethiopia. Pp. 173 – 217 In: Hailu G. Mariam, Tanner, D.G and Mengistu Hulluka (eds.), Wheat Research in Ethiopia: A historical perspective. Addis Ababa: IAR/CIMMYT. Pp. 173 – 217.

12. Mengistu Hulluka and Yeshi Andnew. 1991. Stability of the reaction of wheat differential lines to stem and leaf rust at Debre Zeit, Ethiopia, In: proceedings of the 7th Regional Wheat Workshop for Eastern, Central and Southern Africa Sept, 16 – 19, 1991, Nakuru Kenya.

13. Mengistu Hulluka and Yeshi Andnew. 1991. Variation within indigenous durum wheat germlasm for response to stem and leaf rust races in Ethiopia. In: proceedings of the 7th Regional Wheat Workshop for Eastern, Central and Southern Africa Sept. 16 – 19, 1991, Nakuru Kenya

14. Hulluka, M. 1990. Current status of tef diseases in Ethiopia. In: proceedings of the Ethiopian phytopatological committee, 15th Annual meeting, 13 – 14 March, 1990. Addis Ababa, Ethiopia.

15. Hulluka, M. and Seid Ahmed. 1990. Evaluation of Fungicides for the control of downy and powdery mildews of grape. In: proceedings of the Ethiopian Phytopatological Committee, 15th Annual meeting, 13 – 14 March, 1990. Addis Ababa, Ethiopia.

16. Ahmed, S., Beniwal, S.P.S. and Hulluka, M 1990. Chickpea and lentil diseases in Ethiopia: A review. In: proceedings of the Ethiopian phytopatological committee, 15th Annual meeting, 13 – 14 March, 1990. Addis Ababa, Ethiopia.

17. Andnew, Yeshi and Hulluka,M. 1990. Studies on seed borne mycoflora of durum wheat. In: proceedings of the Ethiopian phytopath. Committee, 15th Annual Meeting, 13 – 14, 1990. Addis Ababa, Ethiopia.

18. Hulluka, M. 1992. Vulnerability of crops to diseases in Ethiopia. In: proceedings of the joint conference, Ethiopian phytopathological committee and committee of Ethiopian Entomologists, 5 – 6 March 1992. Addis Ababa, Ethiopia.

19. Taffese, A. and Hulluka, M. 1992. Effect of smut (*Ustilago Scitaminea*) on yield of sugarcane in Ethiopia. In: proceedings of the joint conference of Ethiopian phytopathological committee and committee of Ethiopian Entomologists, 5 – 6 March 1992. Addis Ababa, Ethiopia.

20. Abrha, B. and Hulluka, M. 1992. In vitro and in vivo evaluation of fungicides for control of sugarcane smut (*Ustilago scitaminea*). In: proceedings of the joint conference of Ethiopian phytopathological committee and committee of Ethiopian Entomologists 5 – 6 March 1992. Addis Ababa, Ethiopia.

21. Ahmed, S. and Hulluka, M. 1992. Evaluation of fungicides for control of garlic rust (Puccinia allii). In: proceedings of the joint conference of Ethiopian phytopathological committee and committee of Ethiopian Entomologists 5 – 6 March 1992. Addis Ababa, Ethiopia.

22. Hulluka, M. 1992. Aspects of forest tree disease in Ethiopia. In proceedings of National Workshop on Setting Forestry Research Priorities in Ethiopia, 27 – 30 April, 1992 Addis Ababa, Ethiopia.

23. El-diaydu, Y. H., Mamluk, O.F., Sherif S.O., Mengistu Hulluka and Ahmed, M.S. 1994. Race dynamics and gene expression of wheat leaf and stem rust in the Nile Valley countries. In: Ezzahiri, B. and Bouhache, M. (eds). Fifth Arab Conferess of Plant Protection, 27 November 2, December 1994. Fez, Morocco.

24. Eshetu Bekele and Mengistu Hulluka. 1995. Sources of primary inoculum of stem and leaf rust of wheat in the Nile Valley region; report from Ethiopia. Nile Valley and Yemen regional program on cool-season food legumes and cereals. The Fifth Regional Coordination Meeting, 24 – 27 Sept., 1995, ICARDA, AKPPO, SYRIA.

