# DETERMINANTS OF BIOGAS TECHNOLOGY ADOPTION THE CASE OF SODO WOREDA; GURAGE ZONE, ETHIOPIA

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This is to certify that the thesis entitled "Determinants of Biogas Technology Adoption In the Case of Sodo Woreda; Gurage Zone, Ethiopia" submitted in partial fulfillment of the requirements for the degree of Master's with specialization in Biogas Technology, the Graduate Program of the Department of Environmental Science, and has been carried out by Renewable Energy Utilization and Management Id. No R017/2010, under my supervision. Therefore I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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## Abbreviations and Acronyms

| | |
|---|---|
| **ABPP** | African Biogas Partnership Program |
| **BLT:** | Branches, Leaves and Twigs |
| **ADALYs** | Averted Disability-Adjusted Life Years |
| **EEPCO** | Ethiopian Electric Power Corporation |
| **EREDPC** | Ethiopian Rural Energy Development and Promotion Center |
| **FAO** | Food and Agricultural Organization |
| **FDRE** | Federal Democratic Republic of Ethiopia |
| **GHG** | Green House Gas |
| **Ha** | Hectare |
| **HAP** | Household Air Pollution |
| **IEA** | International Energy Agency |
| **Kg** | Kilogram |
| **Km** | Kilometer |
| **L** | Liter |
| **LVIA** | Lay Volunteers International Association |
| **MoWIE** | Ministry of Water, Irrigation and Electricity |
| **NBPE** | National Biogas Program of Ethiopia |
| **NBPEPID** | National Biogas Programme Ethiopia Programme Implementation Document |
| **NGOs** | Non-Governmental Organisations |
| **PASDEP** | Plan for Accelerated and Sustained Development to End Poverty |

| | |
|---|---|
| **PID** | Program Implementation Document |
| **SNNP** | Southern Nations Nationalities and Peoples |
| **SNV** | Netherlands Development Organization |
| **SPSS** | Statistical Package for Social Sciences |
| **UNDP** | United Nations Development Program |
| **UNEP** | United Nation Environmental Program |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WHO** | World Health Organization |

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**Abstract**

*The very high degree of dependence on wood and agricultural residues for household energy has impacts on the social, economic and environmental well-being of society. Adoption of biogas as alternative source of energy has many advantages including creation of local jobs, improving agricultural production, financial diversification and provision of cheap reliable energy , reduce pressure on forests, women work load and indoor air pollution. Biomass energy contributes 92% of the national energy requirements and is expected to remain the main source of energy in the foreseeable future. The purpose of this study was to identify the determinant of biogas technology adoption. The study was carried out in in Guraghe Zone Sodo Woreda.*

*Descriptive survey research design was used. Sodo Woreda was purposely selected from the rest of Guraghe Zone's Woredas. 58 kebeles were found in the woreda. 34 kebels were purposely selected because of the suitability of the area to implement the bio gas technology. 5 kebeles was randomly selected from 34 kebeles. A total number of 324 households head were sampled. 60 biogas adopters were purposively selected that had already installed the system. While 264 non- adopters were randomly selected from the study population based on the administration boundaries. Primary data was derived from field surveys using questionnaire, focused group discussion, key informant interview and direct observation. Analysis of the data was done by use of Statistical Package for Social Sciences. Descriptive statistics as well as logistic regression were used to establish relationships between variables.*

*Having all this, the study revealed that income of household ($p<0.001$), level of education ($p<0.04$), and number of cattle ($p<0.001$), significantly influenced the uptake. In addition to the above findings the peoples had better understanding level of awareness and attitude towards the biogas technology. Finally the involvement of government institution were not fully engaged in users training gaps maintenance service gaps, loan access gaps, the supply and accessories of spare part gaps and the activities of steering committee gaps and also nothing non-governmental organization were involved in promoting biogas technology in the study area.*

*The study recommends that the following: the Sodo woreda administration should improve level of education of the households, improve female participation the ownership of biogas technology, create conducive environment for households to access loan from financial institution, Standby biogas technicians who can give immediate maintenance services should be assigned at 'woreda' level in the earliest time possible, supply spare parts, giving training to the users. The government should create enabling environment to participate the non-governmental organization to promote the biogas technology, and the steering committee should play a great roll in giving training to the biogas adopter, follow the quality of building digester, and follow the managements of biogas adopter.*

*Key words: Biogas utilizer, renewable energy, Binary Logistic Model.*

# CHAPTER ONE

# INTRODUCTION

## 1.1. Background

About two-fifths of the human population still relies on solid cooking fuels combusted in their homes (Jeuland et al., 2015). The Sub-Sahara Africa over 80% of relies mainly on solid biomass, that is to say firewood, charcoal, agricultural byproducts and animal waste in order to meet basic needs for cooking and lighting (Davidson et al, 2007; Brown, 2006).

And also at the national energy balance is dominated by a heavy reliance on traditional biomass energy (wood fuels, crop residues, and cattle dung), which accounts for 92 percent of total energy consumed. Petroleum and electricity contribute only seven percent and one percent, respectively (Overview, 2012). The heavy dependence on traditional biomass is leading to different environmental and socio-economic problems including soils erosion, water pollution, and indoor air pollution and most importantly deforestation which affecting the limited forest resources of the country (Bizzarri, 2010).

Therefore, to avoid or reduce the above negative impact renewable energy one of the best medication in urban as well as in rural area. The need for clean, renewable energy is especially acute in the developing world, where little efficiency has been introduced. Biogas technology is, therefore, a very good solution to local energy needs, which can be used to Substitution of traditional fuels by biogas, is expected to result in generally positive impacts on household health due to reduced exposure to smoke and improved management of waste, (Mekonnen Lulie, 2009). In addition to that using of improved household energy technologies for the very poor can prevent almost 2 million deaths a year attributable to indoor air pollution from solid fuel use (Countries and Africa, 2009).

Therefore, based on national biogas program (2008) biogas technology was introduced in Ethiopia as early as 1979. Over the past four decades, the progress of biogas digester construction has remained very low. But again in formal way in four area pilot project had launched implementation of successive domestic biogas program. It already completed the dissemination of the first phase (2009-2013) and has begun implementing its second phase. In the first phase, it was able to build 8,063 (57.6 %) out of the 14,000 domestic biogas plants intended to be constructed in the period (Kamp and Forn, 2015, 2016) respectively.

Therefore, assessment of factors affecting the pace of biogas technology dissemination and the cumulative impacts of biogas installations on sustainable rural livelihood is a timely and crucial area of research to the future up scaling.

The aim of this study, therefore, is to assess the success rate of the biogas technology projects and the factors that determine and influence the adoption and sustainability of the technology in the rural Ethiopia. The outcome will identify under which conditions biogas technology can work best.

### 1.2. Statement of the Problem

The establishment of the NBPE, the dissemination of particularly domestic biogas technology has been given due attention in the country. Lessons are believed to have been learnt from previous failures. The program commenced with new institutional structure, standardized design, shared costs of installations that involve beneficiary households, and linking installations with credit associations. The countries already completed the first phase (2009-2013) and second phase (2014 -2019). Nevertheless, the first phase able to construct only 57.6 % of the total 14,000 and the second phase 59.3% of the total 20,000 biogas installations intended to be built in the first and the second program period. Therefore, thorough understanding of the problems why the progress of biogas technology adoption has been low in rural Ethiopia, and to what extent the biogas installations, which have been built to date. Indeed, there are some researches done on biogas technology in Ethiopia. To mention a few examples, the research works include: the operational status of biogas installations (Negusie, 2010; Yilma 2011), the environmental-impacts of replacing dung combustion by a biogas-system (Lansche et al, 2011), and the role of biogas generation and use in reducing GHG emissions (Amare, 2014). However, none of these studies provided due attention to the involvement of institutional (government and non-governmental organizations) and the level of people's awareness and attitude towards biogas and socio-economic determinants of the dissemination and adoption of domestic biogas. Thus, this study aimed at filling this knowledge gaps. Besides, interest on the problem was initiated due to personal experiences and observations. In the area where I worked for long time, due to scarcity of wood-fuel, it is very common to observe children and women competing for dung fuel in communal grazing fields. Seeing the problem of household energy in the area, it was about a dozen years ago that the government built model biogas installations in the area. But for a couple of reasons that in fact needs assessment, the biogas installations did not survive for long. Therefore, the findings of this research will give information to the concerned body to take an action on the study area and also it can be the initial information for further study on the field.

### 1.3. Objectives of the Study

#### 1.3.1. General Objective

General objective of the study is to identify the determinant of biogas technology adoption in the study area.

#### 1.3.2. The Specific Objectives of the Study are:

- To assess the socio-economic profile of the study area.
- To assess people's awareness and attitude towards biogas technology adoption in the study area.
- To assess the involvement of government institution and nongovernmental organization in promoting biogas technology in the study area.

### 1.4. Research Questions

1. What are the people's socio economic profiles?
2. What are the people's awareness and attitude towards biogas technology adoption?
3. What look like government institutions and non-governmental organizations in promoting biogas technology?

### 1.5. Significance of the Study

The findings of the study may be useful to government and non-governmental organizations who are interested in promoting , enhancing the biogas technology adoption in a sustainable ways and to find the solution of non-functional biogas technology of the adopters. The data collected will contribute to the pool of knowledge in the study area and it will help in shaping energy and environment policies as regards resource use and environmental conservation.

## 1.6. Scope tf the Study

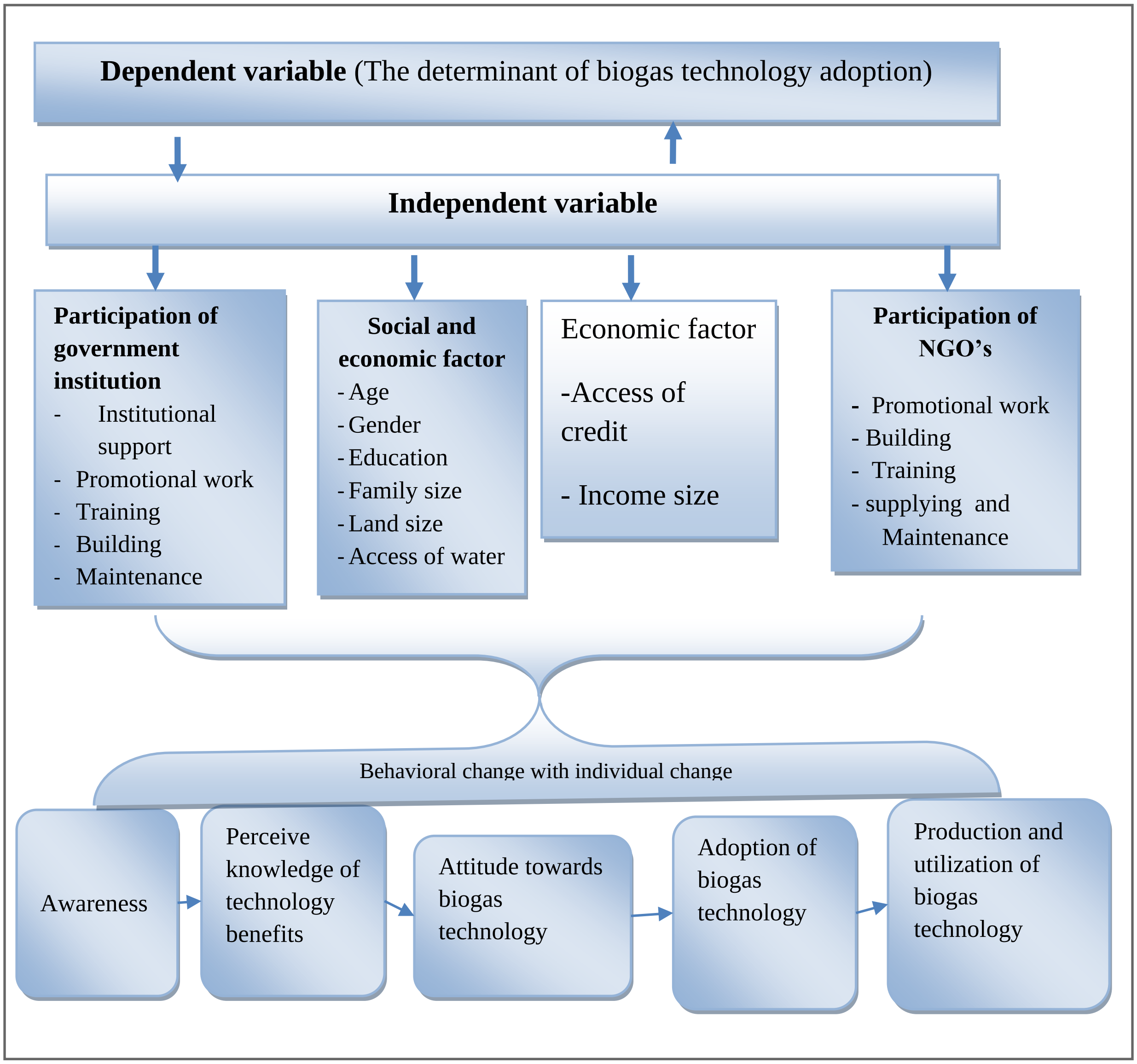
The study was aimed identifying the determinants of biogas technology adoption . The study focused on households to understand the underlying causes to the continued low rates of adoption despite the continued the awareness and attitude , the socio economic profile and the involvement of gevernment and non-governmental organization on promotion of the technology.The respondents were head of households since they are the ones who make decisions regarding all matters in the family.

## 1.7. Conceptual Framework

The framework has been developed on the basis of statement of the problem and review of related literature. Hence, the diagrammatic form of the conceptual framework that displays interrelationships among key factors and their likely outcomes is depicted in Figure 1. The adoption and dissemination of biogas technology in a given society depends on a number of factors some of the main factors include: social factors such as age of household, education, gender of house hold number of family and access of water within a reasonable distance (to mix dung with water to keep the ratio); Economic factors such as access of loan, size of land and enough number of cattle to feed the digester and size of household easily to operate the biogas installation ; The participation of government institution factor such as quality of building, access of spare parts near to the woreda , and access of maintenance service and giving training to the relevant stakeholders Institutional support and Promotional work ; the participation of non- governmental organization factor such as Promotional work, controlling the quality of building ,and giving training to the stakeholders.

Thus, based on the interplay of all the aforesaid factors, households can acquire knowledge and awareness on biogas technology, evaluate its importance, and develop attitude towards using the technology, and finally may decide to adopt and start the actual use of the technology.

Figure 1: Conceptual framework depicting the adoption of biogas technology




(Source: adapted from Mulu, 2016)

## Definition of terms

**Attitudes:** The opinion about biogas fuel.

**Awareness:** The understanding of biogas fuel.

**Bio digester**: Is a sealed container that facilitates anaerobic Digestion.

**Biogas fuel:** A bio-fuel derived from organic matter containing methane and carbon dioxide.

**Biogas fuel adoption**: Use of biogas fuel.

**Dependent Variables**: Are variables that will be measured and will be affected during the experiment.

**Independent variables:** Are variables that will affect the dependent variable.

**Wood fuel**: The wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use (FAO, 2010).

**Livelihood**: A means of attaining a living through involving assets, capabilities, and activities (Chambers and Conway, 1991).

