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Analysis of Current Status and Problems of Domestic Biogas Plants in Gomma Woreda.

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Analysis of Current Status and Problems of Domestic Biogas Plants in Gomma Woreda.

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ABSTRACT

Increasing population, scarcity of resources and material, environmental pressures, and climate change are issues that challenge our current fossil-based economy. Anaerobic digestion of cattle manure produce energy rich biogas and nutrient rich fertilizer, while reducing environmental pollution and indoor pollution, work load of women's etc. For the promotion of biogas in Ethiopia, the standardized SINIDU fixed dome model have been introduced with varying sizes of 4, 6, 8 and 10 m^3, covering the daily energy demand excluding the periodical Injera baking. Several programs have been implemented to disseminate biogas technology in many parts of Ethiopia, but still 2014 G.C only 8,063 plants were installed. Their success rate was however been poor. This study assessed the current status and analyzes problems of 40 installed household biogas plants in Gomma Woreda of Jimma zone by using questionnaire, observation and interview of biogas owners and other stakeholders. Out of the 39 plants under analysis, 27 (69.23%) plants were functioning satisfactorily without defects, 10 (25.64%) plants were functioning partly with defects, 2 (5.13%) plants were not functioning and the remaining 1 plant is not started at all during the time of field investigation. Reasons for the defect and non-functioning include missed information given during promotion, non-availability of cow dung for feed, breakdown of structure, leakage of gas holder due to corrosion, absence of maintenance services, lack of operational knowledge.

Key words: Gomma W0reda, Biogas, Bio-slurry.

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Abbreviations and Symbols

UN	United Nations
MDGs	Millennium Development Goals
RETs	Renewable Energy Technologies
BT	Biogas Technology
AD	Anaerobic Digester
BC	Before Christ
ESCAP	Economic and Social Commission for Asia and the pacific
FAO	Food and Agriculture Organization of the United Nation
UNIDO	United Nations Industrial Development Organizations
WHO	World Health Organization
UNEP	United Nations Environment Program
CRGE	Climate Resilient Green Economy Strategy
GTP II	Second Growth and Transformation Plan
G.C	Gregorian Calendar
NBPE	Ethiopian National Biogas Program
SNV	Netherlands Development Organization
EREDPC	Ethiopian Rural Energy Development Program Centre
PID	Project Implementation Document
UNDP	United Nations Development program
GHGs	Green House Gas
UNCDM	United Nation Clean Development Mechanism
CO_2	Carbon Dioxide
CH_4	Methane
H	Hydrogen
H_2O	Water
SNNPR	Southern Nations, Nationalities and Peoples Region
BPE	Biogas Program Ethiopia
MOWIE	Ministry Of Water, Irrigation and Energy
DBDs	Domestic Biogas Digester
masl	meters above sea level

CHAPTER ONE

1. INTRODUCTION

1.1 BACKGROUND

Ethiopia is the second largest country in Africa in terms of population size and total area with diversified culture, linguistic composition and large ethnic compositions. And 84% of the populations live in rural areas; mostly in small and very scattered settlements. The remaining 16% of the population lives in urban areas. The country is situated in the horn of Africa between latitudes 3.5 and 13.5 degrees North and longitude 33 and 48 degrees East. The total area of the country is about 1.1 million sq. km and estimated population of over 79.2 million with an annual growth rate of 2.5% [8].

The future of life on our planet is a matter of increasing concern, as well as being confronted with several warning about the growing fragility of the earth's life support system. More than 1 billion people or 15% of the global population, still lack access to electricity. With a total installed capacity of roughly 147 GW, all of Africa has less power generation capacity than Germany. Moreover, approximately 2.9 billion people lack access to clean forms of cooking [21]. Expanding our understanding to the life support systems to sustainable development is the most important issues humankind presently facing and challenge from the perspective of sustainability. Most of developing countries are suffering from energy crisis, which contribute to the depletion of locally available energy resources and dependant on imported fossil fuels. For Ethiopia the main sources of energy are woody biomass (78%), dung (8%), crop residue (7%) and petroleum (5%). As deforestation increases impacts like environmental pollution, health problem, soil erosion, work load on women increases, landslides etc become significantly visible [4, 5]. To overcome those problems, alternative energy sources have recently become more and more attractive due to the increasing demand for energy, the limited resource for buying fossil fuel, the environmental concerns, and the strategy to survive post-fossil fuel economy era [5]. Renewable energy sources that meet domestic energy requirements play an important role in the energy and directly help to mitigate the climate change by reducing greenhouse gases emission in the global and a long term process. Harvesting the renewable energy in decentralized manner is one of the options to meet the rural and small scale energy needs in a reliable, affordable and environmentally sustainable way [1, 2, &18].

Biogas is a renewable energy used for cooking and lighting as well as heating purposes. It is a mixture of gases that is composed mainly of CH_4 40- 70 %, CO_2 30-60 % and other gases 1-5 %. The calorific value of biogas is about 16-20 MJm^{-3}[3]. This is produced by bacteria that decompose organic matter under anaerobic conditions. For the biogas production different substrates can be used such as waste water, organic waste from household, animal manure, human excreta, agricultural wastes etc. Energy production from biogas has dual benefits, renewable and clean energy production for household purpose in one hand and in another hand the effluent that comes as slurry is rich with various plant nutrients such as nitrogen, phosphorous, and potash, which are essential for plant growth. Based on a daily manure production from four cattle heads, domestic biogas can replace the equivalent consumption of five kilograms of firewood, 1.5 kilograms of charcoal or 0.6 litres of kerosene per day. Biogas can also be used to power internal combustion engines, refrigerators or radiant heaters, yet their application is even less widespread as lighting or cooking. DBD's can raise the use of cleaner energy sources in Ethiopia and in parallel offer valuable co-benefits to their users such as increased agricultural productivity from the use of bio-slurry as fertilizer, reduced workload and time savings through the avoi dance of firewood collection and reduced indoor air pollution[6].

1.2. DISSEMINATION OF BIOGAS IN ETHIOPIA

To up-scale domestic biogas in Ethiopia, the Ethiopian National Biogas Program (NBPE) was developed and launched for a first stage of implementation between 2008 and 2013. From five year it was planned to build 14,000 family-sized biogas plants between 2008 and 2013 and the NBPE was launched. The slow development of the NBPE was evidenced by the small amount of biogas plants that were built. Official sources have stated that 8,063 biogas plants were built during this phase and dist ributed as follows: 2,480 biogas plants in Oromia, 1,992 in Tigray, 1892 in Amhara and 1,699 in SNNPR. The second phase of the NBPE takes place from 2014 until 2017 and aims to construct 20,000 additional biogas plants. In 2014 alone, the government expected to build 3,600 bio-digesters in the four regions of implementation. A significant goal for this second phase has been to enab le private sector involvement; a goal that was not accomplished in the first stage of the NBPE [6]. Here in Goma Woreda (the study area) the number of households in the Woreda was 45,567 (CSA, 2007), but only 40 domestic biogas digesters were installed and 13 ongoing projects. However, there is no documented information on the status of the digesters. Therefore, this study targeted to assess the performance and operational practices of installed biogas digesters in Goma Woreda of different kebele for further growth.

1.3. STATEMENT OF THE PROBLEM

.Ethiopian energy demand exceeds the supply mostly in rural area of the country. Thus domestic energy consumption is dependent on imported fuel, burning fuel wood, dung cake, charcoal and biomass residues, which causes economical, environmental, health and other social impacts internally and globally. But Ethiopia has enormous potential of renewable energy resources. The government and donor agencies planned to disseminate those renewable energy technologies with subsidies and grants. But the proper design and implementation of these technologies does not grow as expected.

Biogas technology is one of the renewable energy technologies which have been programmed to implements throughout the country and even though the technology is old in the country, its rate of development did not go as expected or it was not successful. Ethiopia has high potential to install domestic biogas plant, but now on the ground is only 8,063 domestic biogas plants throughout the country [6]. Here in Jimma zone Goma woreda around 40 biogas plants were installed, but no study shows their current status. In this study the current status and situation of installed domestic biogas plant were analyzed by collecting user's response and observation of the plant.

1.4. OBJECTIVE OF THE STUDY

1.4.1. GENERAL OBJECTIVE OF THE STUDY

The main objective of this study is to access performance, operational status and analyzing problems of domestic biogas plant in Gomma woreda.

1.4.2. SPECIFIC OBJECTIVE OF THE STUDY

- Observing the physical status of different parts and functions of biogas plant.
- Identifying the way of site selection.
- User's perception on technology.
- Assessing way of mixing, and loading rate of the plant.
- Assessing use of the bio-slurry.
- To identify the financial benefits of the households using biogas at home by using the savings they get from energy and fertilizers.
- To find out the amount of fuel wood saved by biogas users in fuel equivalent to number of trees.
- To evaluate the potential and sustainability of biogas digesters in the selected area.

1.5. RESEARCH QUESTIONS

Research question aimed at the following questions:

- Does the biogas plant have leakage, blockage or crack problems?
- Does the site selection considered the availability of sunshine, space for making compost, water and substrate?
- What challenge faced during construction of the plant?
- What are challenges faced during operation of the biogas plant?
- Does any economic benefit observed?
- How the size of plant selected?
- What is the previous experience of domestic energy use?
- Does the temperature (elevation) of the area relevant for biogas production?
- Is there integration between stakeholders? How they work?

1.6. SIGNIFICANCE OF THE STUDY

Assessing the performance of biogas digesters and identifying factors which affect sustainability.

In general this study could give:-

- the sustainability and potential of biogas plant in the Gomma Woreda
- Give relevant information on the status of biogas plants and challenges faced by users Gomma Woreda.
- Inform factors affecting biogas plants in the Gomma Woreda specially temperature, pH of the slurry and others.
- Evaluate the potential and sustainability of biogas systems in the selected area.
- Serves as source of information to upgrade the performance of biogas plants.
- Evaluate advantage of the slurry as fertilizer.
- Evaluate the size of the plant and cattle population per house hold

1.7. SCOPE OF THE STUDY

Researcher limited the scope of the study to specific place particularly in Gomma woreda where 40 installed biogas plants in 17 kebele. The study also limited to assess physical status of different parts of digesters, operational practices, assessment of leakage, blockages, and cracks, site selections, bio-slurry and also interview to get in depth information from the biogas operators, users and experts.

CHAPTER TWO

2. REVIEW OF LITERATURE

2.1. RENEWABLE ENERGY

The way we produce and use energy today is not sustainable. The world main fossil fuel sources oil, coal and gas-are finite natural sources; we are depleting them at rapid rate [3]. The oil crisis in 1973 prompted many countries to review their energy policy and identify alternatives to fossil fuels [10]. Furthermore they are main contributors to climate change, and the race to the last “cheap” fossil resources evokes disasters for the natural environment as seen recently in the case of oil spill in the Gulf of Mexico. In the developing world regional and local desertification is caused by depletion of fuel wood and other biomass sources that are often used very inefficiently causing substantive in-door pollution and millions of deaths annually. A fully sustainable renewable power supply is the only way we can secure energy for all and avoid environmental catastrophe [3]. In practice renewable energy refers to hydropower, biomass energy, solar energy, wind energy, geothermal energy and ocean energy. Except ocean energy, all forms of renewable energies are relevant in Ethiopia. These sources are constantly replenished by nature and cleaner source of energy. Basically renewable energy sources are suitable for decentralized application, environmentally friendly (pollution- free) help to fight global climate change and directly associated with sustainability. Moreover, they have short lead-time for planning and construction, they can increase energy security in diversifying energy supply and they contribute to local or regional economic development because money spent on non-renewable energy stays at home [4]. The switch from traditional use energy sources to renewable energy technologies (RETs) is lengthy and has not delivered as expected. The renewed interest for renewable energy was boosted in 2000 when the national assembly of United Nations (UN) agreed on eight major goals to address the world’s main development challenges and which are known as the millennium development goals (MDGs). Although energy is not explicitly mentioned, the importance’s of access to energy services to achieve all the MDGs are recognized [10].

