CHALLENGES AND OPPORTUNITIES OF BIOGAS TECHNOLOGY ADOPTION FOR SUSTAINABLE HOUSEHOLD ENERGY IN WARD 4 OF DOMBOSHAVA COMMUNAL AREA

BY

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Declaration

This research project report is my original work and it has not been submitted to any other examination body. No part of this research project should be reproduced without my consent or that of Midlands State University.

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Dedication

This dissertation is lovingly dedicated to my grandmother, Mrs Marian Sakarombe for all her support and sacrifices of raising me since the untimely death of all my parents when I was still an infant. Without her, this academic journey would not have been possible.

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Abstract

The research sought to comprehensively examine challenges and opportunities of biogas technology adoption for sustainable household energy in rural areas of Zimbabwe. Focus was on Domboshava Communal Area, Ward 4 where potential of the technology is hundred folds higher than the present status. The research adopted both qualitative and quantitative research techniques to answer the objectives. Total enumerative sampling technique (census) was used and 56 biogas adopters within the study area were sampled. In addition, purposive sampling technique was employed to select key informants from EMA, SNV, ZERA, Environment Africa and the Ward Councillor. Questionnaires, key informant interviews and observations were used to collect data in the field. Collected data was analysed using Statistical Package for Social Sciences and Microsoft Excel and then presented in frequency distribution tables, graphs and pie charts. Despite a notable positive attitude towards biogas technology, results of the research revealed a worrying lack of technology awareness in Ward 4 of Domboshava Communal Area. The research further revealed that factors like employment status and level of education attained do not influence biogas adoption while funds availability, awareness, promoters and gender of the household head were seen to have a major effect. The research concluded that lack of adequate knowledge about the technology and lack of required resources are the main constraints inhibiting biogas technology adoption by households in Ward 4. This is despite various potential opportunities such as high nutrient content organic fertiliser, reduced time spend on firewood collection and reduced in-house air pollution being enjoyed by the adopters. The study recommends the Ministry of Energy and Power Development to embark on massive education and awareness campaign in rural areas, provide loans and subsidies, provide accessible technical services and set up demonstration centres in every ward with a view of encouraging rural households to adopt biogas technology.

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List of Acronyms

CH_4	Methane
CO_2	Carbon dioxide
DCDA	Domboshava Community Development Association
EA	Environment Africa
EMA	Environmental Management Agency
GHGs	Greenhouse gases
LPG	Liquefied petroleum gas
MoEPD	Ministry of Energy and Power Development
MW	Mega watts
NDBP	National Domestic Biogas Programme
NGOs	Non-Governmental Organisation
SDG	Sustainable Development Goals
SNV	Netherlands Development Organisation
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
USA	United States of America
ZERA	Zimbabwe Energy Regulatory Authority

CHAPTER ONE: INTRODUCTION

1.1 Background of Study

Ngumah et al. (2013) defined biogas technology as the use of biological processes in the absence of oxygen (anaerobic digestion) to degrade and stabilise organic matter and other biodegradable raw materials to create a mixture of methane and carbon dioxide that can be utilised as fuel. Similarly, Mwakaje (2008) characterised biogas as a mixture of methane and carbon dioxide produced by bacterial degradation of organic matter while Parawira (2009) sees it as any gas fuel derived from living matter such as ethanol from sugarcane or methane from decaying substances. The processes and procedures involved in anaerobic digestion results in two crucial end-products which are energy rich biogas and nutrient rich digestion residues. According to Smith (2012) biogas technology has a great potential to reduce wood energy consumption and providing sustainable household energy, enabling therefore household members to engage into other socio-economic activities. Wamuyu (2014) additionally reaffirmed that biogas production process is carbon neutral and therefore does not add or remove carbon dioxide from the atmosphere making it an imperative way of mitigating climate change in comparison with the use of wood based energy. Unlike wood energy, Wamuyu (2014) comparably observed that biogas burns without smoke thereby improving indoor air quality and thus saving women and children from respiratory distress and ailments.

The need for sustainable energy remains a very critical issue in Africa's efforts of development where a large number of people do not have access to modern sources of renewable energy. Scarlet et al. (2015) suggested that access to energy is an indispensable condition to develop economic activities and to improve the quality of life. This explains why the provision of sustainable, affordable, clean, adequate and efficient energy remains at the core of many country's interests in sub Saharan Africa (SSA). In spite of the efforts in place so far to provide sustainable energy for all, nearly 1.3 billion people globally did not have access at all to modern sources of sustainable energy in 2010 (Adeola et al. 2014). Sadly, the lion's share of people living without access to renewable energy lives in Africa representing around 57% of the World's population (UNDP 2013). This alone heavily militates against efforts to fight abject poverty and full realisation of the Sustainable Development Goals (SDG) in Africa.