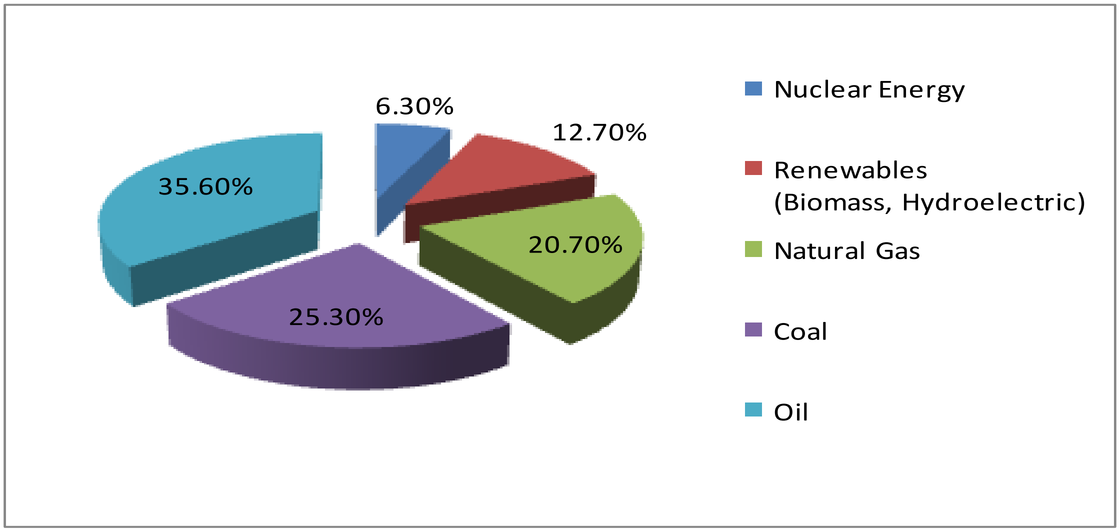
# CHAPTER TWO

# LITRATURE REVIEW

## 2.1. Global Energy Consumption

Energy security is dependent on two factors namely: the source of supply and the distribution systems. On the global perspective, energy security is dependent on the availability of primary energy.  According to Enger and Smith (2006) over 90% of the energy consumed in the United States comes from three sources; oil, coal and natural gas (see figure 2). For many years there have been predictions that energy supplies particularly oil would run out and cause recessions from which the world will not recover. Production of oil, gas and coal would not be able to keep up indefinitely with growing global demand (Day, 2010). According to Day, (2010), at some stage there must be a supply gap. The recent reports as quoted by Day, estimate that there will be a gap of 5% in energy supply by 2010 rising to 23% in 2015 and 32% in 2020.  Further comments that, as the world oil fields decline, the prices will rise, as evidenced from year 2008 where prices rose from $ 100 to over $ 139/barrel against a long term trend of under $ 50.  The above data shows that there is an increasing energy supply gap caused by the diminishing supply of non- renewable energy sources.

Figure 2: Energy sources and their usage amount in percentage in industrialized countries




**Source:** Enger and Smith (2006)

In the developed nations of the world, energy for cooking, heating and lighting is readily available at a relatively lower cost. This is due to the fact that developed nations have invested in both centralized sources and extensive distribution systems to make that energy available to citizens and business.

In the developing world on the other hand, processing and cooking of food is accomplished mainly by biomass energy on which women spend a significant part of their time during the day gathering fuel wood. They are exposed to harmful smoke and other by-products of burning organic materials (English Articles, 2010). Continental wise, recent data show sub-continent of India is the highest consumer of fuel wood followed by Africa and the least consumer being Oceania (see Table 1).

Table 1: Worldwide fuel wood consumption (TJ) by 2005

| Continent | Fuel wood | Charcoal | Black liquor | Total |
|---|---|---|---|---|
| Africa | 5633 | 688 | 33 | 6354 |
| North America | 852 | 40 | 1284 | 2176 |
| Latin America | 2378 | 485 | 288 | 3150 |
| Asia | 7795 | 135 | 463 | 8393 |
| Europe | 1173 | 14 | 644 | 1831 |
| Oceania | 90 | 1 | 22 | 113 |
| **Total** | **17921** | **1361** | **2734** | **22017** |

Source**:** FAOSTAT (2005)

### 2.2. Energy Resource and Consumption of Ethiopia

The main indigenous sources of energy in Ethiopia are biomass, hydropower, fossil fuels, natural gas, coal, geothermal, solar, wind and oil shell (see table 2). To meet domestic energy requirements, rural populations use various forms of biomass almost exclusively (e.g.: fuel wood, agricultural residues and animal wastes like dung). In addition to heavy dependency on biomass, there is limited use of electrical energy and a generally low level of energy consumption (Snv and Sonder, 2006).

There is significant generation resource in the country. Ethiopia's hydropower resources, which are distributed in nine major pertinent river basins and their numerous tributaries, are estimated to generate 650 TWh per year. The technically feasible potential is estimated to be 40% of the theoretical potential i.e. 260 TWh per year (45 GW equivalent with 65% plant factor). This would constitute about 15% of the total technically feasible potential of Africa, which is 1750 TWh per year(Renewable, Program and Final, 2012).

For instance, so far the country has developed less than 5% (around 2000 MW) of its total hydroelectricity generation capacity (EEPCO, 2011; FDRE, 2015). According to Dhabi, and

Derbew, (2013), with the completion of the present three hydroelectric power projects under construction: the Grand Ethiopian Renaissance Dam (6000MW), Ghibe III (1,870 MW) and Genale dawa III (254 MW) with total installed capacity of 8,124 MW, the country's hydroelectric power generation capacity will develop to 9,221.7 MW which will be about 20 % of the potential (MoWIE, 2011).

In addition, from the existing wind power potential of the country, Ashegoda (120), Adama I (51 MW), and Adama II (153MW) wind farms have already started operating and generate a total of 273 MW (MoWIE, 2015). According to ministry of water and energy (2011) Aluto langano geothermal plant is also under construction to upgrade its installed capacity from 7.2 to 35-70 MW. The energy sector in Ethiopia is composed of three main sources as: biomass, petroleum and electricity. Energy consumption is very low, with an estimated total per capita consumption which is only about 0.2 tone oil-equivalent.

Table 2: Energy Resource Potentials of Ethiopia

| **Resource** | **Unit** | **Exploitable Reserve** | **Exploited Percent** |
|---|---|---|---|
| Hydropower | MW | 45,000 | <5% |
| Solar/day | kWh/m2 | Avg. 5.5 | <1% |
| Wind: Power<br>Speed | GW<br>m/s | 1,350<br>> 6.5 | <1% |
| Geothermal | MW | 7000 | <1% |
| Wood | Million tons | 1120 | 50% |
| Agricultural waste | Million tons | 15-20 | 30% |
| Natural gas | Billion m3 | 113 | 0% |
| Coal | Million tons | 300 | 0% |
| Oil shale | Million tons | 253 | 0% |

(source : Trade and Forum, 2015)

Table 3: Energy consumption in Ethiopia

| Energy consumption by sector and source (TJ) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Woody biomass | Crop Residue | Dung | Charcoal | Electricity | Petroleum | Total | % |
| Urban hh | 34969 | 2824 | 3263 | 5856 | 1832 | 4161 | 52905 | 7.1 |
| Rural hh | 507172 | 49186 | 50629 | 2709 | | 3171 | 612867 | 82.1 |
| Agriculture | | | | | | 1497 | 1497 | 0.2 |
| Transport | | | | | | 26743 | 26743 | 3.6 |
| Industries | 17101 | 1409 | 1396 | 112 | 1864 | 4573 | 26455 | 3.5 |
| Services | 22110 | 1031 | 1046 | 109 | 1145 | 331 | 25772 | 3.5 |
| Total | 561352 | 54540 | 56334 | 8786 | 4841 | 40476 | 746239 | |
| % | 77.9 | 7.3 | 7.5 | 1.2 | 0.6 | 5.4 | | 100 |

(source :'NBPEPID', 2008)

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 it is not yet well developed due to lack of capacity and absence of investment. For example, only less than 1% of the total hydropower potential of the country is known to have been utilized so far. In Ethiopia, there are compelling reasons to promote household biogas technology. First, the country has large livestock population mainly cattle. Second, dung is increasingly used as household fuel. Third, the soil structure and fertility has negatively been affected as it is deprived of its natural fertilizer-dung (Lucia and EEA, 1990).

Subsequent to assessing the financial, technical, social, and institutional dimensions for the possibility of mass dissemination and taking into account the various intervening limitations.

Adoption and dissemination of biogas technology in a given society depends on a number of reasons. Some of the major reasons include: social issue of households; economic issue of households including access to alternative sources of energy like electricity and photovoltaic; biophysical factors such as access to woody biomass, land, and water resources; legal and institutional factors such as promotion work, supports, and subsidies; Private sector participation in promotion, construction, and manufacturing and supplies of appliances and spare parts; and Attributes of the technology itself. According to Mulu, (2016), the household's head can obtain knowledge and awareness on biogas technology, evaluate its importance, and develop attitude towards using the technology. Once biogas technology is adopted, sustained and efficient utilization of the technology can lead to different development results. Some of the major sustainable development results may include: accessing energy needs, saved time, decreased workload, reduced health risk, reduced expenditure, increased income and job opportunities , increased productivity, reduced deforestation, reduced GHG emissions, enhanced soil fertility, reduced indoor air pollution, and improved sanitation.

### 2.3. Biogas technology

Initially Biogas is a mixture of gasses that is produced by anaerobic digestion of organic materials as agricultural wastes, animal dung and human excreta. The main compounds of biogas are methane (roughly 60%) and carbon dioxide (roughly 40%); along with other trace gasses (Frost and Gilkinson, 2011). Methane is a flammable gas that is produced by anaerobic fermentation of materials of organic matter by activities of micro-bacteria. If properly mixed with air, this gas burns with a blue flame and no smoke is produced (Laramee and Davis, 2013). The most important factors that influence the biogas production are the temperature and the level of acidity of the organic materials. It is well known that bio-digesters perform optimally with a temperature of around 35 degrees Celsius and a neutral pH, because a pH range between 6.7 and 7.5 allows the methanogens to grow optimally (Ward et al., 2008; Rajendran et al., 2012).

The primary end use application of domestically produced biogas is cooking; However, especially in remote rural areas where electrification does not exist, biogas is also used for lighting purposes. The residue of the biogas process, bio-slurry, can be collected relatively easy and can be used as organic fertilizer and soil improver (Ghimire, 2013). According to Bonten et al., (2014) nutrients in bio-slurry (mainly nitrogen (N)) are more readily available in comparison to undigested farmyard manure. This means that that bio-slurry can have a better fertilization effect in short term. However, the higher amount of N can also lead to greater risks for losses of this nutrient during storage, usage and application through and leaching volatilization.

Table 4: characteristics of biogas

| **Component** | **Percent (%)** |
|---|---|
| Methane ($CH_4$) | 50-75 |
| Carbon dioxide ($CO_2$) | 24–45 |
| Water vapor ($H_2O$) | 2-4 |
| Nitrogen ($N_2$) | < 2 |
| Oxygen ($O_2$) | < 2 |
| Hydrogen sulphide ($H_2S$) | 20-20,000 ppm (2%) |
| Ammonia ($NH_3$) | 0-0.05% |
| Hydrogen ($H_2$) | 0-1% |

(Sources: WBA, 2013)

Domestic bio-digesters are a simple construction that converts either human excrement or animal dung at household level into small but valuable quantities of biogas ( Laramee and Davis, 2013). Throughout the world, various kinds of digesters are used. In developing countries, three major types of biogas reactors are used for the waste of livestock: the Indian floating drum digester, the Chinese fixed dome digester and balloon (or tube) digesters (Plöchl and Heiermann, 2006). All three types of digesters are usually sized to consume animal and human waste from a single household. Generally, the energy that is generated flows directly back to the respective family. The volume of most bio- digesters varies between 2 and $10m^3$ and produces about 0.5 $m^3$ biogas per $m^3$ bio-digester volume. Nonetheless, this volume differs from country to country. In Vietnam and Pakistan, also larger bio-digesters of up to 50 $m^3$ are used (Ghimire, 2013).

The principle of how a bio-digester works is the same; regardless of the different digester designs. Generally the process is as follows. Feedstock enters in to the bio-digester through the inlet pipe. This can be done either directly or after mixing a pit. Under anaerobic digestion the waste is fermented with the help of methanogen bacteria, which in turn produces biogas (Heegde, 2010). After a substrate retention period of 20 to 100 days, the biogas is collected upon the slurry before it escapes through the outlet pipe (Ghimire, 2013).

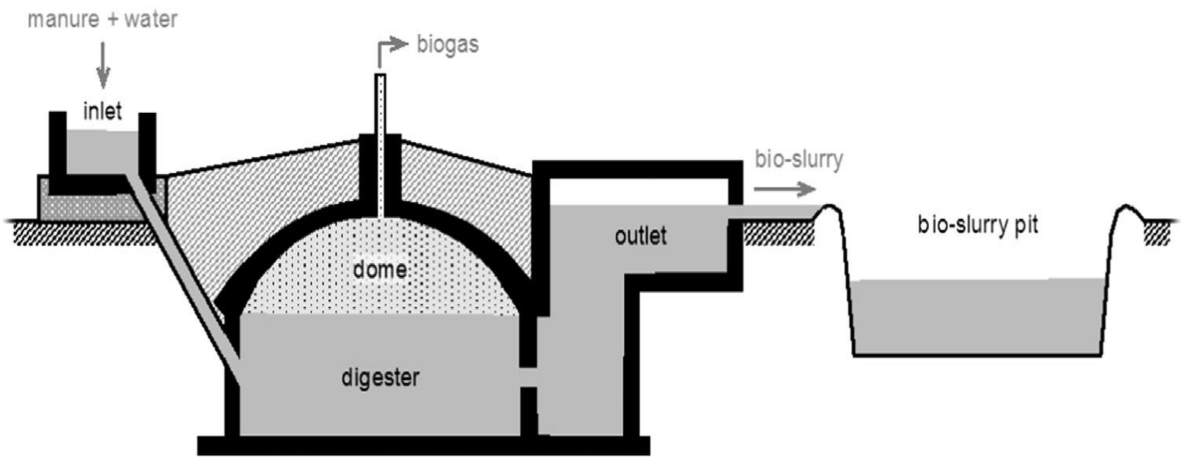
Fixed dome digesters are the most popular design for rural households. The reason for this is their low maintenance requirement, reliability and ease to construct. In addition, it requires only locally and widely available materials for construction, such as stones, bricks, clay and cement. This type of bio-digester only has fixed parts, which are not affected by erosion or rust, and is constructed underground to protect it from physical damage. Resulting in a life span of more than 20 years. Moreover, the underground construction helps to obtain a stable temperature regime to stimulate the bacteriological processes. Additionally, the underground construction saves space. Building the underground construction is labor intensive, which provides opportunities for local employment (Heegde, 2010). The technology is gradually gaining popularity in developing countries, especially in Africa where the lack of clean and sustainable energy source represents damage to the environment and its people (Amigun & von Blottnitz 2009).