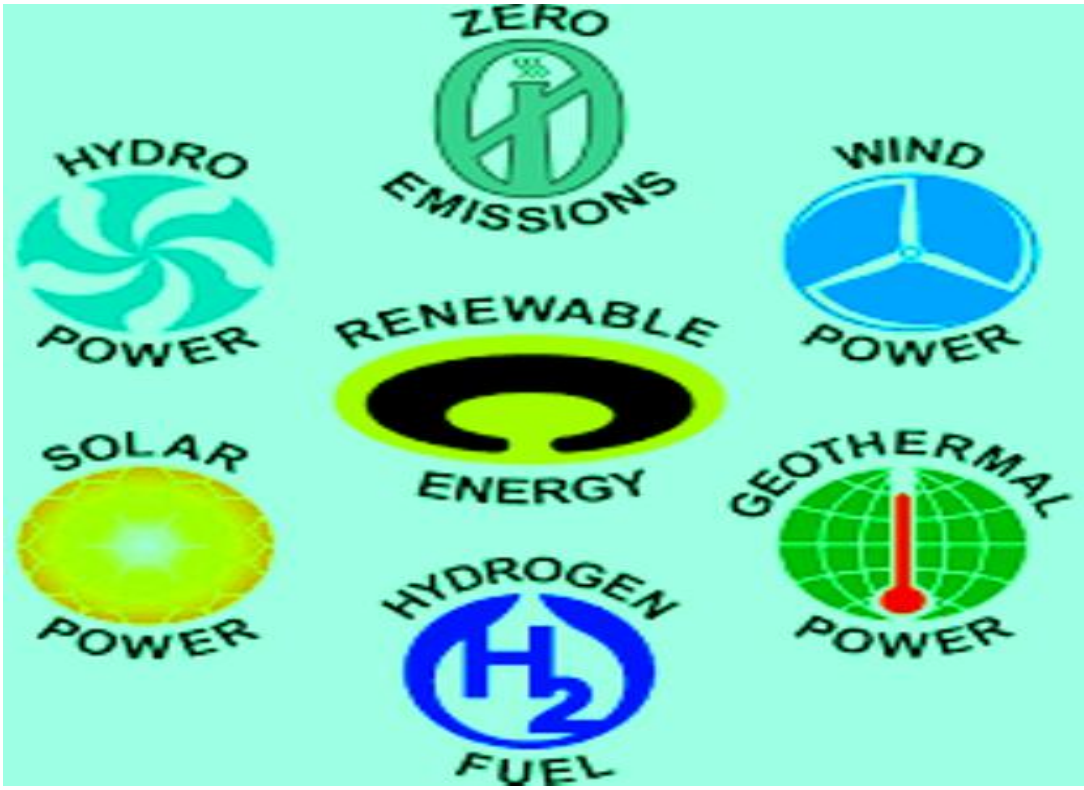


Figure1: Renewable Energy (source from www.renewablenergypictures.com)

The basic problem to promote all renewable energy technology is the perceived finance of their application. It is often less obvious, because they have high investment costs. However, many renewable appliances operate more economical than conventional (coal) fuel ones if one looks at the life time costs (i.e. total life cost= investment cost +running cost) [4].

2.2. BIOGAS TECHNOLOGY

2.2.1 .HISTORY OF BIOGAS TECHNOLOGY

Historical evidence indicates that the anaerobic digester (AD) process is one of the oldest technologies. Biogas was used for heating bath water in Assyria during the 10^{th} century BC and in Persia during the 16^{th} century BC. Early awareness of methane generated during anaerobic process was recorded as mysterious flickering flames in swamps and marshland known as "will-o-wisp". Van Helmont in 1630 first determined that flammable gases could evolve from decaying organic matter. In 1976 Volta concluded that there was a direct correlation between the amount of decaying matter and the amount of flammable gas emitted. He also determined that certain proportion of this flammable gas were explosive in air. In 1808 the British chemist sir Humphry Davy determined that methane was present in the gases produced during the anaerobic digestion of cattle manure. The industrialization of anaerobic digestion began in 1859 with the first digestion plant in Bombay, India. In 1896 biogas from sewage sludge was used to fuel street lamps in England. Further advances were due to the development of microbiology. Applied research began by Buswell's work in the 1920s in which the established fermentation stoichiometries, the fate of nitrogen and developed a farm scale digestion system. Since that time numerous studies and demonstration project have been attempted with the widest application of anaerobic bioconversion for the disposing municipal sewage [8].

At present china is the world leader in the application of anaerobic digestion technology. The Chinese government implemented a biogas program in the 1970s, installing seven million digesters, providing biogas for cooking and lighting to about 25 million people. About 10,000 large and medium size digesters were distributed to farms to provide electricity. Unlike Asia experiences in domestic biogas in African countries has been ambiguous. The exact number of plants installed in Africa is not known but that most units were installed in Tanzania, Kenya and Ethiopia and few units in other countries. Currently many international organizations have done considerable work in developing and disseminating biogas technology, such as economic and social commission for Asia and the pacific (ESCAP), food and agriculture organization of the united nation (FAO), united nations industrial development organizations(UNIDO), world health organization(WHO), and united nations environment program(UNEP). At present over 210 organizations in more than 40 countries of the world are engaged in varied biogas activities. These include research and development of more efficient and less expensive biogas plants and applications financing the promotion of the use of biogas in the rural areas and other activities [4].

2.2.2. BIOGAS COMPOSITION & PROPERTIES

Biogas offers an attractive option to replace unsustainable utilization of wood, dung cakes and charcoal. Also biogas technology (BT) is a promising option for the most efficient utilization of organic waste materials in a fermentation tank. It involves organic matter, micro organism, environment that lack air (oxygen) and favorable temperature to produce biogas [4]. Biogas is produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. Biogas is mainly composed of 50% to 70% methane (CH_4) 30% to 40% carbon dioxide (CO_2) and small amount of other gases [10].

Table 1: Composition of Biogas (source: FAO/CMS, 1996)

Substance	Symbol	Percentage (%)
Methane	CH_4	50-70
Carbon Dioxide	CO_2	30-40
Hydrogen	H_2	5.0-10
Nitrogen	N_2	1.0-2.0
Water Vapor	H_2O	0.3
Hydrogen Sulphide	H_2S	Traces

Methane and carbon dioxide are odorless and colorless gases. Hydrogen sulfide is colorless but it has an odor of rotten eggs in addition to its toxicity (FAO/CMS, 1996). Carbon dioxide, hydrogen sulfide, ammonia and water vapor considered corrosive substances (Schomaker et al., 2000). In general; biogas with all its components is colorless, odorless and lighter than air (FAO/CMS, 1996).

2.2.3. THE BENEFITS OF BIOGAS TECHNOLOGY.

Well-functioning biogas systems can yield a whole range of benefits for their users, the society and environment in general:-

- Production of energy (heat, light, electricity).
- Transformation of organic waste into high quality fertilizer.
- Improvement of hygienic conditions through reeducation of pathogens, worm eggs and flies.
- Reduction of workload, mainly for women.
- Environmental advantages through protection of soil, water, air and forested vegetation.
- Micro-economic benefits through energy and fertilizer substitution, additional income.
- Macro-economic benefits through decentralized energy generation, import substitution and environmental protection.

2.2.4. FUEL REPLACEMENT VALUES OF BIOGAS ENERGY

According to SNV (2010) $1m^3$ of biogas has fuel replacement value for different fuels as shown in Table below. Small sized eucalyptus tree which is planted for construction and fuel wood purpose have average height and diameter of 18cm and 12cm respectively. The total biomass of the tree can be calculated by using the equation below that could be seen as an “average” of all the species.

Equation…….1) W=0.25*D2*H for trees D<11 feet.

DW=W*72.5%

Where: W = Above-ground weight of the tree in pounds

D = Diameter of the trunk in inches

H = Height of the tree in feet

DW= Dry weight of the tree in pounds

72.5%= average dry matter content of the tree.

In addition to this the report by Oromiya Forest and Wildlife Enterprise Fin fine Firewood Project Office shows that one hectare of planted forest has 2500 trees seedlings out of this 70 percent will become mature trees. One adult healthy tree can decrease the Carbon emission by storing 6 kg of carbon per year. The international current price for carbon credits ranges from 3.50 to 15.80 USD per ton of CO_2 sequestered. This will bring economic benefit to the country as well as the social and environmental benefits.

Table 2: Properties of different fuel.

Fuel	Unit	Calorific value KWh/U	Application	Efficiency percent	U/m^3 biogas
Cow dung	kg	2.5	Cooking	12	11.11
Wood	kg	5.0	cooking	12	5.56
Charcoal	kg	8.0	cooking	25	1.64
Hard coal	kg	9.0	cooking	25	1.45
Butane	kg	13.6	cooking	60	0.40
Propane	kg	12.0	cooking	60	0.39
Diesel	kg	12.0	cooking	30	0.55
Electricity	KWh	1.0	motor	80	1.79
Biogas	m^3	6.0	cooking	55	1

2.3. ENERGY POLICY AND BIOGAS PROGRAM IN ETHIOPIA

2.3.1. ENERGY POLICY OF ETHIOPIA

A. CLIMATE RESILIENT GREEN ECONOMY STRATEGY (CRGE)

Like most countries, Ethiopia is experiencing the effect of climate change. For Ethiopia green growth is a necessity as well as an opportunity to be seized. It's an opportunity realizes our country's huge renewable energy and a necessity so as to arrest agro-ecological degradation that threatens millions of our citizens in poverty. Ethiopia shifts from conventional growth to climate resilient green economy strategy (CRGE). Since conventional growth path is characterized by fossil fuel dependency, deforestation (land erosion, health issues), unsustainable agriculture (reduction in soil fertility, increased vulnerability to drought and floods), rapid growth of conventional transportation. But CRGE concern on use of alternative energy sources. The green economy (CRGE) has based on four pillars:-

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

B. THE SECOND GROWTH AND TRANSFORMATION PLAN OF ENERGY SECTOR (GTP II)

1. Hydro-Power Generation
2. Geothermal energy.
3. Windmill power plants
4. The solar energy.
5. Biomass power Generation plants [13].

2.3.2. THE BIOGAS PROGRAM OF ETHIOPIA (BPE).

Biogas technology was introduced in October 12, 1966 G.C, when the first batch type floating digester was constructed in Ambo University (figure below) to generate energy required for the purpose of welding [8]. The Ethiopian national biogas program (NBPE) developed and launched for a first stage of implementation between 2008 and 2013. From February to July 2007 a team from SNV and EREDPC conducted an extensive consultation process with relevant stakeholders in order to develop a project implementation document (PID). On June 16th 2007 the draft of the PID was presented and approved. The Ethiopian government decided constructing 14,000 domestic biogas plants over a five year program and the NBPE launched to build [6]. Even if the program is launched and many biogas was constructed the assessment was not done for most of the area in Ethiopia. I observed that no domestic biogas status assessment were done in Jimma zone specifically Gomma Woreda. But there are many domestic biogas digesters constructed for community. Furthermore a subsidy was provided to biogas users to compensate for the initial cost and hence improve the affordability of the biogas plant. This was also important since the alternative firewood was freely available. The provision of the subsidies depended on the compliance of the technical criteria set by the NBPE. Hence it was limited to single model for the biogas digester; the SINDU MODEL which is an adaptation of the Nepalese GGC-2047 fixed dome digester. During this period SNV build 98 biogas plants for demonstration in four regions. At the end of the five year plan official sources shows 8,063 biogas plants were constructed (2,480 in Oromia Region, 1,992 in Tigray Region 1,892 in Amhara Region, and 1,699 in SNNPR [6].