In sub-Saharan Africa (SSA), Adeola et al. (2009) stressed that biomass energy in the form of firewood, charcoal and crop residues accounts for 70 - 90 per cent of primary energy supply. Strikingly, Miyuki et al. (2014) similarly highlighted acute energy poverty in sub-Saharan

Africa where according to their study 90% of the population rely on firewood and charcoal particularly for cooking, lighting and heating. In another fascinating development, the US Department of Energy concluded that over 75% of wood harvested in Africa is used for household energy needs (Collins et al. 2013). This situation poses a great threat to human and environmental security and also constitutes a major stumbling block to progress towards growing economies as well as realising goals of sustainable development agenda in Africa.

Zimbabwe has a growing understanding of sustainable energy supply as a critical factor for national development judging from the National Energy Policy of 2012. Currently, the country's energy requirements are met through a combination of biomass energy, thermal and hydro-electric power plants as well as imports. ZERA (2013) noted that Zimbabwe has a national power generating capacity of 1400 megawatts MW against a national peak demand of 2400 MW. This leaves a worrying power deficit of over 1000 MW at national level. Moreover, it has emerged that Kariba Hydro-electric power station is facing climate change challenges with perennial droughts reducing the lake capacity, thus threatening the generating capacity of the plant (Herald 2015). In the same way, the available thermal power stations have passed their lifespan and the equipment is now obsolete resulting in serious inefficiency and frequent breakdowns. For these reasons, prospects of fast connecting rural households with electricity has henceforth remained inconceivable. The lion's share of energy consumption in the country has remained dominated by wood based energy, agricultural residues and cattle dung thus presenting a disastrous threat to environmental sustainability.

According to Hivos (2012) wood based energy consumption in Zimbabwe is particularly high and unsustainable accounting for up to 95% of total energy consumption in rural households. On a sad note, Mbulayi (2013) stressed that most rural communities are now facing acute shortage of household energy supply mainly because of unsustainable firewood harvesting and land clearance for agriculture. Another worrying development as observed by Mbulayi (2013) is that people in rural areas mainly women travels long distances to collect firewood at the expense of engaging in other productive economic activities. Other than this, continued reliance on firewood for energy has been linked to increased respiratory ailments among users due to incomplete combustion and smoke emissions in poorly ventilated houses common in rural areas. In a study on indoor air pollution from biomass combustion and acute respiratory illness in pre-school ages in Zimbabwe, Mishra (2003) found out a worrying high incidences of respiratory related deaths. This therefore calls for an urgent shift to other alternative sources of energy which are clean, affordable and sustainable with biogas technology being one of the best option.

Efforts to disseminate biogas technology among rural households in Zimbabwe dates back to the 1980s. This follows a full realisation of the huge potential exhibited by the technology in answering Zimbabwe's main question of sustainable household energy in rural areas. However, the initiative suffered still birth since it never yielded results as initially planned and envisaged. A survey carried out by Hivos (2012) revealed that only 140 digesters has been constructed across the country by 1999 and in 2012, of the 140 digesters only a handful were still operational.

Efforts to disseminate biogas technology amongst rural communities in Zimbabwe were reignited in 2012 following a partnership between the government and developmental organisations. The National Domestic Biogas Programme was thereafter launched with an aim to establish a vibrant biogas sector set to benefit many rural households across the country. Given the inter-related challenges of poverty and energy demand, climate change, indoor air pollution and human health, accelerated and large scale dissemination of biogas technology is now necessary more than ever (Hivos 2012). Regrettably though, benefits and challenges of adopting and using the technology have never been comprehensively documented from the users' perspective and little has been done at household level. This research therefore seeks to understand why households choose to adopt or not adopt biogas energy technology, challenges of adoption and also opportunities availed by the technology from the adopters point of view.