**2.3.1. Biogas plant**

The bio digester is a physical structure that provides anaerobic conditions needed for biogas production. It can be of any shapes and sizes and can be built with various construction materials. The following are some of the commonly used bio digester designs for domestic use like Floating drum digester, plastic bag digester and fixed dome digester. From the above type of digester the Ethiopian uses Nepalese fixed dome model with local name-SINIDU (meaning ready)  means ease of operation, opportunity to accommodate high shares of local materials, correct sizing and low cost. In addition, as the design has been used intensively over a long period of time, construction and after sales service standards and a variety of training materials can readily be adopted ('NBPEPID', 2008).

The Fixed Dome Dig ester or Chinese Model Digester: The fixed dome biogas plant was designed and developed in China in 1936. Since then the design has been adapted in various countries in the world. The plant is constructed underground, protecting it from physical damage and saving space. The underground digester is protected from temperature fluctuations which has a positive influence on the bacteriological process. The cost of constructing a fixed dome plant is relatively low. It is also simple as it does not have moving parts. There are also no rusting steel parts and hence it has a long life of 20 years or more. The construction of fixed dome plants is labor-intensive, thus creating local employment.

Figure 3: The Chinese fixed dome design plant




(Source : Manon and Bermúdez, 2016)

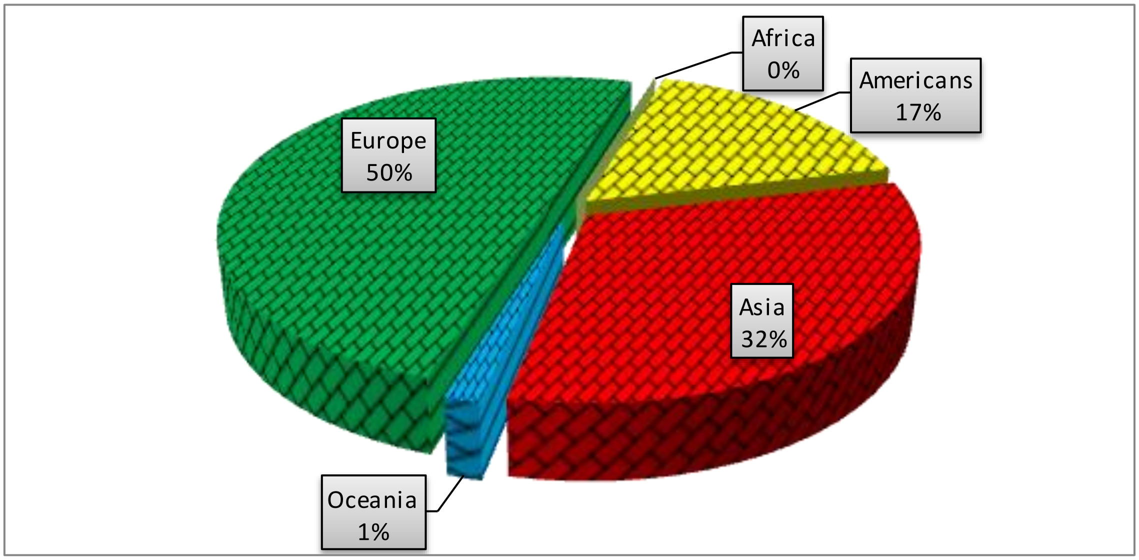
**2.3.2. History of Biogas Technology**

**2.3.2.1. Global overview of Biogas Technology Disseminations**

Global biogas generation has increased rapidly since 2000. During 2000 – 2014, the average growth of production was 11.2%. In 2014, the production of biogas was 58.7 Nm3. Using an average energy density factor of 21.6 MJ/$Nm^3$, the total biogas production was 1.27 EJ.

Almost half of the global biogas production occurs in Europe • EU – 28 nations dominate biogas production with more production than the rest of the top 5 combined Almost half of the global biogas production occurs in Europe (Figure 4), 32% in Asia and 17% in Americas. Less than 2% of the production occurs in Africa and Oceania continents (‘WBA GBS’, 2017).

Figure 4: Biogas productions in continents in 2014




(Source: WBA GBS , 2017)

Roughly 50 million biogas cook stoves have been installed worldwide, and the number is growing at about 10% annually (IRENA, 2014a). China leads the world in biogas digester installations for cooking, accounting for over half of all installations globally. African countries, specifically sub- Saharan countries, also would stand to benefit from their uptake.

In May 2007 the "Biogas for Better Live: an African Initiative" was launched in Nairobi. The purpose of this initiative was to provide 2 million households in Africa with domestic biogas plants. The initiative aims to achieve the following by 2020: 2 million biogas plants installed (90% operation rate) ,10 million Africans benefiting in daily life from the plants, 800 private biogas companies and 200 biogas appliances manufacturing workshops involved or established , 100,000 new jobs created , comprehensive quality standards and quality control systems developed and in use , 1 million toilets constructed and attached to the biogas plants ,80% of the bio-slurry utilized as organic fertilizer , agriculture production raised by up to 25% , health and living conditions of rural household improved and death of rural household reduced by 5000 each year , drudgery reduced by saving 2 to 3 hours per day per household for fetching wood, cooking and cleaning the pots , health costs saved by up to US$ 80 to 125 per family per year , 3 to 4 million tons of wood saved per year and greenhouse gas emissions annually reduced by 10 M tones of $CO_2$ equivalent (‘NBPEPID’, 2008).

**2.3.2.2. Biogas Technology in Ethiopia**

Ethiopia has a high potential for biogas production with its sufficient resources. Ethiopia’s livestock population according to 2009/10 CSA survey is about 150 million. One third of this is cattle, whose refuse can effectively be used for biogas generation. Recent estimates show that about 1.1 million potential owners of household-size digesters exist in the four major regions. The effort to generate biogas from cattle dung started in early 1970s in Ethiopia. Over the last two decades, around 1,000 biogas plants were deployed in Ethiopia with sizes ranging between 2.5 and 20 cubic meters for households, communities and institutions (Boers & Esthete, 2008). During this period, different models were used (e.g. fixed-dome, Indian floating-drum and bag digesters). However, According to multiple consulted actors there was no local capacity to neither up-scale the technology nor sustain it. Hence, just 40% of the aforementioned bio digesters are still operational (Esthete *et al.*, 2006).

The first phase of the program was implemented in selected woredas in Oromia, Amhara, SNNP and Tigray regional states. Although the program is planned to gradually cover the whole country, it is important to mention the rationale for starting in these four regions during the first program implementation phase. The main reasons for this include: the presence of most of the human (>70%) and livestock population (~70%); the loss of vegetative cover as a consequence of severe deforestation and resulting in a huge imbalance for the rural household energy; the relatively advanced status of the regions with regard to educated human resources and technology adoption experience; and the availability of relatively well-documented information crucial to start the program ('NBPEPID', 2008).

According to the feasibility study made in 2006 on biogas potential in Ethiopia (Eshete et al., 2006b), in ANRS there are nearly 3.2 million households with a total number of cattle holding estimated at 2.6 million. Nearly 83% of the households in the region own cattle with 43% keeping four or more animals. In the region, only 10% have reasonably close access to water.

### 2.4. Awareness and Attitudes of Biogas Technology

Biogas fuel is described as an excellent tool for improving life among local communities (Raskovic et al., 2009) and is investment, advanced one of many biomass energy sources which require more technology and resources than basic bio-digesters provide (Jury et al., 2010). This technology is a very good solution to local energy needs and provides significant benefits to human and ecosystem's health. The technology is also considered as a means leading to rural development (Raskovic et al., 2009). Biogas plants do not require big capital to set up and offer solutions to existing environmental problems and many unexpected benefits besides (Drabez et al., 2009). Therefore, the awareness stage people get general information about a new idea, product or practice for the first time but not its details. With the detailed information people decide whether the idea is good or not after which the potential adopter would try the new idea or practice a little and more late (Rogers, 1995).

## 2.5. Involvement of Government Institution and Non- Governmental Organization on Promotion of the Technology

Stakeholder is defined as actors or institutions that involve and support biogas development spreading in national, provincial and local levels. Support can be given in the form of policy, financial and technical supports and every actor/institution can play in one or multiple roles. The development of biogas was highly affected by national policy, but capability of local actors determined the sustainability of biogas development (Fallde & Eklund 2014). Many government institutions in the national level involve in renewable energy sector and the participation of private sector and NGO's in the countries to promote and to create awareness on the society play a great role.

## 2.6. Technology adoption

The biogas adopters with a minimum of one year old biogas installations was to acquire clear-cut information about whether or not they utilize bio-slurry as organic fertilizer. Besides, respondents from such households were expected to have relatively better experience and familiarity with the technology's benefits and drawbacks. Among the non-adopter households, only those who owned four or more heads of cattle potential biogas adopters (EREDPC and SNV, 2008).This is because with the exception of toilet connections to some biogas digesters, cattle dung is the only source of biogas in rural Ethiopia.

### 2.6.1. Adoption process

At the awareness stage people get general information about a new idea, product or practice for the first time but not its details. With the detailed information people decide whether the idea is good or not after which the potential adopter would try the new idea or practice a little and more late (Rogers, 1995).

### 2.6.2. Theory of Innovation Diffusion

Rogers (2003) described the innovation-diffusion process as "an uncertainty reduction process" and he proposes attributes of innovations that help to decrease uncertainty about the innovation. These attributes includes five characteristics of innovations: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. "Individuals" insight of these characteristics predict the rate of adoption of innovations" The presence of these factors speed up the innovation-diffusion process. Theory further considers the categories of adopters as determinant of technology adoption. Rogers defined the adopter categories as "the classifications of members of a social system on the basis of innovativeness" This classification includes innovators, early adopters, early majority, late majority and laggards. Innovators are the first individuals to adopt an innovation and they are very few 2.5%followed by early adopters 13.5%. Early adopters consist of younger generation with high social status and finances to invest. Early majority and late majority 34% follow later and finally the laggards up 16% as the last group to adopt. In addition to the gatekeepers and opinion leaders who exist within a given community, change agents may come from outside the community. Change agents bring innovations to new communities– first through the gatekeepers, then through the opinion leaders, and so on through the community.

## 2.7. Barrier to Adoption

### i) Policy and Legal Barriers

Experience in the region shows that the introduction and success of any renewable technology is to a large extent, dependent on the existing government policy. Government policies are an important factor in terms of their ability to create an enabling environment for new technologies dissemination and mobilizing resources, as well as encouraging private sector investment (Sampa and Sichone, 1995).

### ii) Technical skill Barriers

The introductions of unfamiliar technologies such as new technologies require the development of technical skills. The importance of technical know-how in the increased adoption of new technologies has been recognized in the region, but in spite of efforts by governments, there is a continuing shortage of qualified personnel (Baguant and Manrakhan, 1994). Technical knowledge is important in order to build over the long term, a critical mass of professional African policy analysts, economic managers and engineers who will be able to manage all aspects of the new technologies development process and to ensure effective adoption of already trained African analysts and managers (World Bank, 1996). Trained manpower capable of developing and manufacturing renewable energy technologies is a prerequisite for their successful dissemination.

Government and ministries in Africa suffer from a shortage of qualified new technologies personnel. In Kenya, for example, there is a lack of general expertise in all aspects of wind pumps in the relevant ministries and NGOs (IT Power, 1987). In addition to that a shortage of construction and maintenance skills, which affects many developing countries, is a key reason why not all of the installed biogas plants in India are actually in use. As discussed previously, the discrepancy of training men when women are responsible for maintaining the biogas system results in a lack of effective knowledge, reducing the number of plants in use. Thus, cultural and social customs should be taken into account with the transfer of knowledge. In addition, building technical capacities in remote areas is key to expanding biogas use for cooking (Renewable and Agency, 2017).

**iii) Financial Barriers**

According to Karekezi, (2003), financing plays a major role in the formulation of new technology policies. Studies have shown that one of the main obstacles to implementing renewable energy projects is often not the technical feasibility of these projects but the absence of low-cost, long-term financing (News at Seven, 1994). This problem is complicated by competition for limited funds by the diverse projects and becomes critical if the country is operating under unfavorable macro-economic conditions. Governments and private enterprises must therefore seek creative ways of financing new technologies projects. Consequently, the private sector is left to bear the burden of financing new technologies. Most advanced and electrical Technologies are not affordable to majority of the population in Africa who are poor, with national poverty levels of 50-70% (World Bank, 1996). Financial expertise often is lacking to appropriately value the revenue streams that a domestic biogas plant for cooking will generate, making it hard to obtain loans for such facilities (Klaus, 2015). An effective approach to overcome this barrier could be training courses for loan officers to better evaluate the impact of technology uptake on income flow. The Inter-American Development Bank has a program in Colombia which teaches loan officers to properly evaluate the value of energy efficiency projects, including the expected return on investment which could be used to increase the cash flow and corresponding loan collateral value (Pegels et al., 2015).

**iv) Socio-Economic Barrier**

The factors namely age, educational level, family size, gender, ethnicity, religion and wealth (Nhembo, 2003). Education level is associated with greater access to information and improved capacity for creativity, so educated individuals are expected to be more aware of and have more knowledge on a new technology. Age and experience have a range of influences on household decision making in adoption. Older ages, according to Nhembo (2003) may influence an individual in the direction of not adopting new ideas due to conservatism. However, with regard to experience, older people may have more experience and more resources that allow them to adopt capital-intensive technologies than younger people (Shiferaw and Holden, 1997). Household size may have positive or negative influence on adoption of technologies. For labor intensive technologies, family size positively influences adoption (Simon, 2006). Income is also an important reason in adoption of technologies. Availability of cash enables an individual to gather costs associated with a technology to be adopted. Gender can influence adoption of a technology positively or negatively depending on gender responsibilities and ownership of resources (Simon, 2006). The gender responsibilities can be in form of performing tasks among men and women in energy supply and management systems and differences in resource ownership such as livestock, houses and land.