According to a feasibility study on domestic biogas in Ethiopia (Getachew et.al., 2006), for example, from approximately 1000 biogas plants constructed since the 1970s across the country only 40 percent were functioning at the time of the field visit. In the same study (Getachew et al, 2006), the report indicated that at least over one million households in Tigray, Amhara, Oromiya and Southern Nations, Nationalities and Peoples regional states qualify for the installation of a domestic biogas plant. The domestic biogas technology attracted interest mainly due to consideration of the animal dung, the raw material that is plenty in many rural households in the country. After the establishment of the National Biogas Program Ethiopia in 2009, close to 859 biogas plants have been constructed and are in regular use. Out of the 859 functional biogas plants, 206 are found in Tigray Region, 143 are in Amhara Region, 330 in Oromiya Region and 180 are found in SNNP regional states (Claudia and Yitayal, 2011).

Figure 2: The first biogas plant installed in Ambo University (source; Meaza Ketsela Gebretsadik, 2012*).*

Since 85% of peoples living in Ethiopia depend on agriculture there was high potential to construct domestic biogas plant. Currently most of the farmers can have the capacity to afford the cost of single domestic biogas plant. The NBPE planned to construct 20,000 domestic biogas plants 2014-2017, but only 8063 domestic biogas plant were constructed in 2014 [6].

2.4. ANAEROBIC DIGESTION

4.4.1. PROCESS (PRINCIPLE) OF ANAEROBIC DIGESTION

Biogas technology (anaerobic digestion) is biological method for degrading and stabilizing organic, biodegradable raw materials in special plants in a controlled manner. It is based microbial activity in oxygen-free (anaerobic) conditions and results in two end products, energy-rich biogas and nutrient-rich digestion residue. Anaerobes access oxygen from sources other than the surrounding air. Therefore the oxygen source for these microorganisms can be the organic materials itself or alternatively may be supplied by inorganic oxides from within the input material [4]. Anaerobic degradation of biodegradable materials also happens in nature e.g. in swamps, soils, sediments and in ruminant metabolism [7].

2.4.2. APPLICATION OF ANAEROBIC TECHNOLOGY.

The application of biogas depends upon the development level of a nation in addition to the problem related to the source of input material. In the developed nation, the primary application of anaerobic digestion technology is to control pollution also employed to generate electricity through the diesel engine. However in developing country the primary objective of the rural digester is for energy generation and to use the manure as organic fertilizer. Thus simple home and farm based anaerobic digestion systems offer cheap and low cost energy for cooking and lighting. As a result anaerobic digestion facilities have been recognized by the United Nations development program (UNDP) as one of the most useful decentralized source of energy supply. Livestock manure, left to decompose naturally emits two particularly potent GHGs-nitrous oxide and methane. According to the inter governmental panel on climate change, nitrous oxide warms the atmosphere 310 times more than carbon dioxide (CO_2) ;methane does 21 times more. Using methane as energy or simply flared if energy production is not economical results in a net reduction of carbon dioxide equivalents and other green house gases enabling the sale of carbon credits [4].

Presently, projects for anaerobic digestion in the developing world can gain financial support through the United Nation Clean Development Mechanism (UNCDM) if they are able to show they provide reduced carbon emission. Pressure from environmentally related legislation on solid waste disposal method in the developed country has increased the application of anaerobic digestion as a process of reducing waste volume and generating useful by products. Utilizing anaerobic digestion technologies can help to reduce emission of green house gasses through replacement of fossil fuel, reducing methane emission from landfill and substituting inorganic chemical fertilizers. There are four key biological and chemical stages of anaerobic digestions. These are hydrolysis, acidogenesis, acetogenesis and methanogenesis. Hydrolysis is a process which involves the breakdown of complex organic waste into sugars and amino acids. Acidogenesis, process then convert those products into organic acids. Then acetogenesis convert organic acid into hydrogen, carbon dioxide and acetate. Finally methanogenesis process produce biogas from acetic acid, carbon dioxide and hydrogen. Hydrolysis In the first step (hydrolysis), the organic matter is enzymolyzed externally by extracellular enzymes (cellulose, amylase, protease and lipase) of microorganisms. Bacteria decompose the long chains of the complex carbohydrates, proteins and lipids into shorter parts. For example, polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids.

Acidification

Acid producing bacteria, involved in the second step, convert the intermediates of fermenting bacteria into acetic acid (CH_3COOH), hydrogen (H_2) and carbon dioxide (CO_2). These bacteria are facultative anaerobic and can grow under acid conditions. To produce acetic acid, they need Oxygen and Carbon. For this, they use the Oxygen solved in the solution or bounded oxygen. Hereby, the acid producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical standpoint, this process is partially endergonic since bacteria alone are not capable of sustaining that type of reaction.

Methane formation

Methanogenes involved in the third step, decompose compounds to low molecular weight. For example, they utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, methane producing microorganisms occur to the extent that anaerobic conditions are provided, e.g. under water (for example in marine sediments), in ruminant stomachs and in marshes. They are obligatory anaerobic and very sensitive to environmental changes. In contrast to the acidogenic and acetogenic bacteria, the methanogenic bacteria belong to the archaebacter genus, i.e. to a group of bacteria with a very heterogeneous morphology and a number of common biochemical and molecular-biological properties that distinguish them from all other bacterial general. The main difference lies in the makeup of the bacteria's cell walls. Microbiological Process in biogas microbes consist of a large group of complex and differently acting microbe species, notable the methane producing bacteria. The rate and efficiency of the anaerobic digestion for biogas production is controlled by maintaining anaerobic condition, seeding or bacterial population, substrate characteristics, loading rate temperature, dilution consistency of inputs, PH and alkalinity, retention time, C/N ratio and toxicity [4].

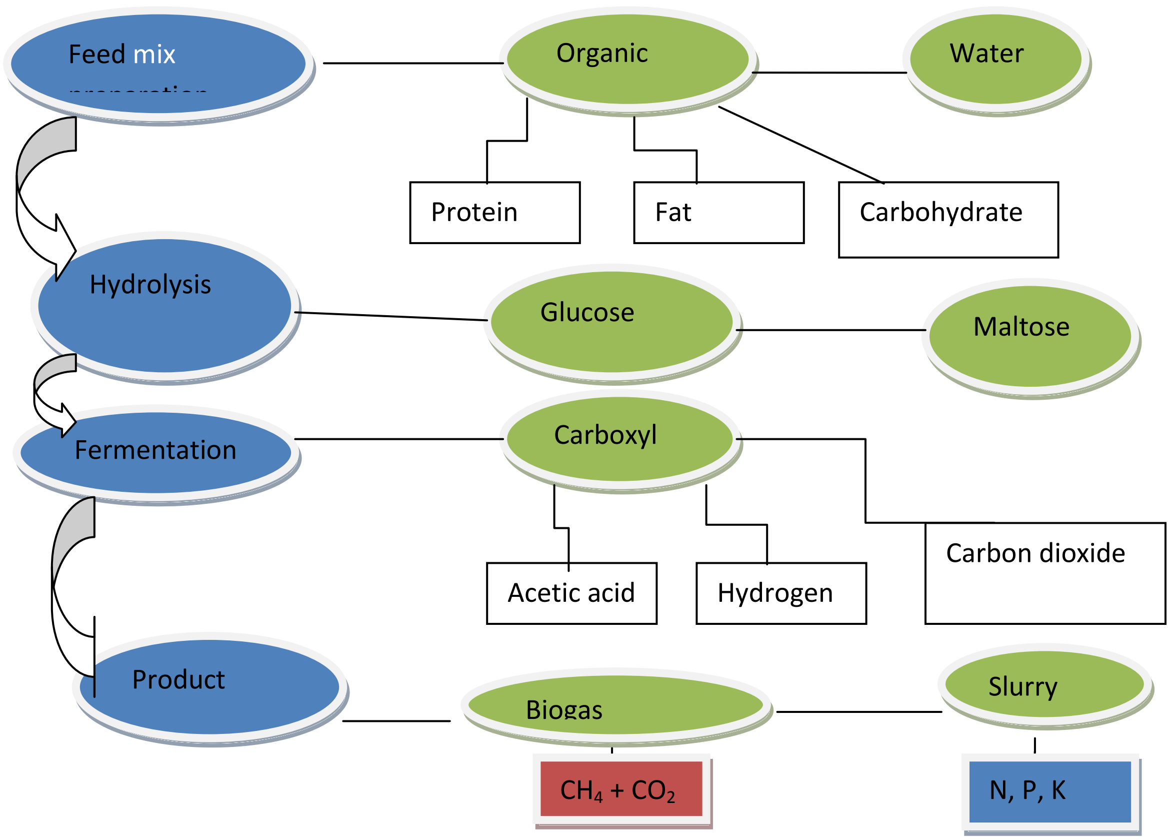


Figure 3: The biogas production cycle (source, Tadesse lulie Nigisie Nigusie 2010).

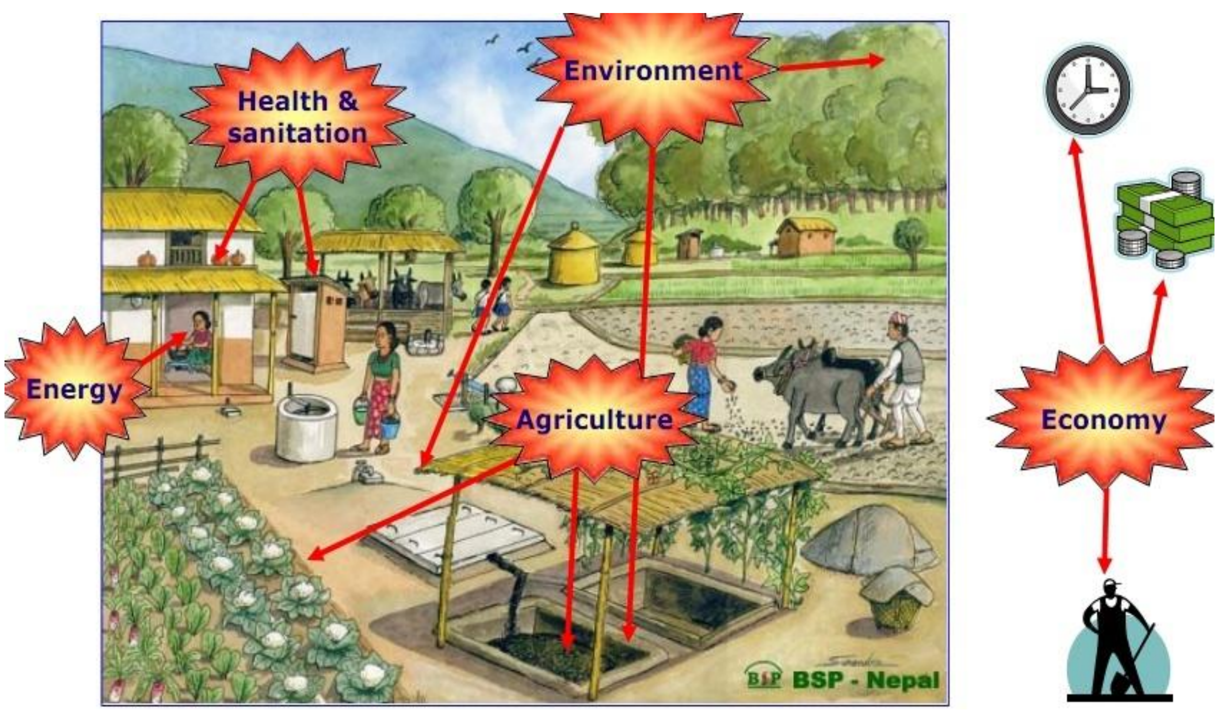


Figure 4: The biogas application (Nepal national biogas program 2000 G.C)

2.5. TYPE OF BIOGAS DIGESTER

2.5.1 Concerning the feed method

Three different forms can be distinguished: -

a) Batch plants**:-** are filled and then emptied completely after a fixed retention time. Waste is fed into the system in batches, usually with a starter (5 percent to 30 percent by volume) and left for gas production until thorough degradation occurs. The digester is then emptied and a new batch of feedstock is added. Each design and each fermentation material is suitable for batch filling, but batch plants require high labor input. As a major disadvantage, their gas-output is not steady.

b) Continuous plants**:-** are fed regularly once the first feed starts generating gas. They empty automatically through the overflow whenever new material is filled in. Therefore, the feedstock is fed after mixing with water and in course of time, the digested slurry overflows through the outlet. Once the digestion process gets established, the gas production rate becomes fairly constant, and higher than in batch plants. Today, nearly all biogas plants are operating on a continuous mode.

c) Semi-batch:- if straw and dung are to be digested together, a biogas plant can be operated on a semi batch basis. The slowly digested straw-type material is fed in about twice a year as a batch load. The dung is added and removed regularly.