Editorial Services

Hailu Gebre-Mariam, Tanner, D.G., and M. Hulluka (eds.) 1991 wheat research in Ethiopia: A historical perspective. Addis Ababa: IAR/CIMMYT.

Other Publications

1. Hulluka, M. 1968. Research on plant disease, part I plant pathology section, College of Agriculture, Addis Ababa University Haramaya, Ethiopia.
2. Hulluka, M. 1972. Weather at Haramaya, Ethiopia. College of Agriculture, Addis Ababa University. Plant Science Annual Research Report 3: 1 – 5.
3. Hulluka, M. 1973. Preliminary survey of sorghum disease in Hararghe province, Ethiopia. Plant Science Annual Research Report 3: 131 – 134.
4. Hulluka, M. 1976. Sorghum diseases at ESIP sites. ESIP progress report 4:62 – 66.
5. Hulluka, M. 1981. Research on plant disease, part II plant pathology section, college of agriculture, Addis Ababa University, Haramaya, Ethiopia.
6. Hulluka, M. and Asnakech Estifanos. 1986. Weather report (1979 – 1985) – Haramaya Station. Crop protection section, plant science department, Haramaya University of Agriculture, Haramaya, Ethiopia.
7. Hulluka, M. and Solomon Bithane. 1986. Check – list of plant disease specimen in the phytopatological herbarium. Crop protection section, plant science Dept. science Dept., Haramaya University of Agriculture, Haramaya, Ethiopia.
8. Hulluka, M. and Ferderiksen, R.A. 1987. Evaluation of selected Ethiopian sorghum germplasm for diseases resistance department of plant pathology, Texas Agriculture Exp. Station, Texas A & M University, College Station, Texas.
9. Hulluka, M. 1991. Forest tree diseases in Ethiopia: a perspective FRC Newsletter 2: No. 1 & 2.
10. Hulluka, M. 1992. Report on baseline survey of forest diseases in Ethiopia. Forest Research Center, Addis Ababa, Ethiopia.

Manuals

1. Hulluka, M. 1980. Laboratory exercises in plant pathology, crop protection section, plant science. Dept., Haramaya University of Agriculture.

2. Hulluka, M. 1990. Check-list of diseases of major crops. Crops protection Dept. Haramaya University of Agriculture.

3. Hulluka, M. and Ahmed, S. 1990. Vegetable crop diseases in Ethiopia and their control Crop protection dept., Haramaya University of Agriculture.

4. Hulluka, M. 1992. Introduction to Forest Protection. Faculty of Forestry, Haramaya University of Agriculture.

5. Hulluka, M. 1993. Introduction to Forest Protection. Faculty of Forestry, Haramaya University of Agriculture.

6. Hulluka, M. 1993. Wheat rust disease. Crop protection department, Haramaya University of Agriculture.

7. Hulluka, M. and Amare Ayalew, 1996. Post-harvest diseases of food crops. Haramaya University of Agriculture.

8. Paul, V.S., Eshetu Bekele, and Mengistu Hulluka, 1995. Classification of plant pathogenic fungi (a training manual). Institute of Agriculture Research, Addis Ababa, Ethiopia.

Invited Presentations

1. Hulluka M. 1987. Changing patterns of crop disease development in Ethiopia. Departmental Seminar, Department of Plant Pathology and Microbiology, Texas A & M University, College Station, Texas.

2. Hulluka, M. 1989. Key note address. Ethiopian phytopathological committee, annual meeting, 30 – 31 March 1989, Ambo, Ethiopia.

3. Hulluka, M. 1992. Proposal on merging the various crop protection disciplines into one society. Joint conference of Ethiopian Entomologists and pathologists 5 – 6, March, 1992, Addis Ababa, Ethiopia.

4. Hulluka, M. 1993. The role of crop protection in national development: Education in crop protection. Panel discussion paper. Crop protection society of Ethiopia, First Annual Conference, 14 – 15 April 1993. Addis Ababa, Ethiopia.

5. Hulluka, M. 1993. Key – note address, the 7th National Research and Extension Liaison Committee Conference, 7 – 8 June, 1993. Addis Ababa, Ethiopia.

6. Hulluka, M. 1993. Closing address in the curriculum review workshop on agricultural extension, 14 – 15 June 1993.

7. Hulluka, M. 1995. Key note address crop protection society of Ethiopia, Third Annual Conference, 18 – 19 May 1995. Addis Ababa, Ethiopia.