## CHAPTER THREE

## MATERIALS AND METHODS

### 3.1. Introduction

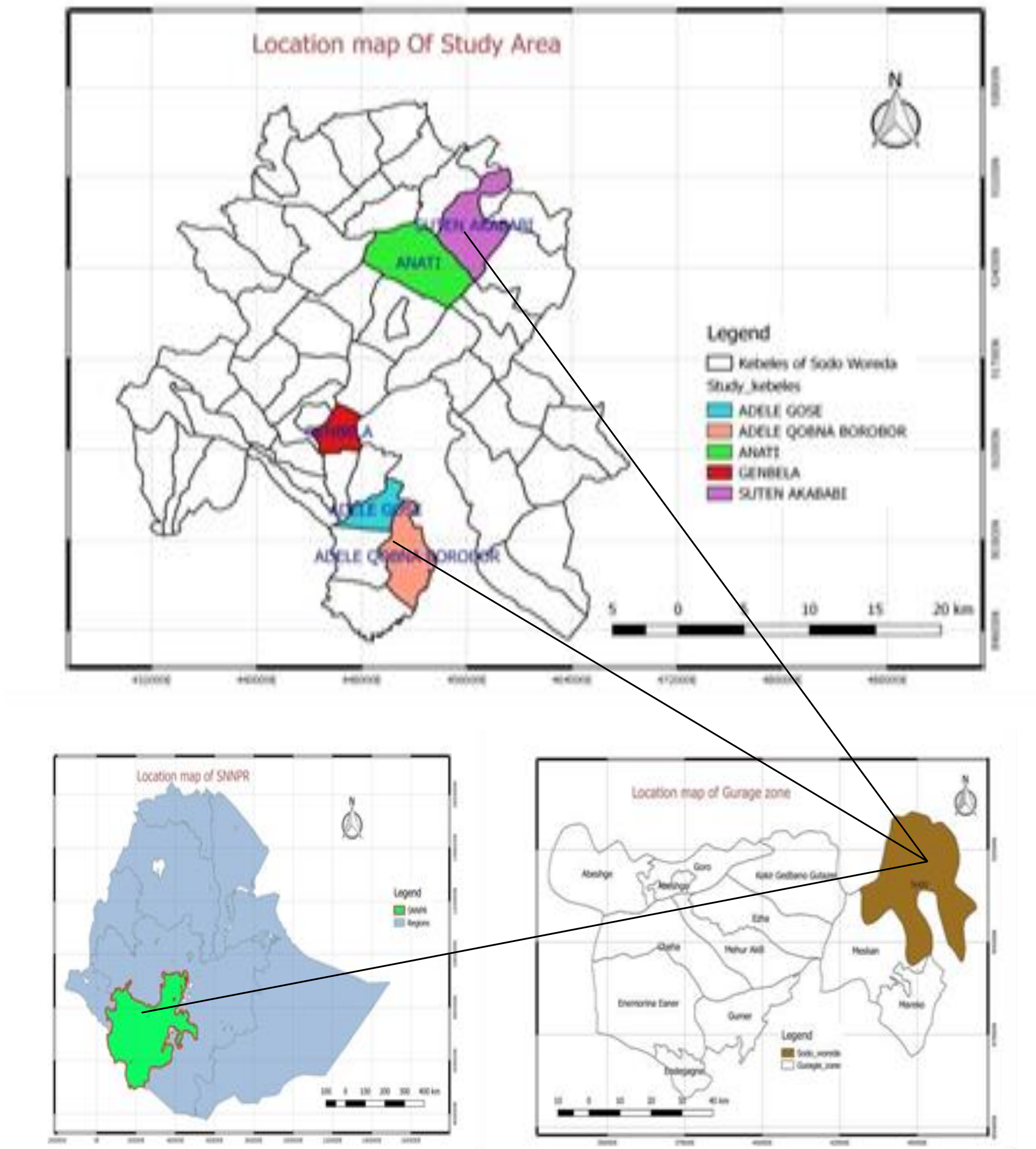
In this chapter, the study includes: description of the study, research design and plan, nature of data, data collection methods, reliability and validity of instruments, Selection of the study area, and data analysis procedure.

### 3.2. Description of the study area

#### 3.2.1. Location of study

Sodo woreda is one of the woredas in the 13 woredas and 2 town administrations in Gurage Zone of the SNNP. Sodo woreda lies between latitude and of 8º09’ - 8º3’ N latitude and 38º37’- 38 º 6’ E longitudes and an altitude elevation of the woreda ranges from 1800 - 3040 meters above sea level. Sodo woreda shares common local administrative boundaries. It is located to the southwest by Meskane woreda, and to the north, west and east by the Oromia Region. The administrative center of Soddo woreda is Bue (Woreda of finance,economy development office,2018). It contains 4 urban and 54 rural kebeles. The distance of the administration center is 126Kms far away from Wolikite the Gurage zonal capital town and 103 km far away from Addis Ababa and also 198 Kms far away from Hawassa (Woreda of finance, economy development officce, 2018). The Climatic condition of the woreda consists of 25% Kola, 40% Wionadega and 35% Dega. The woreda rainfall amount ranges from 801mm to 1200 mm per annum. The same fashion is recorded regarding temperature ranges from 10°C and 32°C lowest and highest respectively (Woreda of finance and economy development office, 2018).

Figure 5: location map of study area




(Source: by the author, 2019)

### 3.2.2. Population of the Study Area

The Sodo Woreda has a total population of 134,683. Out of the total number of the population, 13,720 peoples live in the urban areas, while the remaining 120,963 peoples live in the rural areas (CSA , 2007). On the other way urban areas consists of 3,979 household heads and the rural areas contain 25,152 household heads., finally both the urban and rural areas together contain about 29,131 total household heads.

### 3.2.3. Vegetation

In general the woreda has 94,841.33 hectare of land from which flat topography consists of 40%, rugged topography contains 23%, zigzag topography contains 30% and mountain areas 7% and in addition to this 60 % brown, 22% black, 12% red and 6% grays are associate with soil types found in different parts of the woreda. Biomass fuel in the form of firewood is the main source of energy used in households and commercial premises for cooking (Woreda of finance and economy development office, 2018).

### 3.2.4. Land Use and Socio –Economic Activities of the study area

Sedentary agricultural is practiced following a complex system of crop production and planting trees. Crop rotation is one of the oldest practices in the study area. In the Dega area of the study area Ensete is the main staple food to the community. In addition to enset barely, wheat, teff, corn, sorghum, pea, bean, chickpea, are produced and animal husbandry is practiced. The woredas have a livestock population of 571,615 from these 188,275 cattle, 74,309 sheep, 61,719 goats, 221,158 poultry, 4,608 horse, 2,221 mules and 19,325 donkeys. Free grazing livestock is the main practice (Woreda of finance and economy development office, 2018).

## 3.3. Research Design

According to Best and Kahn (1993), descriptive research is concerned with relationships or conditions that exist, attitudes held by people and practices that prevail. Bell (1993) notes that descriptive surveys aim to obtain information for a representative sample of the population; from which the researcher was able to generalize the findings of a large population. It helped the researcher in getting information about the determinant of biogas technology adoption of the sample population.

## 3.4. Nature of Data

Data was collected based on objectives. This includes the socio economic profile, level of awareness and attitude towards biogas technology, the involvements of government and NGO's in promotion of biogas technology. Both primary and secondary data were used to achieve the objectives of the study.

### 3.4.1. Primary Data

Primary data was collected using oral interviews from the study area population and the opinions of various related stakeholders to the technology. This was further facilitated by institutional interviews with resource persons including; government officers from the MoWIE, SNV Coordinator, Department of Agriculture and natural resource agricultural extension workers , micro finance officers , alternative energy officers, women and children affairs and adopter and non-adopter of biogas technology.

### 3.4.2. Secondary Data Sources

Secondary data sources such as books, policy documents, published and unpublished documents, journals, and websites that were relevant and strengthened the researcher's understanding about the study were reviewed and studied (District and Amare, 2014).

## 3.5. Data Collection Methods

For successful collection of data in the field, a questionnaire, focus group discussion, key informant interview and field observation and observation guide were used to collect data.

### 3.5.1. Questionnaires

Questioners prepared for both household and institutional respondents were used to collect relevant data for the study. They had both open and closed ended questions that would be suit for the collection of both qualitative and quantitative data that would make easy to analyze. The use of closed ended questions helped the researcher in collecting general information while the use of open ended questions enabled the respondents to give greater insight into their feelings or interest thus much information was acquired (Phellas, Bloch & Seale, 2011). The questionnaire was useful in collecting general information about opinions, attitudes and perceptions on biogas adoption among households.

### 3.5.2. Focus Group Discussion

For the study, eight focus group discussions, four per sample woreda, were held. To avoid the possible cultural influences on free discussions, separate groups were formed for two sexes. The optimum size for a focus group discussion ranged from six to eight members (Hennink 2007; Liamputtong 2011). Thus, two male and two female group discussions, having six or seven members per a group, were formed in each sample woreda. To ease, the task of bringing group discussion together, occasions of various social gatherings, such as religious gatherings, public meetings and public labor days, were exploited. Focus group discussion helped to gather information about problems of household energy in the area, barriers constraining biogas technology adoption among households, weaknesses of the biogas program implementation, and suggested solutions to improve the program.

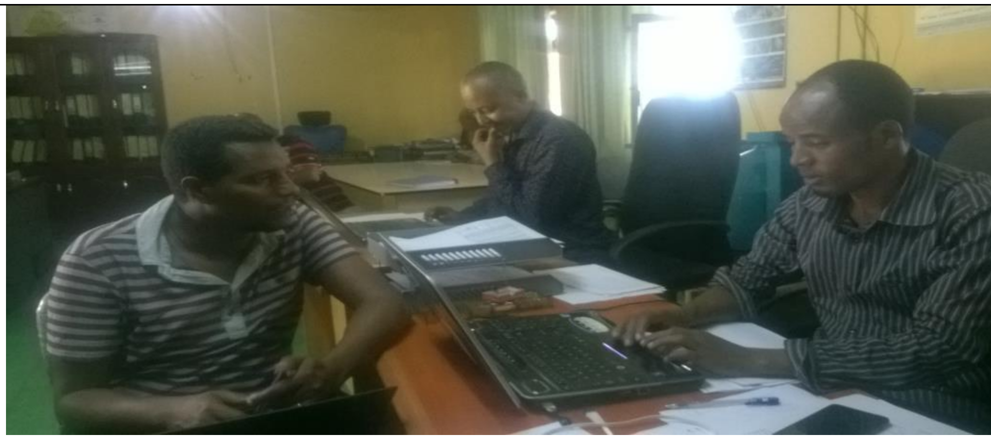
### 3.5.3. Key Informant Interview

In the study area the key informant interview was conducted to supplement that obtained from questionnaires and partly due to its cost effectiveness and its strength of capturing empirical data in both formal and informal settings (Prabhat and Pandey, 2015).

On the other hand semi-structured interviews were conducted with various key informants using an interview guide consisting mainly of open ended questions. In this research, a total of 17 key informants, who were supposed to provide research relevant information, were purposefully selected from various administrative levels.

The key informants were taken from different institutions be it federal, regional, zonal and woreda levels. For example, one officer was participated from the federal (NBPE) monitoring and evaluation and one senior energy expert, one energy coordinator and one senior energy experts from the regional water, mining and energy office , two senior expert and one energy coordinator from the zone water mining and energy office, two higher experts from agriculture and natural resources office, one higher officer from women and child affairs office, one energy coordinator and two senior energy experts from woreda water ,mines and energy office , six agricultural extension workers from agriculture and natural resources office. The researcher had to make prior arrangements through a mobile phone with the respondents and also introduced to them the objectives of the interview. This was followed the realization that some of the key informants were always busy and also to avoid fruitless endeavors in cases of absence.

Plate1: interview with key informant.



Source : key informant interview with SNNP regional state higher expert of water, mining and energy bureau

### 3.5.4. Field Observation

Direct personal observation helped to generate ideas valuable to prepare leading questions for both key informant interview and focus group discussions. Besides, the appropriateness of questions prepared for semi-structured interviewing was checked, inter alia, through directly observing visible phenomena in the real ground and body languages reflected during piloting. Direct observation also assisted to acquire information about the biophysical features of the study sites, type and quality of biomass fuels gathered, current status of biogas installations, the different components of biogas installations, end-use of biogas, and use of bio-slurry

## 3.6. Selection of the Study Area

The study area has Dega, Weinadega and Kola agro ecologies and affected by scarcity of fuel wood. Hence a need for alternative energy sources (woreda finance and economy development office, 2018). Anati and Suten Zuria kebeles from Woina Dega agro ecology and Borober, Gosie and Genbela kebeles from kola agro ecology were part of biogas technology implementing area. Therefore, they were purposefully selected. According to 'NBPEPID',(2008) revealed that the size of the digester was determined by the retention time relative to the amount of bio-slurry fed every day and this was also related to the climatic condition of the locality, essentially the temperature for biogas fermentation, as a result Dega agro ecology was not included. Out of the 58 kebeles, 24 kebeles were found in Dega agro ecology. Therefore, they were not part of the study.

### 3.6.1. Sample Size

The sample size of population were determined by using Chand BM, Bidur P, Upadhyay RM. formula at 95% confidence level with precision of 0.05

$$\mathrm{n} = \frac{NZ^2P(1-p)}{Ne + Z^2P(1-p)}$$

Where n = the sample size required, N = the population size, Z = confidence level at 95%, Z = 1.96, P = estimated population proportion (0.5), and e = the precision level at 5%.

Where n is the sample size, N is the population size (total number of households in the five kebeles), and e is the level of precision.

### 3.6.2. Sample Population

Out of 324 households 60 household adopters were purposely selected, and the remaining 264 households selected random sampling techniques in order to obtain equal chance of being selected from the five kebeles. Further the kebeles were selected based on agro ecology, biogas technology adopter, less number of biogas technology adopters and more number of fuel wood users. Key informants and focus group discussions were selected purposively and pertinent to the target population and the research topic.

As mentioned in the above all adopters were taken as sample as their number is small. For non - adopters' biogas technology households for each sample kebeles were determined based on proportional sampling technique. For this purpose list of all non - adopter households in each sample kebele were taken from the respective kebeles administration offices. The sample size for the selected individual population was proportionately distributed as shown in the table.

Table 5: proportionate of purposive sampling

| No. | Name of Study kebeles | No. of households | Proportionate % | Number of respondents |
|---|---|---|---|---|
| 1 | Anati | 423 | 18.9 | 61 |
| 2 | Suten Zuria | 467 | 20.9 | 68 |
| 3 | Gose | 325 | 14.5 | 47 |
| 4 | borobor | 624 | 27.9 | 90 |
| 5 | Genbela | 397 | 17.8 | 58 |
| | total | 2,236 | 100 | 324 |

(Source: Bordens and Abbort, 2002)

### 3.7. Reliability and validity of the Data

Reliability was the degree of consistency with which an instrument measures the attribute it was designed to measure. The study measured reliability of data based on the set guidelines and ability to meet objectives. Content validity was the extent to which an instrument represented the factors under study. To achieve content validity, the study relied on current data from relevant stakeholders.

### 3.8. Data Analysis

Aided statistical computer components were used to analyse data collected using questionnaires, interview schedules and existing documentary records. This was done using descriptive statistics. Statistical Packaging for Social Sciences (SPSS) and Microsoft excel were used for data analysis. Completed questionnaires were first examined for consistency purposes followed by numerical coding of the qualitative responses. This was done for better storage and analysis.