2.5.2 CONCERNING THE CONSTRUCTION

Various types of biogas plants have been developed; the two most familiar types in developing countries are the fixed-dome plants and the floating-drum plants. In developing countries, the selections of appropriate design are determined largely by the prevailing design in the region. Typical design criteria are space, existing structures, cost minimization, and substrate availability.

2.5.2.1. FIXED-DOME BIOGAS PLANT

Fixed dome Chinese model biogas plant was experimented in China as early as the mid 1930's. This model consists of an underground brick masonry (cement mortar) compartment for the digestion chamber with a concrete dome on the top for gas storage and a displacement pit. Thus, in this design the digestion chamber and the gas storage dome are combined as one unit. It uses the 'displacement principle' of operation. Gas is collected at the upper portion of the digester (Dome). Slurry in the digester pit is forced up into slurry reservoir due to the pressure created by the gas collected in the curved structure (dome) of the digester. As the biogas is used from under the concrete dome, the slurry flows back from the reservoir to replace it. This design eliminates the use of costlier mild steel gasholder. The life of a fixed dome type plant is longer (20 to 50 years) compared to floating drum plant, as there are no moving parts and both concrete and cement masonry is relatively less susceptible to corrosion. The costs of a fixed-dome biogas plant are relatively low. It is simple, as no moving parts exist. The plant is constructed underground, protecting it from physical damage and space saving. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes. The construction of fixed dome plants is labor-intensive, thus creating local employment. Fixed-dome plants are not easy to build. They should only be built where experienced biogas technicians can supervise construction. Otherwise, plants may not be gas-tight (porosity and cracks). Fixed-dome plants must be covered with earth up to the top of the gas-filled space to counteract the internal pressure (up to 0.15 bars). The earth covers insulation and the option for internal heating makes them suitable for colder climates.

Types of fixed-dome plants:

Depending up on the design of the digesters and construction materials there are different model types of fixed-dome plants in different countries as follows: -

Chinese fixed-dome plant:- is the archetype of all fixed dome plants. Several million have been constructed in China. The digester consists of a cylinder with round bottom and top

. Janata model:- was the first fixed-dome design in India, as a response to the Chinese fixed dome plant. It is not constructed anymore. The mode of construction leads to cracks in the gasholder - very few of these plants had been gas-tight.

Deenbandhu:- the successor of the Janata plant in India, with improved design, was more crack-proof and consumed less building material than the Janata plant with a hemisphere digester. This model is characterized by; high skilled mason required, only could be constructed with bricks; and No significant cost cut down.

CAMARTEC model:- has a simplified structure of a hemispherical dome shell based on a rigid foundation ring only and a calculated joint of fraction, the so-called weak / strong ring. It was developed in the late 80s in Tanzania.

Fixed-dome plants must be covered with earth up to the top of the gas-filled space to counteract the internal pressure (up to 0.15 bars). The earth covers insulation and the option for internal heating makes them suitable for colder climates.

Advantages:- Low initial costs and long useful life-span; no moving or rusting parts involved; basic design is compact, saves space and is well insulated; construction creates local employment.

Disadvantages:- Masonry gasholders require special sealants and high technical skills for gas-tight construction; gas leaks occur quite frequently; fluctuating gas pressure complicates gas utilization; amount of gas produced is not immediately visible, plant operation not readily understandable; fixed dome plants need exact planning of levels; excavation can be difficult and expensive in bedrock. Fixed dome plants can be recommended only where experienced biogas technicians supervise construction [4].

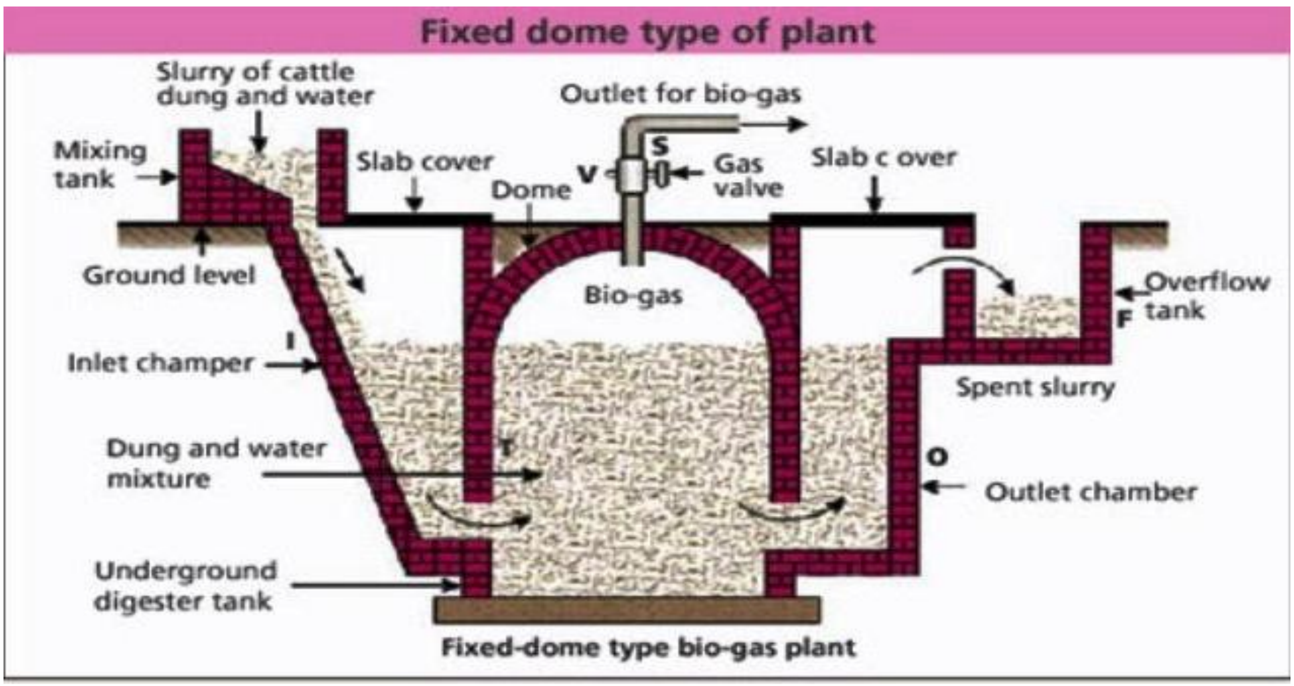


Figure 5: Fixed dome biogas digester (source www.biogaspictures.com)

a) FLOATING-DRUM BIOGAS PLANT

In the past, floating-drum plants were mainly built in India. As the design was simple, it gained popularity in India as well as other countries very soon. Floating-drum plants consist of a cylindrical or dome shaped digester and a moving, floating gasholder, or drum. As the steel drum floats above the digestion chamber, it was named as Floating Drum Digester. The gasholder floats either directly in the fermenting slurry or in a separate water jacket. The drum in which the biogas collects has an internal and/or external guide frame that provides stability and keeps the drum upright. Thus, there are two separate structures for gas production and collection. When methane gas is produced, the gas pressure pushes the mild steel drum upwards and as the gas is being used, the drum gradually lowers down. Thus, by observing the level of drum, one can assess the gas volume available. In this model, as the gas is produced the floating drum moves up similarly as the gas is used the drum lowers down maintaining the constant pressure inside With the introduction of the fixed dome Chinese model plant, the floating drum plants became superseded due to comparatively high investment and maintenance cost along with other design weaknesses. For example, the mild steel drum corrodes and needs to be replaced within 5 – 10 years. Similarly, the drum has to be well anchored to prevent it from overtopping due to high gas pressure. Floating-drum plants are used chiefly for digesting animal and human feces on a continuous feed mode of operation, i.e. with daily input [15].

There are two types of floating drum design. These are Straight design and Taper design. Straight design is used where bricks are not available (stone masonry used), where water table is low, and Needs deep hole. Whereas, Taper design is used where bricks are available, the water table is high, and Needs only a shallow depth. Advantages: Floating-drum plants are easy to understand and operate. They provide gas at a constant pressure, and the stored gas-volume is immediately recognizable by the position of the drum. Gas-tightness is no problem, provided the gasholder is de-rusted and painted regularly. Disadvantages: The steel drum is relatively Costlier to built, Difficult to transport and High investment in maintenance cost. Removing rust and painting has to be carried out regularly. The lifetime of the drum is short (up to 15 years; in tropical coastal regions about five years). If fibrous substrates are used, the gasholder shows a tendency to get "stuck" in the resultant floating scum). Among other site specific factors, the criteria for the selection of an ideal Biogas Model should base on the following considerations: It should be simple in terms of construction and operation; It should be cost effective and durable so that the general population is able to embrace this technology; It should be efficient, i.e., the gas production should be optimum per unit volume of a biogas plant for given type and quantity of input. It should be constructed using of local materials as far as possible; Repair and maintenance requirement should be minimal; and It should be convenient and user friendly. Design for Sizing of Biogas Plants mainly depends upon: - Energy consumption of particular families; and Feeding materials available. The size of the system is determined primarily by the number and type of animals served by the operation, the amount of dilution water to be added, and the desired retention time. The most manageable of these factors is retention time; longer retention times mean more complete breakdown of the manure contents, but require a larger tank. Alternatively, the size of the biogas plant depends on the quantity, quality, and kind of available biomass and on the digesting temperature. It can be also determined by the gas or energy demand of the users [14].