1.2 Statement of Problem

Scarcity of sustainable energy solutions, accompanied by over dependence on wood energy in most rural areas of Zimbabwe has remained one of the challenges the country is facing in its efforts to achieve sustainable development. Over 90% percent of households in rural areas of Zimbabwe depend on wood energy for all their energy needs posing far reaching environmental and health impacts (UNEP 2012). In Domboshava, high wood energy and forest products demand is seriously pushing non-gazetted forests towards extinction. This situation has been made possible and worsened by exorbitant prices of alternative fuel sources such as Liquefied Petroleum Gas (LPG), electricity and solar systems which have remained largely beyond the reach of many rural households. Efforts by the Government of Zimbabwe to disseminate biogas technology in rural areas and Domboshava in particular have been faced with limited success stories since independence in 1980. Only a small proportion of the rural households have adopted the technology across the country and in Domboshava, the majority of households have persistently continued to use the traditional inefficient and unsustainable wood energy systems. In 2013, the Ministry of Energy and Power Development in partnership with some developmental organisations revitalized efforts to disseminate biogas technology to the rural households on a five year plan. Despite an appreciation of the technology as the best option and solution to the current rural energy insecurity, biogas technology has never been adopted to the expected levels resulting into the continued exploitation of forests. It is in relation to the foregoing background that this research seeks to understand challenges and opportunities of biogas technology adoption at household level in Ward 4 of Domboshava Communal Area.

1.3 Objectives of the study

1.3.1 General Objective

To investigate challenges and opportunities of biogas technology adoption for sustainable household energy in Ward 4, Domboshava.

1.3.2 Specific Objectives

a. To establish the level of awareness and attitude towards biogas technology in Ward 4 of Domboshava.

b. To identify factors that influence the adoption and use of biogas technology for household energy in Ward 4, Domboshava.

c. To assess effectiveness of biogas technology in comparison with other household sources of energy in the area.

d. To examine challenges and constraints to biogas technology adoption and use at household level in Domboshava.

1.4 Justification of the study

With the continued loss of vegetation in Zimbabwe, the country has reached a point at which greater effort is required to diversify energy sources, improve efficiency and take climate change into consideration in energy planning and development. Efforts by the Government of Zimbabwe to disseminate biogas technology in rural areas has been faced with limited success since independence in 1980. Regardless of an appreciation of the technology as the best option and solution to the current rural energy insecurity, challenges of adoption and associated benefits have never been adequately and comprehensively documented from the users' point of view and in the Zimbabwean context. This research in Ward 4 of Domboshava therefore seeks to establish the root causes of low adoption of the technology, benefits and the underlying factors, drivers and household motivation for the adoption and use of biogas.

The significance of the study is premised on the fact that it will assist in the bid to achieve sustainable development goal seven (SDG7) which seeks to ensure access to affordable, reliable, sustainable and modern energy for all. The results of this research will go a long way in contributing to a better understanding of the root causes of low adoption of the technology in potential areas like Domboshava. Furthermore, in as much as efforts to disseminate biogas technology in rural areas are in place, the results of this research will assist the Government of Zimbabwe and Non-governmental organisations involved in the promotion of biogas to set key strategies instrumental in increasing the adoption rate of the technology. Likewise, findings of this study shall be used as inputs for decision making by policy makers, planners, non-governmental organisations and other implementers of bio-energy technologies. The Environmental Management Agency, Forest Commission and the Ministry of Environment, Water and Climate change will find the results of this study useful in terms of reducing deforestation, greenhouse gasses emissions and land degradation.

In addition, following the launch and implementation of the National Domestic Biogas Programme in 2013, this research shall be helpful in exposing areas requiring improvement in as far as future biogas programmes are concerned. It is anticipated further that the research findings will be helpful in revealing areas of improvement regarding choice and adoption of renewable energies at household level. The research will go a long way in assisting the Ministry of Energy and Power Development with strategic information on what to prioritise when making policies and how to respond to challenges militating against the achievement of SDG 7 in Zimbabwe.

Lastly the findings will provide additional knowledge to the present literature of renewable sources of energy. This shall henceforth be crucial empirical literature foundation to which future energy policies can be formulated upon. The study shall also be instrumental in stimulating interest on more research in the field of renewable energy sources.

1.5 Study Area

1.5.1 Location of the study area

The study was carried out in Ward 4 of Domboshava, a peri-urban communal area in Mashonaland East province of Zimbabwe (Figure 1.1). Administratively Domboshava falls under the local authority of Goromonzi Rural District Council and lies approximately 29km northeast of Zimbabwe's capital city, Harare. Goromonzi District has a total of 15 wards and a population of about 227 987 people (Zimsat 2012). The district is divided into three political constituencies which are Goromonzi North, South, and East. Domboshava itself is made up of five wards and falls under Goromonzi North constituency which has a total of eight Wards according to (Ingwani 2015). Ingwani (2015) further stated that two of the wards (ward 6 and 7) of Goromonzi North constituency are commercial farms. Ward 4 (study area) is found on the boundary of Harare and stretches all the way to Makumbe Mission along the Domboshava road. According to Zimstat (2015) ward 4 of Domboshava has an estimated 7100 households. The area is found along latitude 31^{0}E and longitude 17^{0}S with an average altitude of 1080m above sea level.