The responses were then entered into both MS word Excel and SPSS version 20 creating data sets of determinants of biogas technology adoption and finally data analysis commands were put in place. The hypotheses were tested at a statistical confidence level of 95%. The data analysed was presented in tables, charts and graphs which made it easier to summarize data while the percentage distribution technique was used to show the particular frequency of respondents preferring a particular alternative and gave face values of determinants of biogas technology adoption of in study area. Interviews with respondents were analysed qualitatively to support or dispute the findings from the questionnaire. A substantial part of the analysis was based on descriptive statistics such as frequencies and correlation coefficients. The logistic regression used to determine: respondents', factors influencing adoption of biogas technology. Logistic regression is a probability estimation model applied when the dependent variable is binary and the independent variable is in any form of measurement scale (Cramer, 2003; Leech et al., 2005). If Y is the dependent variable, it can take values of either 1 or 0.

$$\begin{cases} Yi = 1 \text{ if a household i own biogas plant} \\ Yi = 0 \text{ otherwise} \end{cases}$$

Hence, the logistic regression model for estimating the probability of adopting biogas technology ($P_i$) is specified as follows.

$$\Pr(Yi = 1) = Pi = \frac{1}{1+e^{-Z_i}} = \frac{e^{Z_i}}{1+e^{Z_i}} \text{ -------------------------- a}$$

Similarly, probability of not adopting biogas technology,

$$\Pr(Y = 0) = 1 - Pi = \frac{1}{1+e^{Z_i}} \text{ --------------------------------b}$$

*When dividing a by b, it gives odds ratio* $\frac{P_i}{1-P_i} = e^{Z_I}$ ------------------ c

The logic model is a logarithmic transformation of the odds ratio

$$Li = ln(\frac{Pi}{1-Pi}) = z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_K X_k + \varepsilon_i$$

Where $L_i$ is the log of the odds ratio; e is the base of natural logarithms; $\alpha$ is a constant; $X_1$, $X_2$… $X_k$ are explanatory variables; $\beta_1, \beta_2, \ldots, \beta_K$ are estimated parameters corresponding to each explanatory variable; k is number of explanatory variables; and $\varepsilon_\iota$ is the random error.

When using logistic regression, the data were checked for the existence of multi-collinear. For the analysis of the logistic regression, continuous independent variables were transformed into standardized (z) values. According to Elliott and Woodward (2007), large values of continuous variables can cause odds ratios and $\beta$ coefficients to be small and make it difficult to interpret. Thus, for logical comparison purposes among odds ratios of various continuous variables, all of them were transformed into standardized values.

Table 6: Definition of Explanatory Variables for Biogas Technology Adoption Model.

| **Variable** | **Description** |
|---|---|
| **Gender** | Gender of households head |
| **Age** | Age of household head in years |
| **Income** | total monthly income of household in birr (ETB) |
| **Number of household** | Number of household members |
| **No. Cattle** | Number of cattle owned by household head |
| **Land Size** | Total area of land owned by household in hectare |
| **Educ.** | education level of household head in a years |
| **Water ave.** | Availability of water resource |

Findings from other researchers formed the basis of the selection of the variables to be included in the model. Specific assumptions related to each variable in the model are as follows:

**Age**: Age of household head was expected to affect adoption of biogas either positively or negatively.

**Gender**: Sex of household head was assumed to affect adoption positively or negatively.

**Household income**: Higher income earners are expected to adopt the technology.

**Number of cattle owned**: It was expected that those households that owned a greater number of cows had a high probability of adopting the technology.

**Land size**: it was expected that households with larger acreage of land would adopt the technology.

**Level of education**: More educated household heads were expected to adopt the technology.

**Size of household**: It was expected to influence adoption of biogas positively.

**Availability of water**: availability of water resources was expected to influence adoption positively.

# CHAPTER FOUR

# RESULT AND DISCUSSION

## 4.1. Introduction

This chapter describe the results, interpretation and discussion of the study. The first section presents the characteristics of the respondents. The results and discussion are presented based on the objectives. The objectives include; assessing the socio economic profiles, assessing people's awareness and attitude towards biogas technology adoption in the study area, and assessing the involvement of government institution and non-governmental organization in promoting biogas technology in the study area.

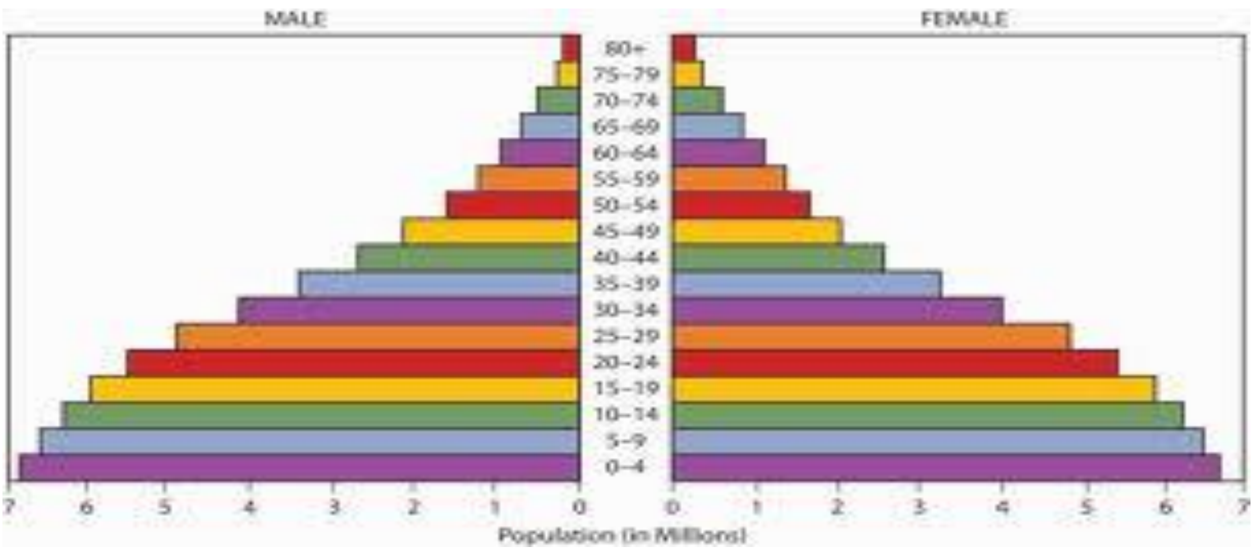
## 4.2. Characteristics of Respondent

Results in table 7: Indicate that the male headed biogas adopter and non-adopter sample of household headed contained 96.7% and 76.1% respectively, while the female household headed biogas adopter and those of non-adopter are 3.3% and 23.9%in the same order. This has an implication on whether a household will adopt and utilize biogas technology or not. According to Simiyo (2012) indicates that house hold decision making was dominated by men. This implies that the decision to take up the technology would be easier if men accepted it as it is useful. However according to Ngw'andu, Shila and Hedge, (2009) this may not be the case as there is a mismatch between the beneficiary and the decision maker.

While woman reap most of the benefits of the installation; they often are not in the position to take the decision to take the investment decision on their own.

The result on table 7 the age of sample area of household head indicated that the age of respondents were above 20 years that means 97.88% found between 21-64 years and the remaining 2.12% were greater than 64 years of age.  The age groups ranges from 0-14 years and age groups range above 64 years are economically non- active, but the age groups in the range of from15-64 years are economically active age groups. The finding shows that these age groups are almost all energetic members of the community implying that, the labour required for biogas production activities such as feeding the biogas plant is available. Biogas plants need labour for operation and maintenance (Bond & Templeton, 2011).

Figure :woreda populations pyramid.




(Source :woreda financeand economy development,2019)

Concerning educational level of surveyed households 11.7% adopters and 20.5% non-adopters had never attended school (who cannot read and write) and 86.7% adopter and 66.6% non-adopter had completed primary school and 1.7% adopter and 12.5% had attended high school and diploma, while such low level of education many respondents may not be in a position to internalize and understand technical terms that might been used in biogas technology training sessions. This highly affects their ability in adopting and utilizing new technology and they may shun it completely. The results concur with those of Fabiyu and

Hamidi (2011) who found out low levels of education act as a hindrance to technology adoption due to limited access to knowledge.

Among the responding households, 56.7% adopters and 53.4 non adopters were found to have family size in the range of 1 up to 4 members, 26.7% adopters and 34.7% non-adopters had a family size of between 5 up to 8, and 16.7% adopters and 11.9% non-adopters of the households had a family size above 8 members. Based on findings there were sufficient numbers to provide adequate labor for running biogas plant operation, in terms of daily plant feeding, cow dung collection, water drawing, and digester cleaning among other things. Similar findings reported by Wang et al. (2011), found out that excess labor influenced positively households' willingness to adopt biogas.

The major economic activities in the sample study area are livestock farming which is indicated by the result of respondents in table 7 where the sample study area of biogas adopter and non-adopter household headed were accounted 20% and 35.2% respectively had high income, 41.7% of adopter and 42.6% of non-adopters had medium economic status and 38.3% of adopter and 22.2% of non-adopter had low economic status. Therefore, this was likely to affect their capacity to save and be able to construct biogas plant which requires relatively high initial cost for construction. The prohibitive high cost of construction hinders adoption of the technology (Mwakaje, 2012). Biogas plants have a high construction cost relative to household income (Bond and Templeton 2011) which can be prohibitive for many households.

Table 7: The Socio Economic Characteristics and Biogas Adoption

| **Variable** | | **adopter** | **Non adopter** |
|---|---|---|---|
| Gender | Male | 58(96.7%) | 201(76.1%) |
| | female | 2(3.3%) | 63(23.9%) |
| Age | 20-35 | 14(23.3%) | 84(31.8%) |
| | 36-50 | 33(55%) | 133(50.4%) |
| | 51-60 | 9(15%) | 35(13.3%) |
| | Above 64 | 4(6.7%) | 12(4.5%) |
| Level of education | None | 7(11.7%) | 54(20.5%) |
| | 1-4 | 30(50%) | 108(40.9%) |
| | 5-8 | 22(36.7%) | 68(25.7%) |
| | 9-10 | 0 | 30(11.4%) |
| | 11-12 | 1(1.7 %) | 3(1.1%) |
| | Above diploma | 0 | 3(1.1%) |
| Number of household | 1-4 | 34(56.7%) | 141(53.4%) |
| | 5-8 | 16(26.7%) | 92(34.7%) |
| | Above 8 | 10(16.7%) | 31(11.9%) |
| Monthly income | Low | 23(38.3%) | 59(22.2%) |
| | Medium | 25(41.7 %) | 112(42.6%) |
| | High | 12(20%) | 93(35.2%) |
| Land size (hectare) | Less than 0.25 | 5(8.3%) | 23(8.7%) |
| | 0.25- 0.5 | 23(38.3%) | 98(37.1%) |
| | 0.6-0.75 | 7(11.7%) | 36(13.6%) |
| | 0.76- 1 | 10(16.7%) | 45(17.0%) |
| | Above 1 | 15(25%) | 62(23.5%) |
| Number of cattle | 1-4 | 36(60%) | 91(34.7% |
| | 5-8 | 17(28.3%) | 128(48.3%) |
| | Above 8 | 7(11.7%) | 45(17%) |

(Source: field survey, 2019)

Table7. 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 and 0.5 hectare, i.e., 38.3 % of adopter and 37.1% of non- adopter, followed by 25 % of adopter and 23.5 % of non-adopter of the households possessing land holdings above 1 hectare. Among the respondents, 16.7% of adopter and 17.0% of non-adopter had land size between 0.76 - 1 hectare, 11.7 % of adopter and 13.6% non-adopter owned between 0.6 - 0.75 hectare and

8.3 % of adopter and 8.7% of non-adopter respondents possess landholdings with less than 0.25 hectare. The average land size of the respondent were 1.44 hectare, out of this the adopter and non-adopter of the average land size of the household were 1.83 and 1.5 hectare respectively, the woreda's average land size was 1.5 hectare (woreda finance and economy development office, 2018)

Table 7 Reveals that the adopter and non-adopter had more than 5 cattle accounts 40% and 65.3% respectively. This is an implication of sufficient cow dung to feed the biogas digester. The households in the study area may be influenced to adopt biogas technology due to availability of substrate. The results are supported by Sufdaret al., (2013) who pointed out that an increase in number of cattle increased the probability of a household adopting biogas technology.

### 4.3. Current status of biogas adoption among household in rural area

Table 8: Current status adoption of biogas in study area

| Variable | | Frequency | Percentage (%) |
|---|---|---|---|
| Type of biogas plant | Fixed dome | 60 | 100 |
| | Floating drum | 0 | 0 |
| | Flexi biogas | 0 | 0 |
| Size of the biogas digester | $4m^3$ | 0 | 0 |
| | $6m^3$ | 47 | 78.3 |
| | $8m^3$ | 13 | 21.7 |
| | $10m^3$ | 0 | 0 |
| Status of biogas | Functional | 25 | 42% |
| | Non-functional | 35 | 58% |
| Reason for non-functionality | Construction not completed | 5 | 8.3% |
| | Improper management | 25 | 41.7% |
| | Poor quality of construction | 30 | 50% |
| Substrate | Animal waste (only dung) | 60 | 100 |
| | Agricultural waste | 0 | 0 |
| | Household waste | 0 | 0 |

(Source: field survey 2019)

Table 8: revealed that 42% of the digester were functional. This is an indication of very low adoption status. The result is similar to the south region assessed report that the SNNPR the expertise group assessed the status of 3,345 biogas plant functionality and non-functionality which have been constructed from 2008 up to 2016 in different woreda's in the year of 2017. Based on their inventory report 54% biogas plant were non-functional. In general based on their finding of the reason of non-functionality 43% feeding stopped, 31% poor quality of construction, 11% construction not completed and 15% others. Sodo woreda was one of the assessed area, therefore out of 219 biogas plant, 73% were non-functional. This is asserted by Abukhzam and Lee (2010) presents a different view indicating that biogas technology adoption and utilization could be hampered by; lack of an understanding, technical difficulties, lack of training, and insufficient support from top management and perceived complexity in its operation. Furthermore, the low level of adoption could be explained by the theory of Diffusion of Innovation advanced by Rogers. Rogers 2003 cited in Sahin, (2006), argues that the rate of adoption of a technology may be slowed by individuals with some individuals adopting the technology earlier and others taking time before deciding to adopt a new technology. The technology may be at its early stages where only the innovators have adopted the technology and the rest are yet to adopt (Rogers, 2003).

Majority of the biogas plant that is 58% were non-functional this was due poor quality of construction, improper management (feeding stop ….) and skills on maintenance. During the south region energy coordinator said that the non-functionality of the digester due to feeding stopped, poor quality of building and construction not completed. Similar findings were reported by Bensah and Hammond (2010) who indicated that lack of skilled personnel in repair of biogas plants had led to most being abandoned. These findings concur with

Ghimire (2008) who comments that none functioning or poorly functioning bio-digesters because not only capital waste but also do a lot of harm to the reputation of the technology itself and to the desired future of biogas programme. The satisfied biogas users on one hand are the main and effective extension media for the promotion of the technology. On the other hand, dissatisfied biogas users spread negative information about biogas technology, hence reduce its adoption. Probably one of the major causes of biogas failures is the lack of extension services, servicing facility for the plants and technical support services from the government and private sector.

Furthermore the subsidy approach used by the biogas project in introducing the technology in the area, on one hand encouraged and enabled low income earners to adopt biogas technology.

Plate 2: A fixed dome digester that has been found due to lack of maintenance.

(Source: field survey done photo, 2019)

Plate 3 : A fixed dome digester that has been abandoned due to incomplete construction.

(Source: field survey photo, 2019)

Plate 4: The inlet filled with dry dung which covered with dress.

(Source: field survey photo, 2019)

Plate 5: The gas gage which was not connected properly

(Source: field survey photo, 2019)

Results in table 8 revealed that 100% of the biogas digester in the study area were fixed dome. They did not use another digester due to high cost of constructing and maintaining such could have been a reason for low adoption.