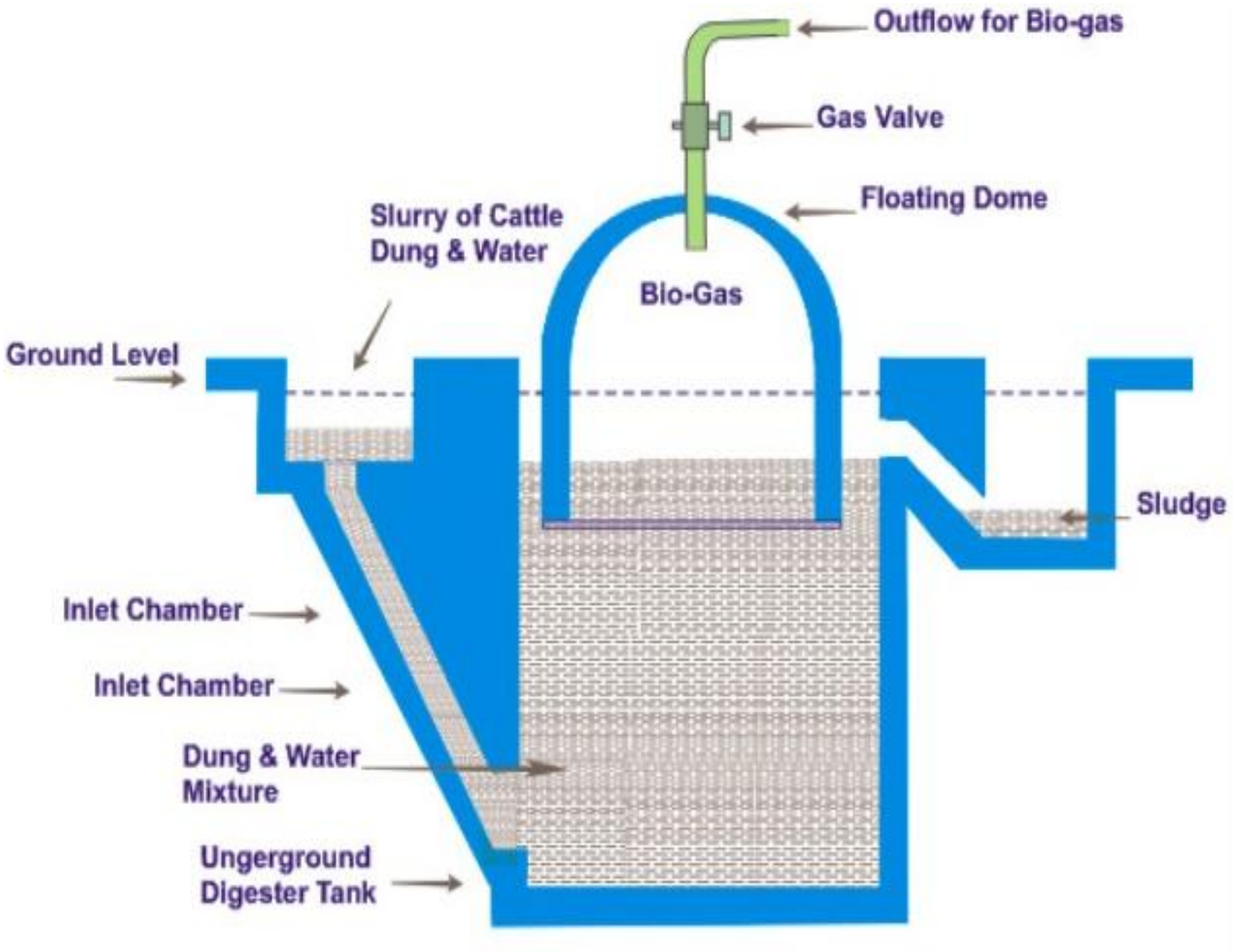


Figure.6. Floating dome type digester (source www.biogaspictures.com).

CHAPTER THREE

3. MATERIALS AND METHODOLOGY

3.1. DESCRIPTION OF THE STUDY AREA

Gomma Woreda is one of the 17 Woredas in Jimma Zone known for predominantly growing coffee. It is located 403 km south west of Addis Ababa and about 50 km west of Jimma town. One of the coffee biodiversity centers in Ethiopia is found in this Woreda. The number of households in the Woreda was 45,567 (35,533 male headed (78%)) and 10,034 female headed (22%)) while the total population of the Woreda was 216,662 from which 110,448 are males and 106,174 females (CSA, 2009). Gomma is the second most densely populated Woreda in Jimma Zone with a size of 96,361.72 ha (94.4 km^2) including the two coffee state farms which cover an area of 2704 ha (IPMS, 2007).

Altitude in Gomma ranges from 1387 to 2870 meters above sea level (masl). Most parts of the Woreda lay between 1387 and 1643; and 1849 and 2067 masl. However, few of the areas in the Woreda have altitudes ranging from 2229 to 2870 masl. Nitosols is the most abundant covering about 90% of the Woreda. These soils are young soils and are generally acidic soils. However, farmers grow crops that are acid tolerant. The pH of the soils in Gomma ranges between 4.5 and 5.5. However, the commonly observed problem related to aluminum and magnesium toxicity as a result of low PH is minimal.

3.1.1. SAMPLING METHOD

Non probability sampling method was used to select households for the survey and a total of 40 sample households were selected out of 53 biogas user households found in the study area. Questionnaires developed for this purpose (Annex 1-3) were used after pretesting to generate reliable data. During the household interviews information were obtained on the number of cattle, energy consumption, type of firewood used, amount of inorganic fertilizer used, the amount of money saved from biogas user households and bio-slurry management and utilization status.

3.2. METHODOLOGY

The study was conducted in close accordance with the objectives. The data was collected with the structured questionnaires and open-ended unstructured interviews with the respective plant user. Additional investigation tools for data collection included observations, especially of different components of biogas plants, household kitchen, biogas plant type, toilet attachment to plant and slurry pits in the sampled households and informal discussions with people in the survey clusters. During the field survey, the study was adopted as an interactive approach rather than a „question and answer session‟ with the biogas plant users to enhance the quality of data and information collected. The numbers of plants to be surveyed were decided to be 40 in totals are shown in table.

Table 3: Biogas plants surveyed.

s/number	Kebele	Number of biogas	s/number	Kebele	Number of biogas
1	Bulado	2	11	k/hixi	1
2	03	1	12	k/seja	2
3	B/konche	1	13	L/sappa	1
4	Beshasha	1	14	o/baqo	1
5	Choche	5	15	o/gurude	2
6	Dalacho	2	16	Prison	1
7	Dh/qacane	1	17	Qota	4
8	Dinu	3	18	x/sedecha	4
9	G/dalach	2	19	Yaci	3
10	G/iibu	3			

The whole study was divided into three major parts based upon the activities carried out:

1. Preparation of questionnaires:

Questionnaire was prepared considering various aspects of biogas technology such as motivation, physical status and functioning, feed material availability, technical soundness, operation and maintenance, perception on technology etc.

Questionnaire was prepared in English language and converted to oromipha by Mr. Kebede negasa, and then collected data converted from oromipha to English by Mr. Melekamu huressa.

2. Investigation and Data Collection:

Data were collected with structured questionnaires, field visit observation and unstructured interview of plant users.

3. Data Analysis:

Data were analyzed by considering various realities of the technology such as physical status and functioning of biogas plant, feed material and operation, operational activities and maintenance by users and user’s perception on technology and efficiency.

3.3. LIMITATIONS OF THE STUDY

- Biogas stoves were either locally manufactured or imported with unknown efficiency or rate of biogas consumption.
- This lack of information together with others was the limiting factor to determine the efficiency of biogas systems.
- Despite genuine efforts, this study having been conducted within a short period of timeframe and with many other constraints might possess some errors methodologically and in the findings presented herein.
- Effect of temperature on biogas production is not measured due to the study done in cold season.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. PHYSICAL STATUS AND FUNCTIONING OF BIOGAS PLANT:

The current physical status of different components of household biogas plants were observed in detail during the field investigation to assess the quality of construction, effectiveness of maintenance activities carried out and the operational status prior to categorizing them. The physical status of different components of household biogas plant has been categorized in three different headings viz:-

- Functioning without defects (>75%).
- Defective but functioning (25%-75%).
- Defective and not functioning (not working) in qualitative manner, dependent on the physical observation of the plant and on questionnaires collected with plant users during field investigation.

The size of digesters and their sites identified, elevation, date of construction and functionality during the field survey is summarized in annex 1. The general condition of biogas plant and its Components are categorized as shown in Table below:-

4.1.1. SIZES OF DIGESTERS

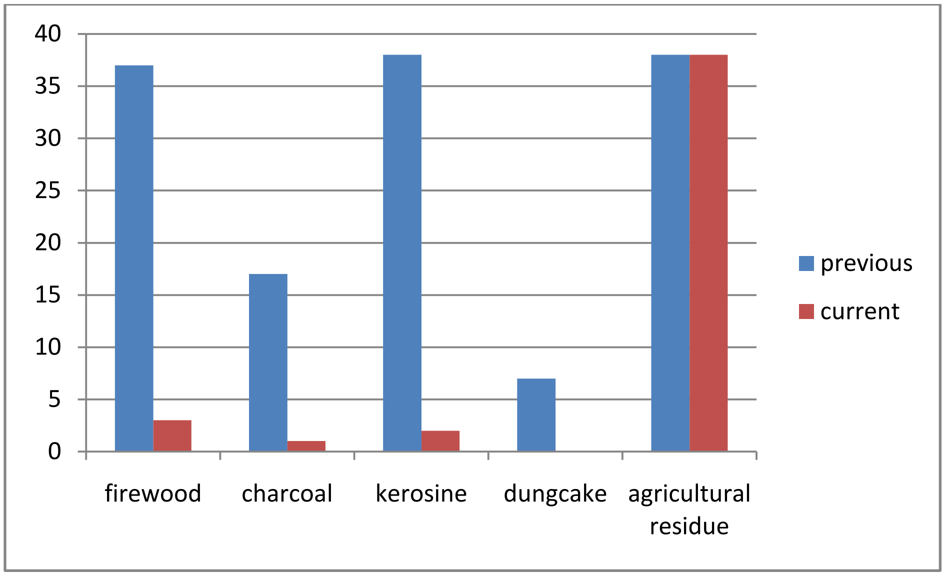
The types of digesters were all SINDU model fixed dome biogas digester and size of digesters were identified during the field visit.

Tabl 4: Size of digester.

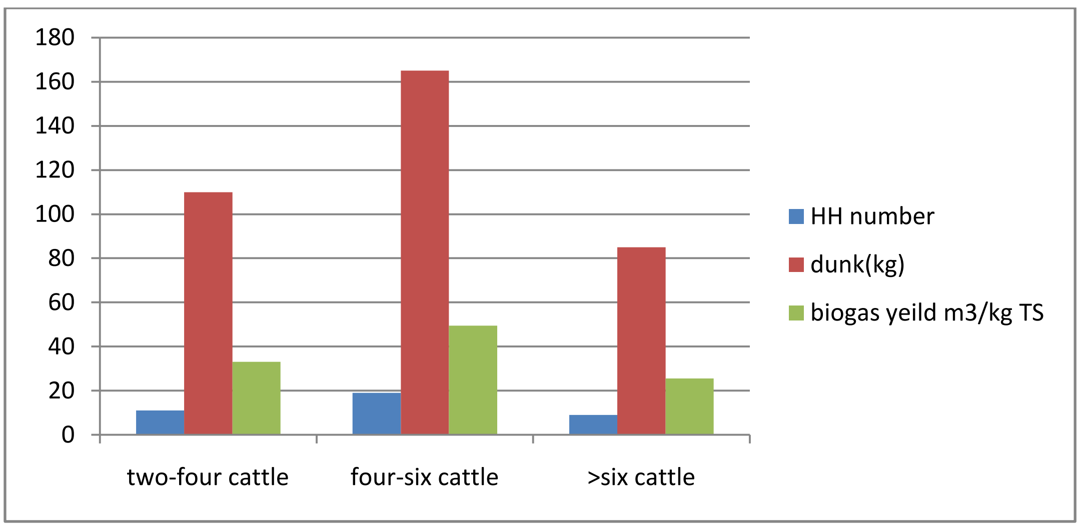
Size of digester in m^3	Number of installed digesters
6	35
8	4
10	1

All the plants were constructed from 2006 E.C to 2007 E.C with trained personnels.