Results in table 8: state that most of the house hold headed had a biogas plant size of $6m^3$(47). The Low level of biogas adoption could also be associated with malfunction in government policy and institutions involvement in biogas information dissemination Wawa (2012).

**4.4. Determinants of Biogas Technology adoption**

Table 9 shows that out of the eight variables included in the study, six were positively correlated with biogas technology adoption. These include gender, level of education, household size, and house hold income, number of cattle and availability of water resource. The age of household head and land size were negatively correlated to biogas technology adoption. Average monthly income of households, which is an indicator of household economic status, was positively correlated with biogas adoption. At P<0.05 the significance is 0.001 indicating that income influences biogas adoption significantly. Increased income implies that household head could have the capacity to install a biogas plant.

Table 9: Binary logistic regression estimate of determinants of biogas technology adoption.

| **Variables** | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Gender | 2.969 | 1.037 | 8.190 | 1 | .004 | 1.042 |
| Age | -.173 | .178 | .943 | 1 | .331 | .841 |
| Education | .041 | .163 | .064 | 1 | .801 | 19.466 |
| House hold size | .038 | .232 | .027 | 1 | .869 | 1.039 |
| Income | .736 | .220 | 11.213 | 1 | .001 | 2.088 |
| land size | -.618 | .272 | 5.158 | 1 | .023 | .539 |
| Cattle | .856 | .254 | 11.333 | 1 | .001 | 2.353 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Water Resource | .148 | .109 | 1.830 | 1 | .176 | 1.159 |
| Constant | -6.046 | 1.753 | 11.894 | 1 | .001 | .002 |

Variable(s) entered on step 1: gender, age, education, house size, income, land size, cattle and water resource.

*No of observations* *236*
*-2 Log Likelihood* *219.59*[a]
*Cox & Snell R Squared* *0.184*
*Nagelkerke R squared* *0.271*
*Percentage of total prediction* *76.3%*

The independent variables chosen correctly predicted household biogas adoption conditions for 76.3% of the total observations. Among the eight variable included in the model, the Wald test results for three of these indicated that they had a statistically significant influence on biogas adoption.

The Wald criterion demonstrated that gender (β=0.05, P=0.004) and income (β=0.736, P=0.001) of the household head and the number of cattle owned (β=0.856, P=0.001) made a significant contribution to biogas technology adoption, while education, family size, land size and age of the household head were not significant in influencing prediction of adoption (Table 9).

The results further revealed that gender of household head positively correlated with biogas adoption. Gender of household head was significant at P<0.05 (0.004) as shown in Table 9. This is an indication that male headed households were more likely to adopt biogas technology as compared to female headed households. In addition to that an indication of men controlling resources and decision making in the family. These results are consistent with results by Njenga (2013) and Kabir et al., (2013) both found out that male headed household adopted the technology since they own resources and they control decision making in the household. The same was also found true by Ng’wandu et al., (2009) who indicated that traditionally the male dominates decision making as well as resource ownership. Women are involved in many responsibilities at home such as cleaning, cooking and child care. Lack of time and revenue constrained them from investing in new technologies resulting in low rates of adoption by Tanellari, et al.,(2012). The implication of these results in regard to biogas adoption and utilization is that, if women headed household are not empowered to make decisions and control resources it may be difficult for them to adopt biogas.

In the above finding which is shown on table 9 that the income of household head positively correlated with biogas adoption. Therefore income was significant at $p<0.05$ (0.001). Similar results were reported by Wanjugu (2012) who emphasized that the level of economic status highly influenced a household's decision to adopt biogas. If households in the study area were to be encouraged to adopt and to adopt biogas their income must be increased substantially to such a level that they would be able to have enough money for basic needs and extra to construct and maintain biogas plants or design plants that equally efficient but relatively cheaper to construct and maintain. Results in Table 7 indicate that most households who owned between 1-4 cattle (60% percent). The results are supported by Wawa, (2012) who found out that number of cattle owned was insignificant in biogas adoption. The probable reason for this is that a large number of cattle may not necessarily generate the amount of cow dung required for daily feeds if the method of management is free range which makes it difficult to collect enough cow dung as much cow dung will be lost in the fields. What really matters is the amount of cow dung that the cattle can generate and not the numbers as asserted by Ngigi et al., (2007) that even two dairy cows which are zero grazed can produce enough substrate for the digester. Contrary to these findings Iqbal et al. (2013) reported that an increase in number of cattle increased the probability of a household adopting biogas technology since they would provide sufficient cow dung. Mendola (2007) acknowledges that the development and management of biogas innovations is far from a purely technical question, and almost always involves numerous economic and social problems, as well as human behavior. Indeed, characteristics of households could be a single most important factor, why households choose to adopt or not.

As the result indicated on table 9 the level of education of the household head was not statistically significant, education level of the households had a positive non-significant (P=0.801) relationship with biogas adoption. With an odds ratio of 1.042 and a logit coefficient of 0.041, the level of education of the household head did not appear to influence biogas adoption. But it was positively correlated. But the survey findings contradicted from Ridell and Song (2012) showed that highly educated workers tend to adopt new technologies faster than those with less education. Low levels of literacy are associated with difficult in flow and comprehension of information which is likely to affect adoption of biogas (Uaiene et al., 2009).

The results from Table 9 show that household size was statistically not significant but it was positively correlated with biogas adoption. The results are contradicted by Wang et al., (2011) who found out that excess labor in families were positively correlated with household's willingness to adopt biogas. But the Findings in Table 7 Indicate that 56.7% adopter had between 1-4 household members but 43.4% adopter had between above 8 household members, on the other hand 46.6% of non-adopter had between 5-8 household members had not adopted biogas. This is an indication that labor availability on its own cannot influence a household head to adopt biogas.

On the above table 7 revealed that the Age of household head was expected to have positive or negative effect, since age of households could have a higher probability of adopting biogas energy. In the current study as depicted by the model however, and contrary to the hypothesis, age of the households had a negative non-significant (P=0.331) and positive relationship with biogas adoption. With an odds ratio of 0.841 and a logit coefficient of -0.173, age of the household head did not appear to influence biogas adoption. This finding supported by Somda et al., 2002, who found that the farmers' age was negatively related to adoption.

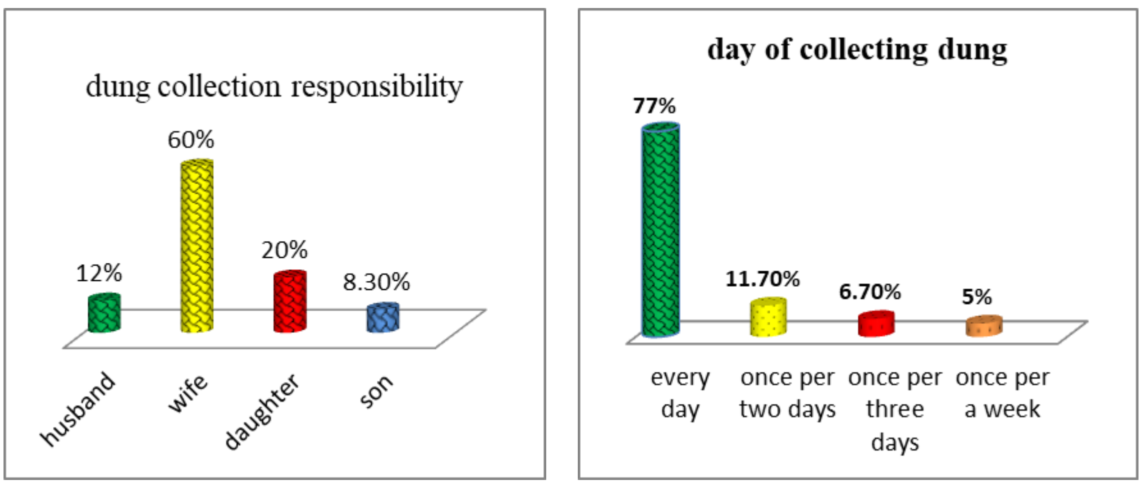
The probability of household adopting and utilizing the technology was higher in households where the heads were middle aged to elderly, compared to those headed by youths (elderly in this case was 61 to 80 years and youth was 21 to 40 years). Age and experience have a range of influences on household decision making in adoption. Older ages, according to Nhembo (2003) may influence an individual in the direction of not adopting new ideas due to conservatism. However, with regard to experience, older people may have more experience and more resources that allow them to adopt capital-intensive technologies than younger people (Shiferaw and Holden, 1997).

### 4.5. Availably of Dung and Manure Management

The presence of sufficient dung is one of the most important factors to operate the biogas technology**.** 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. The majority of the women 80% , including daughters, take the responsibility of dung collection and disposing, although men and son are to a certain extent involved. In addition to this, the survey findings show that nearly 81 % of the households collect dung every day.

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. 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.

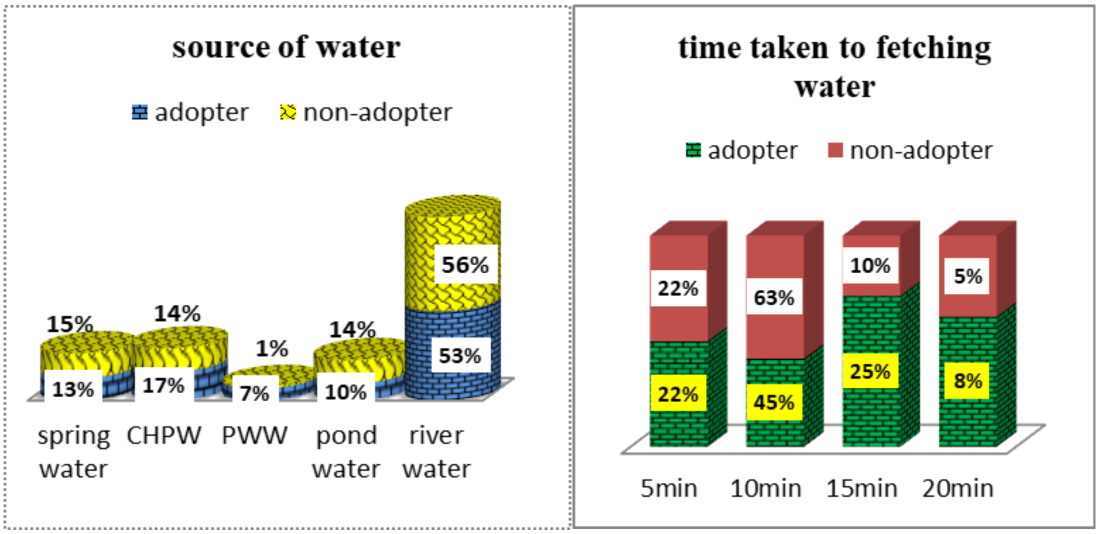
Figure 7: Dung collection and manure management responsibility




(Source: field survey 2019)

## 4.6. Access of Water Resource and Distance of Fetching Water to Home

Figure 8:  Resource of water and distance to fetching water




(Source: field survey 2019)

Water is another critical requirement for biogas technology because it serves both livestock keeping and biogas plants operations. An equal amount of water and/or urine needs to be mixed with feed stocks like cow dung before it is fed into a biogas plant.  According to Eshete G. and Kidane W. 2008, fetching water required to mix with the daily input of 20 kg fresh dung would need 20 liters of water that is a 1:1 ratio should not take more than 20 to 30 minutes. The result in figure 6 state that 53% of adopter and utilizer and 56% of non-adopter of the respondents were got water from river and also 17% of adopter and 14% of non-adopter of respondents also from community hand pump water therefore 92% of adopter and 95% of non-adopter fetch water from water sources not more than 15 minutes .

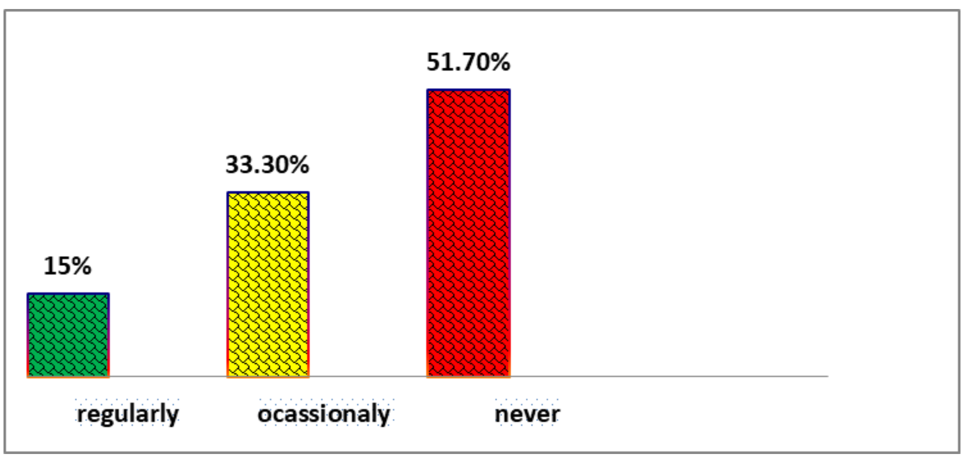
## 4.7. Availability of technical Services

Absence of follow up and maintenance service was one of the major problems identified to the failures of many of the biogas installations constructed prior to the establishment of

NBPE (Eshete et al., 2006; EREDPC and SNV, 2008). So to solve this problem in the newly established NBPE, quality management is designed to be one of the basic programme activities. Quality management, as indicated in the PID, comprises control of construction qualities and maintenance service (EREDPC and SNV, 2008). In the 15-point tri-party agreement among biogas user, mason, and the programme unit, the mason was required to give a two-year maintenance service guarantee for the structural part and a one-year guarantee for appliances and pipelines. One of the enforcement mechanisms designed for this purpose was withholding 10.25 $ from the subsidy allocated per unit biogas installation. So this money is supposed to be given to the mason after two years of free maintenance services upon the approval of the biogas users for the service gained.

However, maintenance service was not given as intended for the following reasons.

Figure 9: access of getting technical service




(Source: field survey by author, 2019)

Table 9: revealed that the unavailability of technical services was the most important factor in biogas adoption as 51.7% of respondent nothing technical service got for their digester. 33.30% respondents occasionally got technical services. The rest 15% regularly got

technical services. The study findings are similar to those reported by Rajendran, Solmaz and Mohammed (2012) who noted that lack of skilled labour and technical knowledge had hindered biogas dissemination and adoption. The problem of lack of technicians was also noted to have contributed significantly to failure of biogas plants in Ghana (Bensah & Hammond, 2010).The lack of technical services in the study area was evidenced by either incomplete biogas plants refer to (Plate 6)

Plate6: Incomplete biogas plants.

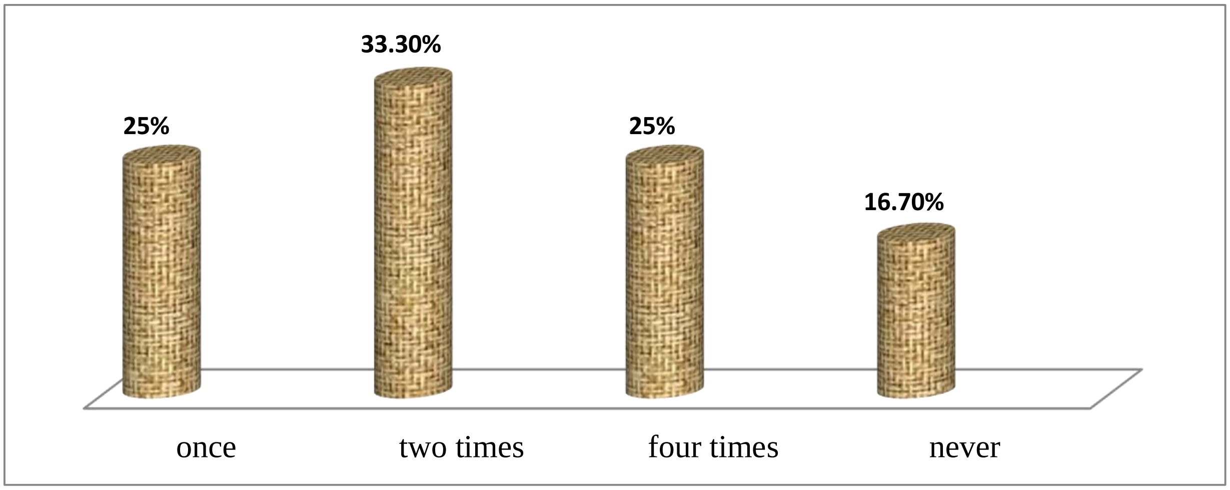
Source : field survey photo,2019)

In table 8 Out of 60 biogas plant 58% biogas installations, plants were non-functional. For various reasons, 35 out of 60 non-operating biogas plants remained incomplete construction, improper management and poor quality of construction. One major justification for this could be absence of maintenance service. There is only one focal person in the woreda. Therefore, the problem of maintenance service needs urgent action. Focus group discussants also emphasized on three issues for immediate improvement in the programme: maintenance service, user training, and availability of spare parts. Hence, one solution may be to assign a standby biogas technician who can give immediate maintenance and advisory services in the woreda. The other solution, which is even more cost-effective, could be the provision of on-the-spot intensive maintenance training to a few, may be three, educated, wise, and committed farmers per rural kebele.

### 4.8. Supervision Services

Closer supervision and follow up is quite essential to control quality of construction, verify adherence to the standardized design, confirm compliance of measurements to the standards set, check proper operation of the biogas installations, and consider complaints on maintenance and other services. Accordingly, the NBPE prepared four types of quality control forms: quality control Stage One (QC1) and Stage Two (QC2), to be filled in by focal persons, construction completion quality control form (CCf) to be filled by regional biogas technicians, and 'after sales services' quality control form to be filled by regional or federal supervisors. QC1 was expected to be filled before and during construction. Starting from site selection, planning, and layouts, QC1 helped to follow up the various stages of construction and check quality and sufficiency of construction materials presented. QC2 was filled immediately after completion of construction (MoWIE, 2010b).

Figure 10: how often supervisors visited their biogas plants after the completion of construction.




(Source: field survey, 2019)

Accordingly, replied that they were visited 25% of the plants were visited once, 33.3% visited twice, 25% visited four times and the remaining 16.7% said no supervisor came at all. Concerning the benefits obtained from supervisors' visits, 51.7% replied that they obtained advices, maintenance services, and motivation. The remaining 48.3% said they obtained nothing. It was also pointed out that supervisors mostly come without any maintenance tools. Hence, they can only maintain the type of problems requiring no maintenance tools.

In the PID, it was indicated that supervisions would be carried out on sample basis (EREDPC and SNV, 2008). If this is so, the proportion of visited biogas plants could be quite enough. But supervisors seemed to be directed towards the operating ones.

### 4.9. Supplies of Spare Parts

Spare parts for biogas technology are commonly used as spare parts for pipe water installations or other construction and are widely available on the market. Those spare parts which are solely used for biogas technology are not available as needed. Two basic problems were raised by group discussants with regard to spare parts, particularly biogas lamp glasses and mantles. First, the spare parts are not available at all times in the woreda offices. Second, sometimes the woreda offices are closed for field or other reasons. For those farmers coming from the remotest parts of the woreda, it is very tiresome. Key informants at various administrative offices admitted the existence of spare part supply problems in the first two years of programme implementation period but the problems were solved afterwards. Even it was pointed out that the spare parts were given freely at the woreda offices. However, in reality, may be because of the problem of distribution or failure to request for the spare parts from the regional or federal offices at the right time, there were complaints about the shortages of supplies of spare parts.

Therefore, instead of even giving the spare parts freely but demanding farmers to travel long distances to the woreda offices, it would be better to put the spare parts at each rural kebele office and sell them to the farmers with reasonable prices.

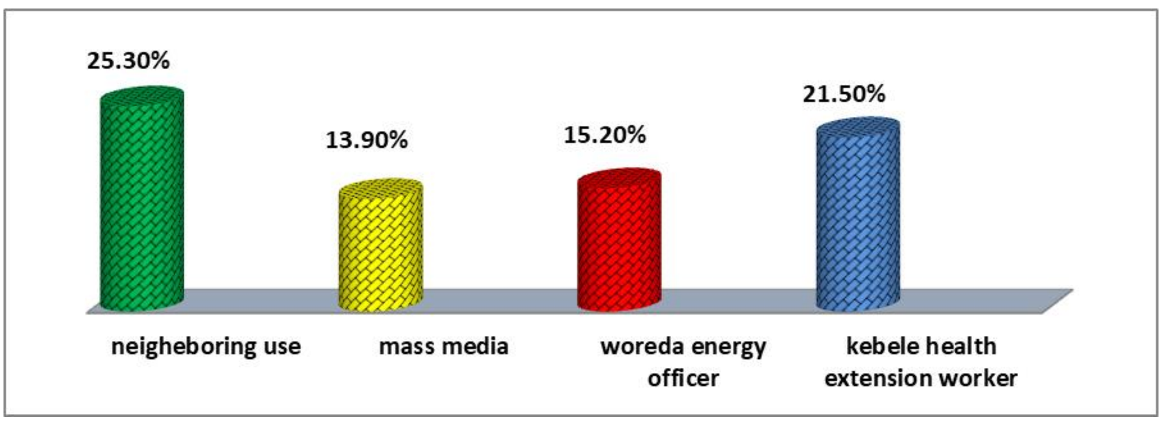
## 4.10. Peoples' Awareness and Attitude towards Biogas Technology

Knowledge and awareness towards a certain technology may have an influence on its adoption. According to Rogers (1995), awareness is just the first stage of adoption process, and it has to be followed by accumulation of knowledge which in turn induces the perception of people on the technology.

### 4.10.1. Biogas Information Dissemination in the Study Area

The study identified various channels of information that sensitize the public about the appropriateness, efficiency and advantages of adopting Biogas technology. These included health extension worker, energy officer, neighbor user who had adopted biogas technology, biogas project staff as well as mass media like radio. After becoming aware people accumulate more knowledge through training, then test the new technology and when satisfied with the result, people take up the innovation (Rogers, 1995). The results in figures 9 indicate that a majority 25.3% of the respondents in the study area were initiated of biogas technology by neighbor user. According to Muriuki (2014) highlighted that potential users are able to see the real benefits derived from biogas technology and thus inspired to replicate. On other way 21.5% of respondents were initiated by kebele health extension workers. From the same table, 13.9% of respondents were initiated through mass media advertisements while 15.2% of respondents were initiated by woreda energy officer. This is in line with the diffusion of innovation theory (Rogers, 1995), which predicts that media as well as interpersonal contacts, in addition to providing information, influences opinion and judgment.

Figure 11: who initiate to build biogas technology.



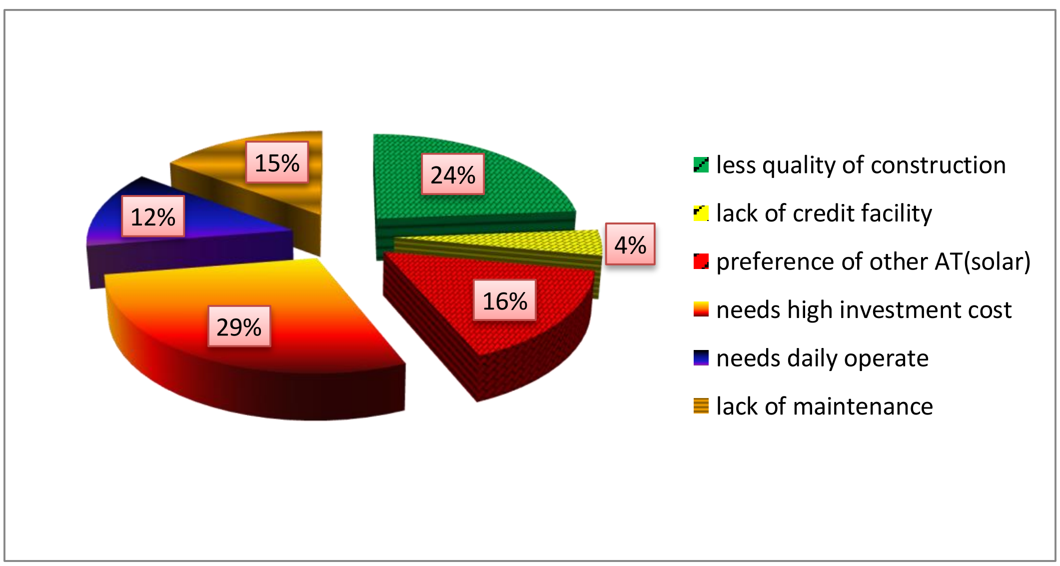

(Source: field survey 2019)

### 4.10.2. Reason for Not Increasing Biogas Technology Adoption

Responses in table11 indicate a slight difference in responses given by adopters and non - adopters concerning on the factors for non-adopter of biogas technology where biogas adopters mentioned high investment cost 29% and less quality of construction 24% as a major factor had followed by lack of maintenance 15% and needs daily operation12%.

According to Quadir et al., (2010), high investment costs in installing biogas units have been blamed for the low adoption rates in many developing countries. In addition to that this agrees with an observation by Barnes et al., (1997) that in developing countries, initial costs of access to modern energy sources are often prohibitive for poor rural populations who in general are not willing to obtain credit. Comparatively non adopters mentioned that less quality of construction and lack of maintenance and as a major factor for low level of adoption of biogas technology on the other way high investments cost and lack of loan also a factor of low adoption. The other respondent revealed that 16% prefer of other alternative energy than biogas technology.

Table12: Responses on why not increase biogas technology user




(Source: field survey 2019)

### 4.10.3. People Attitude towards Biogas Adoption

Attitude is a crucial element in implementation of the technology and it can be a powerful activator or a barrier towards adoption of a technology (Abukhzam and Lee, 2010). In order to measure respondents' attitude several statements related to positive attributes of biogas technology were developed and respondents were required to indicate whether they agreed or disagreed to the statements. Agree was taken to infer positive attitude and not agree inferred negative attitude towards biogas technology. Table11. Shows responses on the known advantages of biogas technology by respondents, it provides advantages that would have positive influence on the individual attitude and hence adoption of biogas technology.

Table 11: Attitude towards biogas technology

| | | **Strongly agree** | | **Agree** | | **Not agree** | | **No idea** | |
|---|---|---|---|---|---|---|---|---|---|
| | | **adopter** | **Non adopter** | **adopter** | **Non-adopter** | **adopter** | **Non-adopter** | **adopter** | **Non-adopter** |
| **Use of biogas** | Save money | **30 (50)** | **77(43.8)** | **15(25)** | **21(11.9)** | **15(25)** | **29 (16.5)** | **0** | **49(27.8)** |
| | Reduce indoor air pollution | **40 (66.7)** | **84(47.7)** | **20(33.3)** | **50(28.4)** | **0** | **22(12.5)** | **0** | **20(11.4)** |
| | Save time | **35 (58.3)** | **81(46)** | **23(38.3)** | **42(23.9)** | **2(3.3)** | **19(10.8)** | **0** | **34(19.3)** |
| | Relieve women workload | **33 (55)** | **72(40.9)** | **24(40)** | **49(27.8)** | **3(5)** | **15(8.5)** | **0** | **40(22.7)** |
| | Reduce the rate of deforestation | **29 (48.3)** | **84 (27.3)** | **26(43.3)** | **52(29.5)** | **5(8.3)** | **9(5.1)** | **0** | **31(17.6)** |

(Source; field survey, 2019)

The results in Table 11: Indicate that generally the results for agreement with the statements were higher than disagreement with the statements for both adopters and non-adopters of biogas technology. This implies that a majority of respondents have positive attitude towards the technology. However the result for biogas adopters were higher in all statements than for non-adopters indicating that the known advantages of biogas technology to the biogas adopters have positively influenced their attitudes towards the technology. Lack of information on advantages has negatively influenced their attitudes hence non-adoption of the technology. The adopters of biogas technology, their neutrality to statements above implies that biogas benefits were yet to be realized by utilizer.

Attitude responses were further captured under the discussion on technological characteristics where both adopters and non-adopter expressed their disappointment towards poor performance of biogas plants. This had negatively affected their attitude on the technology resulting into abandoning using the technology and decrease in adoption rate of biogas technology.

## 4.11. The Involvement of Government and Non- Governmental Organization on Promotion of Biogas Technology

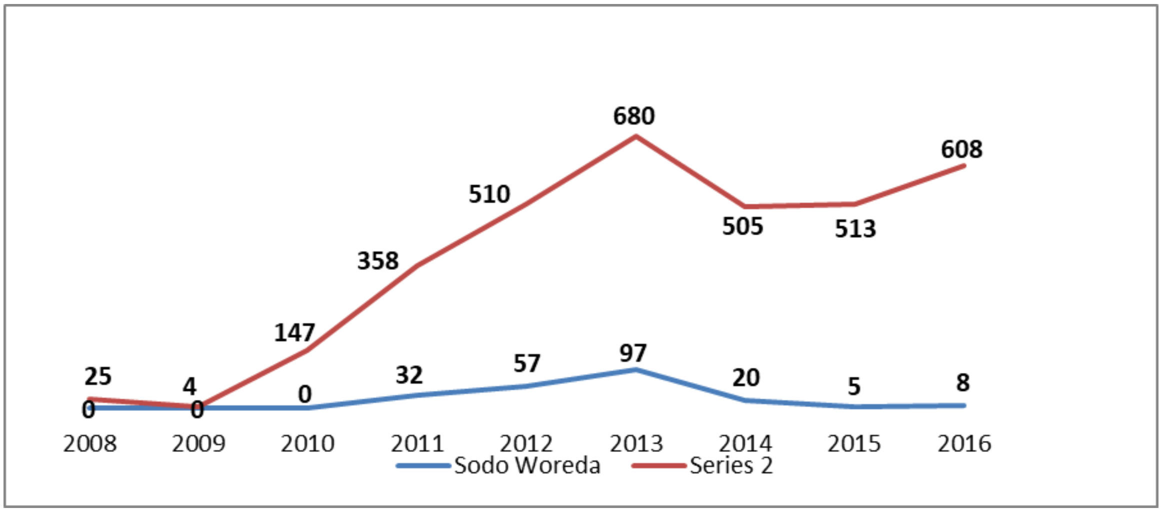
### 4.11.1. The Involvement of Government Institution on Promotion of the Technology

The government commitment in designing, implementing programs and strategies that suit its own country context was one of the success determinants in adoption of biogas technology. Based on this 17 government department coordinators/senior experts were participated from different sectors in interview so as to assess their roles and contributions towards the adoption of biogas technology in a sustainable way.