4.1.2. Previous and Energy consumption



From the graph most of the households stop using firewood, charcoal, kerosene and dung cake, where as they still use agricultural wastes for injera baking. According to respondents11users have two to four cattle numbers, 19 households have four to six cattle and 9 households have above six cattle. From this they will get around 360 kg of dung can be collected and 108.m^3/kg TS of biogas will be produced daily.



From this they will get around 360 kg of dung can be collected and 108.m3/kg TS of biogas will be produced. All users use the biogas for cooking and lighting.

4.1.3. GENERAL CONDITION OF BIOGAS PLANT AND ITS COMPONENTS.

Table 5: General condition of biogas plant and its Components.

S.Number	Plant Component	Plant under study different category					
		>75%		25%-75%		25%	
		No	%	No	%	No	%
1	Biogas Plant as a whole	27	69.23	10	25.64	2	5.13
2	Inlet tank	38	97.44	-	-	1	2.56
3	Digester and dome (gas holder)	37	94.87	1	2.56	1	2.56
4	Outlet (displacement chamber)	36	92.3	2	5.13	1	2.56
5	Pipeline	27	69.23	11	28.2	1	2.56
6	Main gas valve	27	69.23	11	28.2	1	2.56
7	Gas lamp	24	61.54	13	33.33	2	5.13
8	Gas stove	39	100	-	-	-	-
9	Slurry pit	15	38.46	23	58.97	1	2.57

Functional status of biogas plants were analyzed considering biogas plant as a hole, and different components such as inlet tank, digester and dome, outlet, pipeline, main gas valve, gas lamp, gas stove and slurry pit. From the study it was observed that despite number of defects and weaknesses, the functional status of household biogas plants on an average was good. Out of the 39 plants under analysis, 27 (69.23%) plants were functioning satisfactorily without defects, 10 (25.64%) plants were functioning partly with defects, 2 (5.13%) plants were not functioning and the remaining 1 plant is not started at all during the time of field investigation Table 5 above.

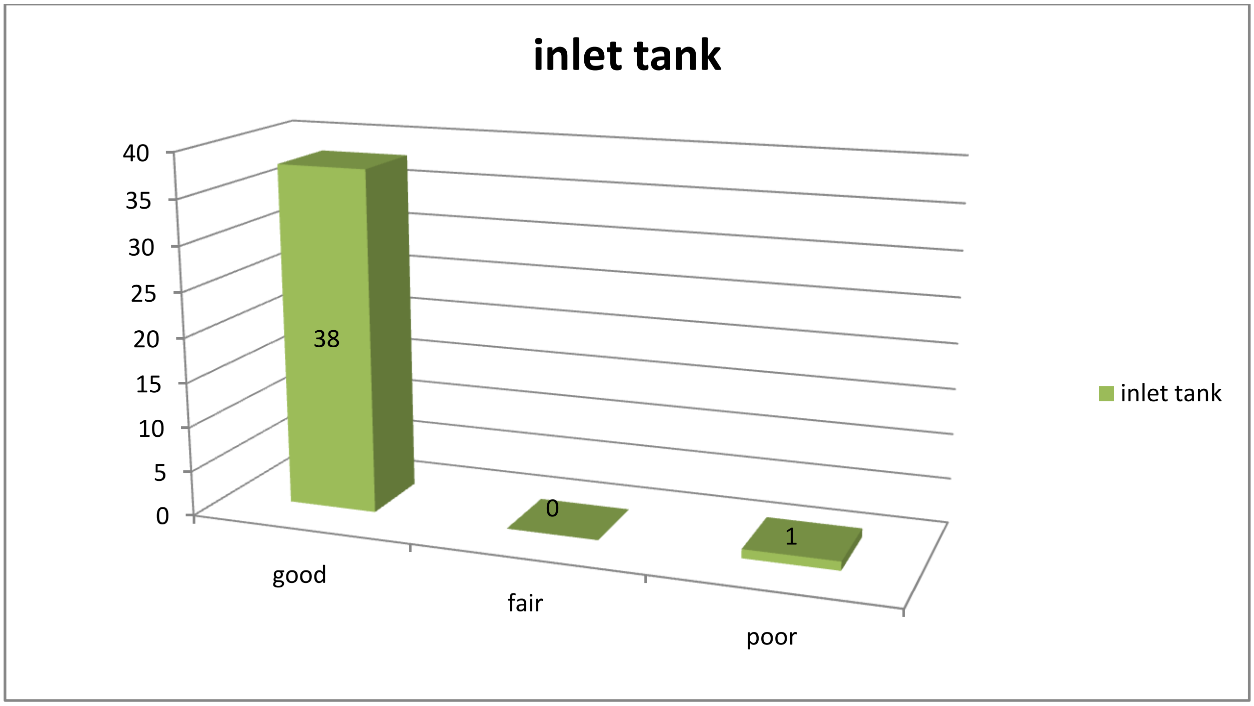


Figure 8: Status inlet tanks.

Inlets of the digester were found above the ground, from 39 digesters 38 were good and 1 is poor, this is due to construction material problems.

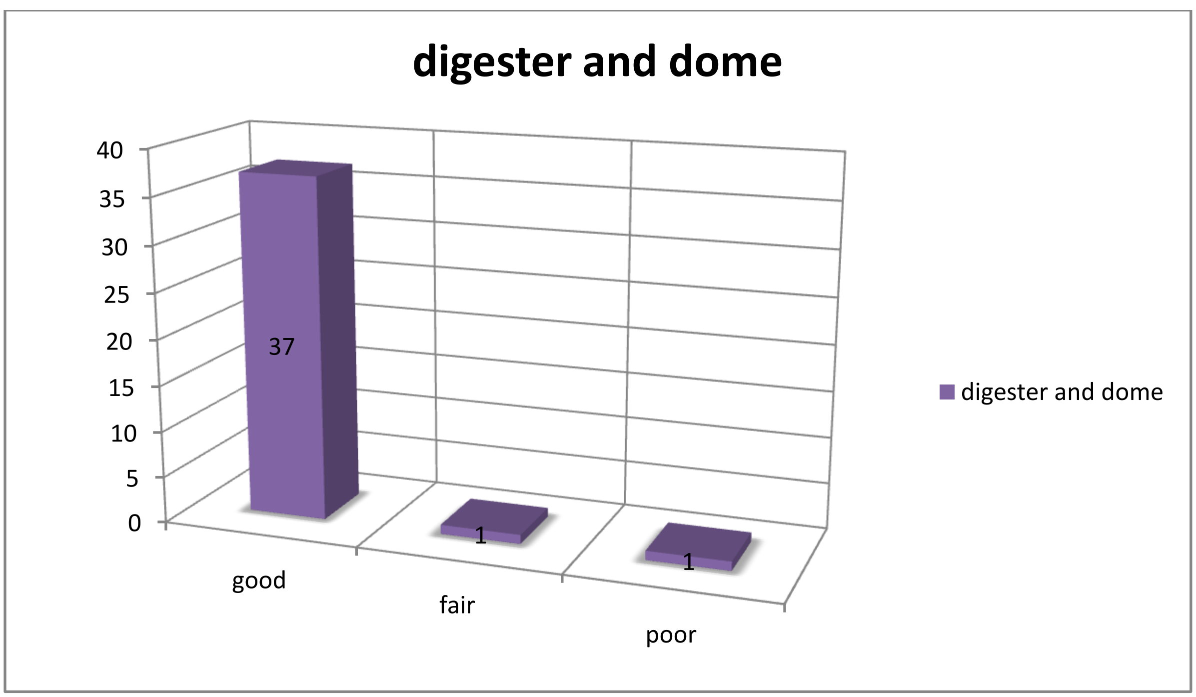


Figure 10: Statuses of digester and dome.

From the observation 36 biogas digesters and dome were working well, is with some defect in the dome and 1 is totally not working now.

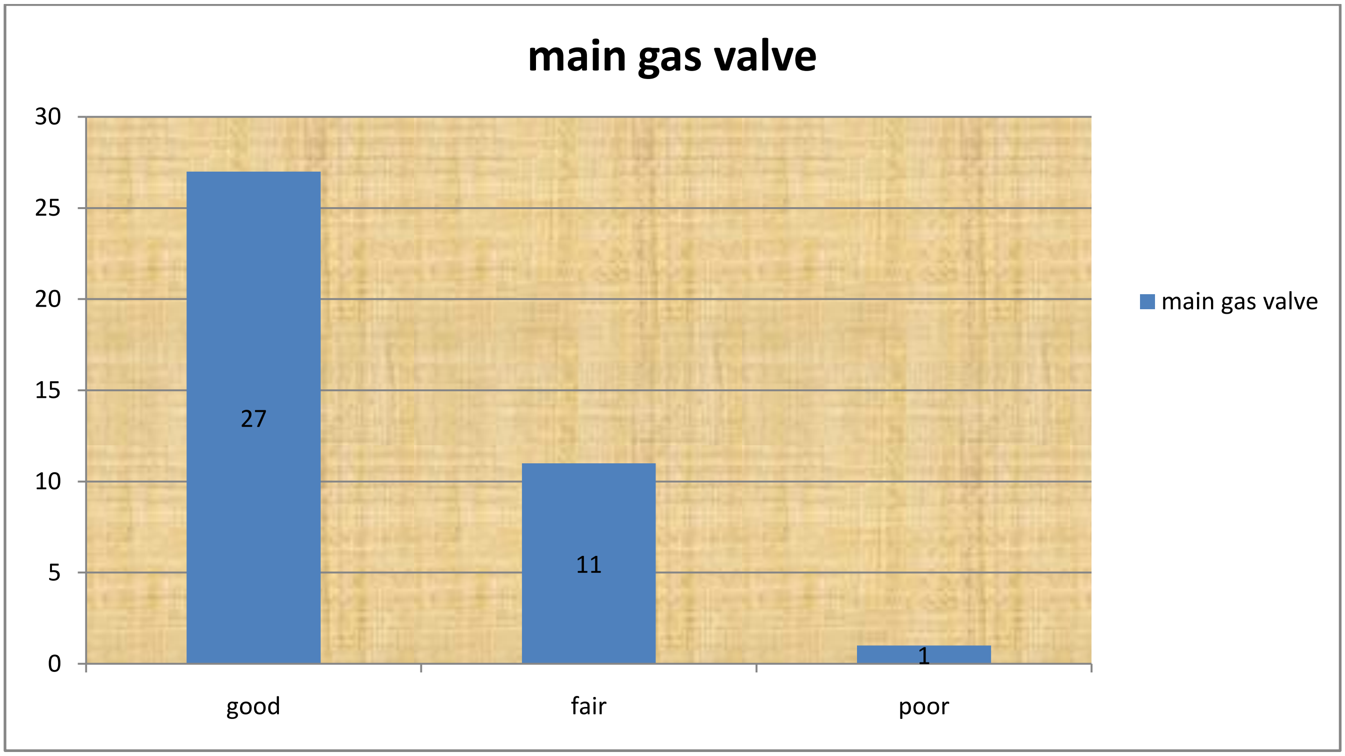


Figure 11: Statuses of gas valves.

Installation of pipe line and gas valves 27 are working well and 11 of them were some defects and is not working. There bad odor in the pipelines those which have defects.

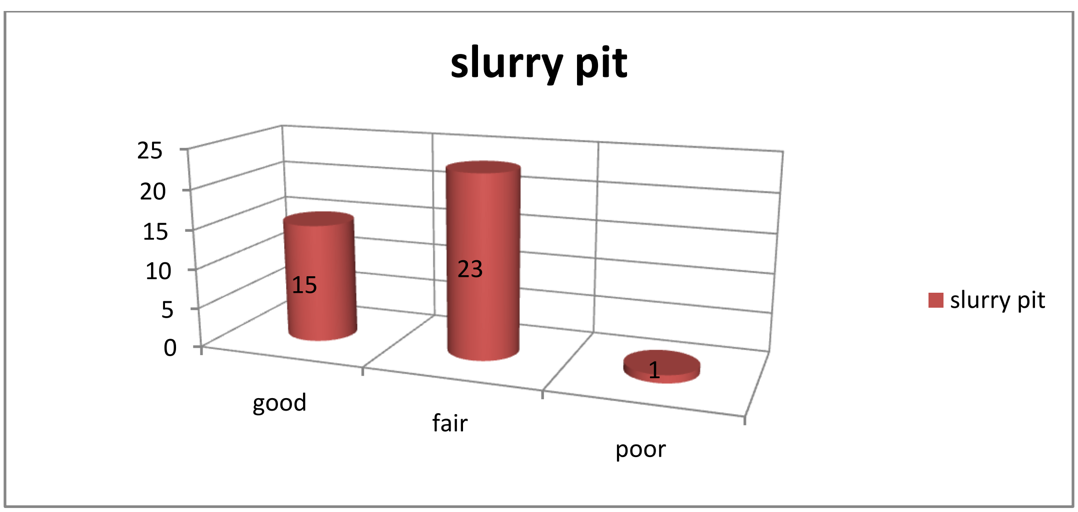


Figure 12: Condition of slurry pit.

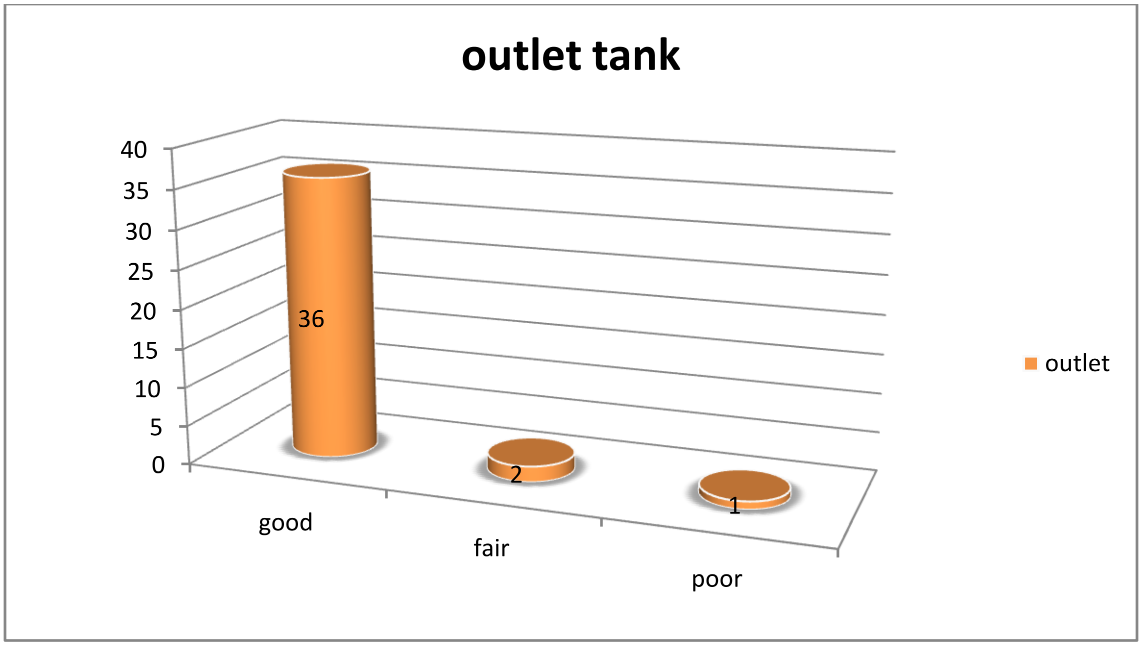


Figure 13: Status of out let tanks.

4.1.4. Feeding and Mixing

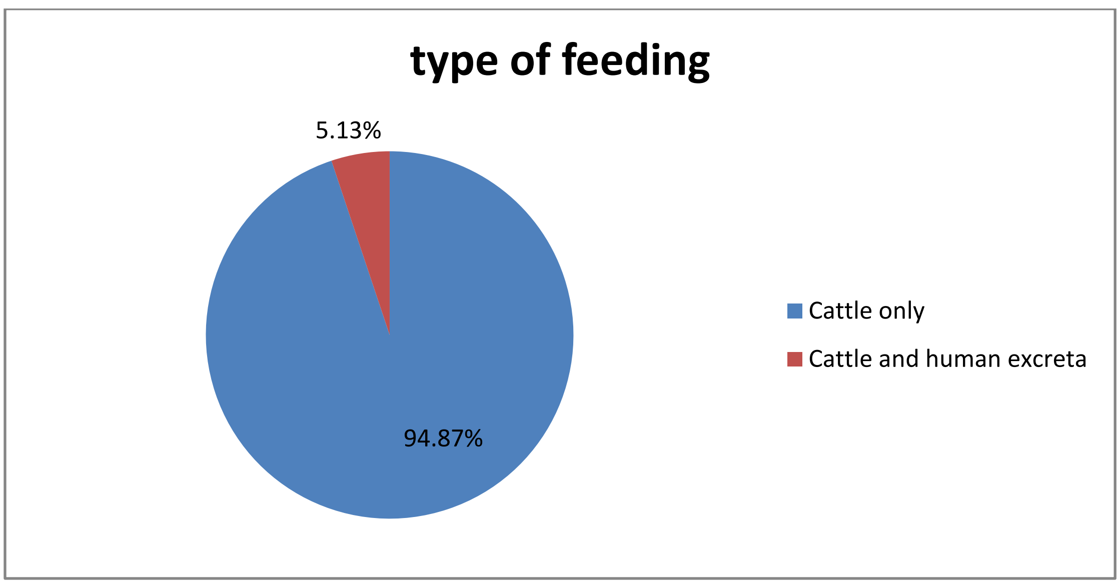


Figure 14: types of feeding.

37 user's use cattle dung only and 2 of the users use both cattle dung and night soil, but all the digesters were constructed with integration of latrines.

The amount of biogas production in household biogas plants depends upon the quantity and quality of feeding added to it daily provided plant is functioning technically all right. The above table shows the composition of feeding materials being used in biogas plants. Out of 39 the biogas plant 37 plants feed only cattle manure for biogas production and 2 biogas plants feed both cattle manure and human waste. But all the biogas plants are constructed with integration of latrine. Proportion of mixing solids and liquids part make anaerobic digestion to activate fast. From questionnaires and observation 33 users mix with the manual proportionally and 6 user mix not proportionally. There is not fixed amount of mixture added, the production of biogas fluctuates and sometimes the slurry from the output would move without finishing digestion had bad odor which is occurred by over addition of manure.

Figure 15: Latrine integrated biogas plant.

4.2. Slurry use and Management in Biogas user Households

Regardless of the high fertilizer value of the bio-slurry most of the biogas owner household respondents were found giving more attention to the gas only. The data from the questionnaire survey shows that 33.33% of users don't use slurry as fertilizer, 61.54% of users use slurry as crop production fertilizers but not in manageable way they simply dump it in field and 5.13% of users the digester is not working.

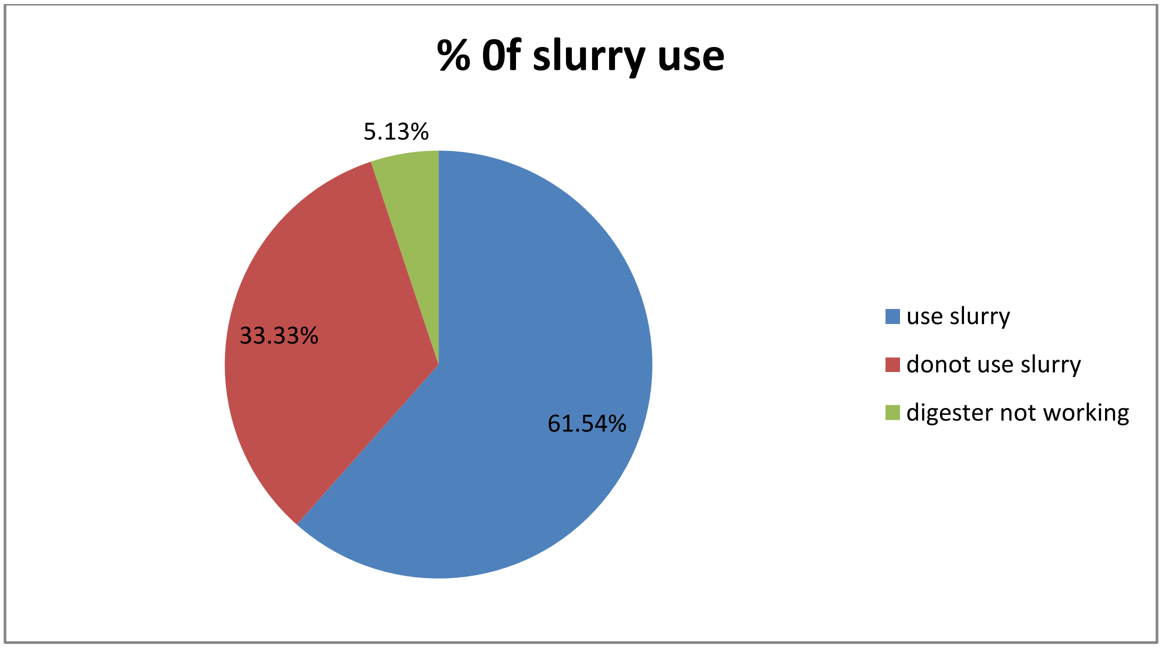


Figure 16: Use of bio-slurry as fertilizer.

Figure 17: Corn which use slurry as fertilizer.

Figure 18: Corn which does not use slurry as fertilizer.

4.3. GAS STOVE AND GAS LAMPS

All biogas stoves were manufactured by Selam Vocational and Technical Training Center and available in markets from Addis Ababa and also all use only one biogas stove. Because of lack of maintenance service, one of gas stove was not functional from observation. Also, because of high pressure, there is sound disturbance when opening to use stove and also bad odor was observed due to leakage. Survey indicates out of 38 biogas stoves, 27 (71.05%) operate without defects, 11 (28.95%) operate with minor defects 1 biogas digester is totally not working and 1 biogas digester not started working. Out of 38 lumps observed, 37 lumps were working and 1 lump is not working. From the survey in all users lump breaks from 2 to 4 times and they didn't get the lump near market.

4.4. SITE SELECTION

4.4.1. SITE SELECTION FOR THE DIGESTERS

During investigation of the site selection, I focused on the following main points: water source availability within 20 minutes, kitchen as close as possible, sunny place, about 10m away from well and finally adequate space for making compost pit.

Figure 19: Site selection problem observed.

4.4.2. WATER AVAILABILITY

There is enough access of water less than 500m (which is standard of national biogas program of Ethiopia) in all the Gomma Woreda kebeles like pond, underground water and from their homes which comes nearby town.

4.4.3. AVAILABILITY OF SUNSHINE

Field visit observations indicated that 75% of biogas digesters were installed in areas where availability of sun shine is high. But some people use the dome area as accumulation of different materials like woods (see figure below). The remaining 25% digesters were placed in areas with less amount of sunshine. This occurs due to users harvest fruits like mango avocado etc in the digester.

Figure 20: Sunshine available.

Figure 21: Dome is used as accumulation of wood.

Figure 22: Dome area used as crop production.

4.4.4. COMPOST AREA

There is no problem of land for compost area, but most users did not prepare compost pits. This is due to their less understanding on the use of slurry as fertilizer and thinking it as bad odor. And also there is no integration between stakeholders for using of fertilizers.