The overall objective of this programs are to improve the living standard of farmers and their families , reducing the over –exploitation of biomass cover and reducing GHG emission in Ethiopia. Therefore, the biogas dissemination of the countries still low as planned number in the last two phases (2009-2013 and 2014-March 2019). Since the launching of the National Domestic Biogas Program (NBPE) in 2009, Ethiopia was able to disseminate 8,161 biogas plants between 2008-2013 (58% out of the planned 14,000 plants). During the second phase 11860 up to June 2018 biogas plant disseminate between 2014-

March 2019 (59.3% out of the planned 20,000). Table 12: revealed that the case of sodo woreda the rate of biogas adoption became decline, especially, from 2013 to 2016.

Figure 13: the activities of biogas installation by the government institution promotion.




(Source: SNNPR inventory report, 2017)

The findings of the survey had revealed

- Sufficient awareness and attitude of the society, access of loan gaps, limited institutional capacity (including knowledge, skill and sufficient staff), inappropriate dissemination strategies and design selection, and limited stakeholders (NGO's) 'integrations are the inhibiting factors that had contributed for lower promotion and disseminations rate.
- The reviewer revealed that there was high commitment on the side of the government to promote and disseminate the domestic biogas technology. However, as the limited attention and priority by some political leaders , especially at woreda level, for the alternative 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 leaders would and commitment in supporting the promotion and dissemination effort declines as one goes from federal to woreda level. Moreover, one of the woreda energy higher experts explained the situation as follows: to control and facilitate the program, the string committee was established based on the NBPE procedure. Based on the above Table 12: the rate of installation of biogas technology from the year 2011 up to 2013 was increased the building of biogas technology, but from 2014 to 2016 was decline the building of biogas technology. According to the woreda office of alternative energy coordinators said that the above happened in the first three year the commitment of string committee and other stakeholder were highly committed by creating awareness and the community showed an interest to construct biogas technology , but after three year the committee and other stakeholders commitment became decline on supporting the activities of biogas users, controlling the qualities of building, facilitate the access of loan and facilitate training . However, their support for the achievement of the production target set in the annual plan. Rather, most of the members of the string committees, including heads of the woreda WME offices were busy with other political assignments.

### 4.11.2. The Involvement of NGO's on Promotion of the Technology

The stakeholders could play a great role in supporting in areas where a gap is observed by the leading organization or in areas where collaborative effort is needed. In dissemination of biogas technology, like promotion, capacity building, research and efforts support from different stakeholders.

According to zone and woreda alternative energy coordinator, said that there were no institutions and organizations has made efforts either privately or in collaboration with the office of energy in promotion, dissemination as well as building of biogas technology in the zone as well as in the woreda. 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. In addition to that government did not create good enabling environment to the stakeholder especially for NGO's.

According to the expertise explanation the promotion and dissemination of 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 building development.

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATION

## 5.1. Conclusion

Adoption and dissemination of biogas technology has not been progressing as it was planned in Ethiopia. The factors that stunt the pace of its adoption and dissemination include the socio-economic, the awareness and attitude of the people and institutional factors. The rate of adoption of biogas technology has been found low among the rural households. The study identified the determinants of biogas technology adoption in the study sites. Sex of the household head is recognized to be an important factor influencing adoption of biogas technology. Male-headed households are more likely to adopt biogas technology than the female-headed ones. Households having access to credit are more likely to adopt the technology than those without this opportunity. Educational level of the household head, heads of cattle and income level are identified to have significant ($p<0.04$), ($P<0.01$) and ($P<0.01$) respectively, have a positive influence in the decisions of households on adoption of biogas technology.

Further the awareness and attitudes influence the adoption and dissemination of biogas technology. The government and NGOs need to step up campaign also play great roles in influencing the adoption of biogas technology.

The institutional structure for NBPE is found to be less suitable for the smooth implementation of the program. It extends only from federal to regional administrative levels. Program implementation level is left to the pre-existing woreda level government structure.

The biogas program steering committee established at different administrative levels is found to be inactive. There is lack of coordination between related offices.

The program does not also encourage private sector, NGOs and other civil society stakeholders adequately.

The biogas users are also not obtaining maintenance service regularly and immediately on demand. The enforcement mechanism is too weak for masons to give regular maintenance service. Therefore, for various reasons, of the total surveyed biogas digesters, 51.4% poor quality of construction, 40% improper management and 8.6% construction not completed. Biogas spare parts, particularly biogas lamp and its accessories, are not available in the woreda. However, due to the frequent breakage of the biogas lamp glasses and burning of the mantles, these spare parts are demanded every time. The regular unavailability of these spare parts has a daunting effect on the further dissemination of biogas technology.

The biogas technology has neither been properly incorporated into energy policy, proclamation, and nationwide development plan like GTP-I in Ethiopia nor has obtained the necessary attention it deserves from its stakeholders. Biogas energy is missing in the country's renewable energy lists. The energy policy document neither exhaustively lists energy resources to include biogas nor has it been updated for two solid decades. It also lacks clearly stated policy instruments that promote involvement of the private investors towards the development of renewable energy technologies including biogas.

## 5.2. Recommendation

1. For further promotion of the biogas technology, attention should be given towards empowering females and female-headed households, improving educational levels of the household heads, and households' access to credit and income levels.
2. The woreda steering committee should actively participated on giving supervision, follow the quality of building of the digester, giving training and encourage the biogas adopter.
3. Biogas being a new technology to farmers, provision of timely user training to each biogas user household involving women and children should not be compromised.
4. Biogas spare parts like biogas lamp and its accessories which are less durable and frequently demanded by the users should be purchased in bulk with revolving fund and be available regularly for sale at centers (rural kebele offices) that are reasonably near to the biogas users.
5. The energy policy of the country should be updated regularly to accommodate dynamic realities and exhaustively identify and incorporate missing energy resources. Policy makers should incorporate biogas technology in energy policies and develop policy instruments that create conducive environment for the involvement of the private investors and the creation of a commercial biogas-sector.
6. The use of biogas technology is found to have various significant positive impacts on the rural households. However, as high as (51.4%), (40%) and (8.6%) of the surveyed biogas households have poor quality of construction, improper management and construction not completed, respectively. Therefore, the NBPE should focus not only on the dissemination of the technology but also ensure the

continuous and proper functioning of the already installed biogas plants.

7. Awareness and attitude are not the only means for the adoption of biogas technology. Therefore, it is better to provide the required information and inspiration of the users to enhance sustainable use of biogas technology.
8. The participation and cooperation of relevant stakeholders like NGO's 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 stakeholders (NGO's) and construction entities in the biogas sector would help to retain the construction and maintenance knowledge and skill at local level.

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APPENDIX 1

Dear respondent: The objective of this interview is to get information about the determinant of biogas technology utilization in sodo woreda. The information you are going to give will help to know your views on the situations, problems and solutions about the determinant of biogas technology utilization. Hence, your genuine and honest response will make the result more valid and reliable. So you are kindly requested to provide your genuine and honest response.

For your valuable cooperation thank you in advance!

## 1. General Information

| | | | |
|---|---|---|---|
| 1. 1 Questionnaire/Household Number | | | |
| 1.2 Respondent's Residence Location: | Name of woreda | Name of kebele | name of village |
| | | | |
| 1.3. Date of Interview: | Date: | Month: | Year: |
| | | | |
| 1.4. Interview Time : | Starting Time: | Ending Time: | Total Time: |
| | | | |

| Survey Check Column: | Interviewer | Supervisor |
|---|---|---|
| Name | | |
| Sex | | |
| Phone Number | | |
| Signature | | |

## 2. Social character

| No. | Name of respondent | sex | Age | Level of education | No. of HH | Marital status | Occupation of HH | Average monthly income | Land size (ha) | No. of livestock |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| | | 1.male<br>2.female | | 1. No formal edu.<br>2.primary (1-4)<br>3.primary (5-8)<br>4.secondary (9-10)<br>5.TVET<br>6.secondary (9-12)<br>7.diploma and above | 1. 1-4<br>2. 5-8<br>3.above 8 | 1. married<br>2.single<br>3.separeted<br>4.widowed | 1.farmer<br>2.civil servant<br>3.business<br>4.others | | | 1. No cattle<br>2. 1-4<br>3. 5-8<br>4. Above 8 |

### 3. Utilizer and non-utilizer

| No. | What type of biogas digester does use? | The size of your digester? | What is Status of biogas? | Reason for non-functionality | What kinds of Substrate you use for feeding digester? | Who is responsible for dung collection? | At what day you collect dung? | Where is the source of water? |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| | a) b) Fixed dome<br>b)Floating drum<br>c) flexi biogas | 1. 4m3<br>2. 6m3<br>3. 9m3<br>4. Other... | 1. Functional<br>2. Non-functional | 1. Construction not completed<br>2. Improper management<br>3. Poor quality of construction | 1. Animal waste (only dung)<br>2. Agricultural waste<br>3. Household waste | 1. husband<br>2. wife<br>3. daughter<br>4. son | 1.every day<br>2. once per two days<br>3. once per three days<br>4. once per a week | 1. spring water<br>2. community hand pump water<br>3. private well water<br>4. pond water<br>5.river |

| N0. | How much time taken to fetching water | What kind of energy is use for cooking and heating? | What type of energy is use for lighting? | Who responsible to collect Fire wood and to buy kerosene? | How much time is taking to collect wood? | Money spent to purchase fire wood per week/ ETB/ | Money spent to purchase kerosene per week /ETB/ | Who initiate to build biogas technology? | Why not increase biogas technology user? |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | 1. 5min<br>2. 10 min<br>3. 15 min<br>4. 20 min | 1. Only use fuel wood<br>2. Fuel wood and BLTs<br>3. Fuel wood and BLT's<br>4. Fuel wood BLT'S | 1. Kerosene<br>2. Electricity<br>3. solar | 1. Husband<br>2. Wife<br>3. Daughter<br>4. Son | 1. 0.5hour<br>2. 1hour<br>3. 1.5hour | 1.30<br>2. 40<br>3. 60<br>4. Does not purchase | 1. 12.5<br>2. 25 | 1. neighboring<br>2. mass media<br>3. woreda energy office<br>4.kebele health extension worker | 1. less quality of construction<br>2. lack of credit facility<br>3. performance of other alternative energy<br>4. needs high investment cost<br>Needs daily operation<br>Lack of maintenance |

| Attitude towards biogas technology | | SA | A | UD | D |
|---|---|---|---|---|---|
| **Use of biogas** | Biogas will reduce the rate of deforestation | | | | |
| | Biogas will relieve women workload | | | | |
| | Biogas will save time spend on fire wood collection | | | | |
| | Biogas will reduce inhalation smoke | | | | |
| | Biogas technology will help improve soil fertility | | | | |
| | Biogas is protect air pollution | | | | |
| | Save wastage of money on buying of fire wood, kerosene and artificial fertilizer | | | | |
| | Prevent desertification | | | | |
| | Key: SA Strongly agree; A Agree; UD Undecided; D Disagree | | | | |

| Observation Schedule |
|---|
| Have they a Biogas plant 1. Yes 2. No |
| Functioning conditions of the biogas digester systems sampled<br>1. Fully functioning 2. Partially functioning 3. Defunct |
| Type of biogas technology ………………………………… |
| Which type of component frequently failed biogas technology |
| Structural problems on biogas technology..........................................................<br>- Cracked digester....................................... - Chocking of outlet/inlet.................<br>- Broken or leaking pipes..................... - Shortage of cow dung.................<br>- No gas............................ - Installation problem………………….. |
| How many time /Date/ takes to repairer the technology with the concerned body? |
| Number of cattle.......................................................................................... |
| Closeness of water to the house …………………………………………….. |
| Cattle rearing method.........................................................................................<br>- Free range................................. -zero grazing.................................. |

| Focus Group discussion question | |
|---|---|
| 1. | What are the major energy sources in your area? |
| 2. | Is there energy problem in your area? If yes to what extent |
| 3. | Do you see a need for alternative energy sources? If yes which alternatives do you think are appropriate to your area? |
| 3. | What is the acceptance status of biogas technology in your area, do you think the technology has been adapted to the expected level. |
| 4. | If you think adoption is low what are the reasons? |
| 5 | What do you think could have contributed to other people adopting the technology and others not? |
| 6. | Some people adopted the technology and stopped using it in the way. What could be the reasons? |
| 7 | Some people think biogas technology is not an appropriate technology and its advantages are less compared to its advantages. What is your opinion? |
| 8 | Are people really aware of environmental and health problems that come as a result of using firewood as a source of energy? |
| 9 | Do you have enough knowledge about biogas to the extent of being able to share the information with others? If not what areas do you think need more education/training? |
| 10 | In your opinion what kind of strategies can be put in place to enhance adoption of biogas in Sodo Woreda? |
| 11 | What are the reasons for biogas technology not functional? |
| 12 | What are the reasons for not adopted by others? |
| 13 | Are the adopters interested to use biogas technology? |
| 14 | What are the reasons for lack of technical services? |
| For key informant interview | |
| 1. | What is the main policy barrier in the Ethiopian rural energy sector? |
| 2 | What are the main factors that determine the sustainability of energy access projects or programs of your agency? |
| 3 | What is the main barrier working or involving in the Ethiopian rural energy sector? (give priority)<br>a. Constraints from Policies and regulations ( )<br>b. Lack of Technical capacity ( ) c. People's awareness ( )<br>c. Low level of private sector involvement ( ) |

| | |
|---|---|
| | d. lack of political commitment ( )<br>e. Low Institutional capacity ( ) f. If other, please State----- |
| 4 | Mention /suggest/ ways of approaches to attract private sectors in rural energy access programs? |
| 5 | What are the main constraints to implement rural energy programs? |
| 6 | How do you promote /introduce/ biogas technology to the rural communities? |
| 7 | What is the reason behind for biogas plants not well spread in the communities? |
| 8 | What are the determinants of biogas technology utilization? |
| 9 | Is your institution continuously followed up the biogas user/implementer? |
| 10 | Is there any problem the institutional set up to promote the biogas technology? |
| 11 | How many biogas technology still now distributed in your woreda ------------------------------- |
| 12 | What kind of biogas technology distributed in your woreda a. fixed dome b. Floating-drum plants |
| 13 | What are the most distributed in your community from the two------------------------------ |
| 14 | Which digester works best to produce biogas efficiently------------------------------------- |
| 15 | Who install the digester in your woreda (skilled person unskilled person) |
| 16 | What is the cost of installing the digester? |
| 17 | Are the farmer trained on how they use/implement /the digester? |
| 18 | Are there social taboos associated with the biogas digester system? |
| 19 | Is any loan access in your woreda? |
| 20 | How regularly should the digester be emptied and cleaned? |
| 21 | How does biogas use change the livelihoods of the local people who have adopted it? |
| 22 | What are the causes of digester failure? |
| 23 | How are these problems solved? |