Figure 23: Slurry accumulated free area not a pit.

4.4.5. WATER TRAP

I observed that 90% of the water traps were closed and no one gave attention to it. Moreover seven biogas digesters' water trap slabs were covered by plants and grass. According to the interviewer and observation, the reason for this is due to the hugeness of the slab, lack of awareness and lack of a handling system on the slabs. If the water is not drawn off, then it accumulates in the pipeline between biogas digesters and stoves. Hence, when the gas tap is opened it can run the water vapor to the stove and will reduce the combustion efficiency of the gas. Beside this, the pipeline and stoves will have the probability to expose for rust due to water accumulation.

4.5. SUMMARY OF SURVEY RESULTS

The survey was in an informal conversation manner that was targeted to interview 40 biogas users, 1 biogas plant contractors and 4 biogas government officers. But one biogas digester (10m^3) is not started production of biogas. The questionnaires and interviews were targeted to collect data on operational practice, general information (funding source, date and year of installation, and cost of installation), technical and operational problems, challenges of the technology, attitude to the technology. Furthermore, the types of household energy used before and after installation of the biogas digesters, motivation and first information, family information and economic data, finally opinions and suggestion from owners, operators and users were also conducted .

Table 7: Summary of Survey Results.

kebele	Size biogas (m^3)	Number of digester	Year of construction	Elevation	Cost Of digester in birr
bulado	6	1	2007	1562	16441
bulado	8	1	2007	1562	19497
o/baqo	6	1	2006	1842	16441
g/dalach	6	2	2006-2007	2076/2072	32882
beshasha	6	1			17301
qota	6	4	2006	2019/1988	65794
Prison	10	1	2008		
03	8	1	2006	1678	19497
o/gurude	6	2	2006	1997/1857	32882
x/sedecha	6	3	2007	1802/1594/195	49323

				1	
x/sedecha	8	1	2007	1785	19497
L/sappa	6	1	2006-2007	1538	16441
choche	6	5	2007	1509-1592	82205
g/iibu	8	1	2007	1759	19497
g/iibu	6	2	2007	1823/1774	32882
k/seja	6	2	2007	1746	32882
dalacho	6	2	2007	2160/1840	
Dinu	6	3	2007	1548/158/1599	49323
Yaci	6	3	2007	1846/1841/1829	49323
k/hixi	8	1	2007		19497
b/konche	6	1	2007		16441
Dh/qacane	6	1	2007	1587	16441

From the table above More than 622,487 ETB was used for the construction of the biogas digester and 24,000EB for promoters in Gomma woreda with users and government which doesn't consist the supervision cost.

4.6. MOTIVATION AND USERS PERCEPTION ON TECHNOLOGY

It was observed that motivating factors were the Subsidy from the government, where the cost of appliances, 75% of contractor payment, Cement, Sand and supervision cost were covered by the national biogas program Ethiopia. It was observed that 100 % plant users were motivated due to subsidy, where as 69.23% plant users motivated by economic benefits associated with technology. This indicates that the potential of subsidy by the various agencies and economic benefits of technology to become tool for promotion of the technology.

4.7. FOREST CONSERVED BY USERS

Daily average biogas consumption per household is 1.64m^3 (Annex 4) which is less than the household's energy consumption, here households use the biogas for cooking and lighting. This result is in agreement with the report by Getachew et al; (2006) and zebidar (2011), which that report the households generate over 1.3 m^3 biogas daily. The annual biogas consumption per household will be 598.6 m^3. According to SNV (2009), 1m^3 of biogas is equivalent to 5.56 kg of firewood; therefore each biogas owner household can save 9.1184kg of wood per day and 3,328.216 kg of wood per year. There are around 38 digester workings, therefore 126472.208kg of wood saved per year.

4.8. THE FINANCIAL BENEFIT OF BIOGAS OWNING HOUSEHOLDS

4.8.1. BENEFIT FROM FIREWOOD REPLACEMENT AND REDUCED USE OF CHARCOAL

The biogas owning households benefit financially in many ways like, benefit from the replaced fuel wood, kerosene, charcoal etc. 94.87% of the households stopped the consumption of kerosene, and on average they consume 0.47 litre of kerosene per day per house hold before construction of biogas digester. After they started using biogas they have completely replaced the above fuels by biogas. The cost of one litter of kerosene is 21 ETB; from this the households save 3602.55 ETB/y. Injera baking is not replaced by biogas still they are using firewood and some of them dung cake.

4.8.2. Benefit from reduced use of fertilizer

61.54% of the biogas owning respondents does not use inorganic fertilizer but 33.33% of them use the inorganic fertilizers and spend about 4000 ETB per year on average which is not affordable for them. After they start using biogas the money they spend on fertilizer (inorganic) decreased by 45 percent. Accordingly, they saved an average of 1800 ETB per year.

CHAPTER FIVE

5. CONCLUSION

The designs of all digesters were fixed dome design which is modified version of the Nepalese model with an Ethiopian name – SINIDU (meaning "ready"). The Nepalese design is preferred because of its robustness, ease of operation, opportunity to accommodate high shares of local materials, correct sizing and low cost. The sizes of the plant under study were from $6m^3$ to $10m^3$. All the plants were constructed with latrine integrated way but only two digesters are working with both cattle manure and human waste. Here during sizing of the plant only the number of cattle were considered which makes the pipes to leak with high pressure, bad odor, to leave the slurry without finishing its digestion and breakage of lumps. The analysis shows that, there is strong dependency within and between the sectors, e.g. between the ministry of water, irrigation and energy and ministry of agriculture. Due to the NBPE program, suitable sector policies were set up at national level, which are a driver for current growth of biogas in Gomma woreda. Since the current biogas stove did not use for injera baking, this is a barrier for further growth. Most of biogas users become benefited financially from reduced use of kerosene and some of them also reduced buying inorganic fertilizer. Biogas improves their health by avoiding smoky stoves and improved sanitary conditions. It also decreases burden to females from fuel collection, cleaning of kitchen and cooking materials. Biogas stoves cook fast and it increased their cooking interest, it saved their time to participate in other social activities and to take care of themselves and their family. Household Biogas users responded reduces using firewood, charcoal, and agricultural residues by 55%, therefore biogas save deforestation and conserve large area of forest. There are 41 kebele and more than 45,567 households in the woreda, but 99.88% households are not biogas user households. So there is a need for strong promotion and consultancy services from the National to woreda biogas program offices and during promotion the right use of biogas digester should be told without any increments which help for further growth. If so the second phase of the NBPE takes place from 2014 until 2017 plan of the National Biogas Program to increase the number of biogas digesters to 20,000 can be achieved. Incorporating biogas technology to an integrated agricultural production system not only helps save firewood and preserve forests, but also contributes towards sustained soil fertility through organic fertilization and ensures the long-term crop-bearing capacity of the soil by improving the physical and chemical properties of the soil.

6. ACCOMPLISHED WORK AND FUTURE WORK

6.1. ACCOMPLISHED WORK

In this thesis report the researcher tried to achieve the main objective of the thesis by accomplishing the specific objectives. Hence, all field works such as physical status of different parts of the digester were observed identifying types of bio-digesters and construction materials were done, systems were checked for leakages, blockages and cracks from upper side of the digesters, perception about the technology were assessed and operators and owners of the digester were interviewed. Then the collected data from field work, and questionnaires were organized and interpreted via qualitative and quantitative methods. Finally the researcher was made conclusions and recommendations based on main findings.

6.2. FUTURE WORK

To have fully documented information on the performance of biogas digesters and operational practices of the households the following additional parameters has to be identified.

- Temperature change in biogas digesters due to change of seasons and its effect on performance of bacteria.
- Manure conversion efficiency analysis: - (analyzing conversion efficiency of manure by taking samples from fresh feedstock, effluent and slurry part then analyze carbon, nitrogen, potassium and other necessary elements of the samples).
- Identifying the quality of biogas or determine percentage composition of CH_4 and CO_2.

7. RECOMMENDATION

- During promotion the right use of biogas digester with its size should be informed to households.
- Appliances and maintenance operators should be prepared in nearby areas.
- Strong promotion must be done on the non-biogas user households with capacity to invest on biogas and to create the opportunity to those who have financial problem to get money from microfinance institutions in long time return.
- There so many government plantation and farmers which are planting coffee, fruits like mango, avocado and other crops. So they can use bio-slurry (organic fertilizer) with cheap price. This will solve the problem of slurry accumulation and create work opportunity and increase income to household.
- Researcher recommend for further study to the problem of breakage of lump in most biogas users which is more than 3 times a year.
- Since there is no mold is prepared during construction of dome they use the soil removed during digester construction as mold, which makes it boredom. So needs researcher preparing the mold.

ANNEX 1

BIOGAS QUESTIONNAIRE FOR USERS

The current status and analysis of problem of domestic biogas plant in goma wereda.

1. Previously what type of fuel were you using?

A) Fire wood B) dung cake C) kerosene D) agricultural residue

E) charcoal F) all G) mention if other

2. How many numbers of cattle do you have?
3. Installed year-------------month-------------
4. Size of biogas A) $4m^3$ B) $6m^3$ C) $8m^3$ D) $10m^3$
5. How much it costs?
6. How much cow manure and water is added respectively? Is daily?
7. Is the biogas plant operating? A)Yes B) No
8. For what purpose is the biogas used? A) cooking only B) light only C) both A & B
9. How many hours used per day?
10. Environmental effect observed?
11. How much money is saved in total (per week or month) on 'traditional' energy sources (LPG, kerosene, firewood, candles) in birr?
12. Is there any change in health conditions, specifically among women and children? After starting using biogas? A) Yes B) No
13. Does the household use the slurry as fertilizer? A) Yes B) No
    If yes what change is observed on agriculture?
14. What problem is faced: -
    a) During installation?

    b) After installation?

ANNEX 2

OBSERVATION

Status of the following parts will be observed:-

A. Observing the site selection have availability of sunshine---
 -Distance from kitchen---------------------------
 - Compost area ---
 - Water access---
B. Number of cattle size and daily feed--

C. Inlet---
D. Digester---
E. Dome---
F. Gas Pipe line
 -Pipeline leakage--

 -water removal (water traps) --

 -Lump--

 -Gauge---

G. Outlet ---
H. Stove--
I. Slurry pit--
 -Way of slurry storage and usage---

 -visiting the farm which uses the slurry as fertilizer. ---

ANNEX 3

Questionnaire for wereda (zone) officers

1. Do the wereda have trained man power for biogas plant construction, installation and supervision?

A) Yes B) NO

2. How many households have ability to afford building biogas plant in the wereda or zone?
3. How was the users selected?

---

4. How was the size of plant selected? ---
5. How funds covered? ---

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6. Does any integration with other sector? A) Yes B) NO

   if yes to which sector have integration?

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7. .A) What problem faced during construction?--

B) What problem faced after construction? ---

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7. What do you suggest (advice or wish) to happen for the future in relation with biogas plant:-

a) from beneficiaries --

----

b) from government --

----

c) from funding agent--

ANNEX 4

User	kebele	Date of construction	Size of family	Size of plant	elevation	functionality	Cost of construction
HH1							
HH2							
HH3							
HH4							
HH5							
HH6							
HH7							
HH8							
HH9							
HH10							
HH11							
HH12							
HH13							
HH14							
HH15							
HH16							
HH17							
HH18							
HH19							
HH20							
HH21							
HH22							
HH23							
HH24							
HH25							
HH26							
HH27							
HH28							
HH29							
HH30							
HH31							
HH32							
HH33							
HH34							
HH35							
HH36							
HH37							
HH38							
HH39							
HH40							

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