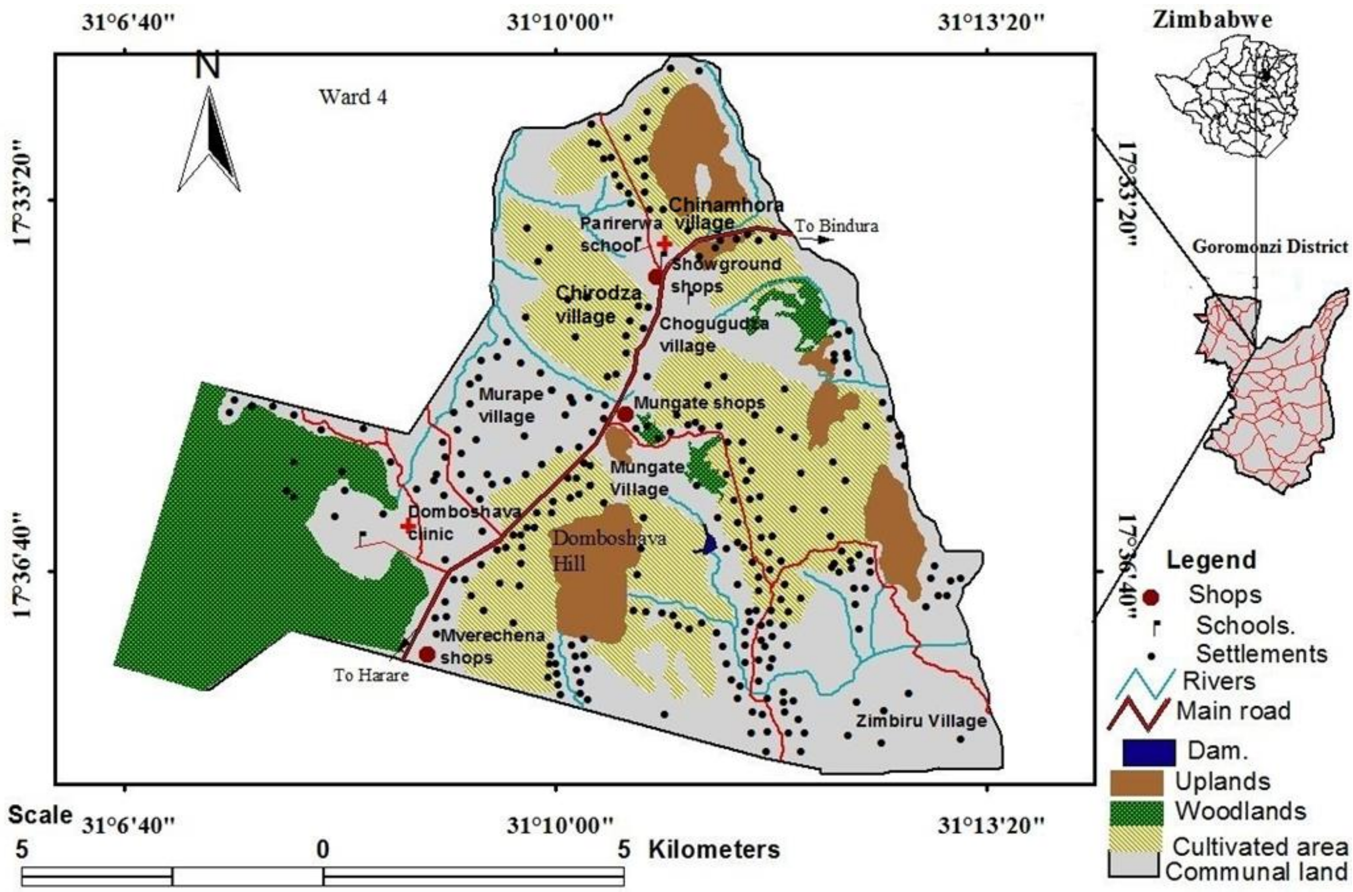

Figure 1.1: A map for Ward 4 of Domboshava Communal Area, Mashonaland East Province

Source: ArcView 3.2

1.5.2 Physical Characteristics

The area is largely a rugged terrain with a drainage dominated by dendritic river patterns, draining to the north-east into the Mazowe main Catchment. Soils in the area are dominantly sandveld, red clay soils, black turf and sandy soils which are derived from the same parent material but differ in properties as they occupy different topographical positions (Host 1992). The area lies in agro-ecological region 2b which receives good rains although subject to frequent droughts, dry summer spells and short rainy seasons (Ingwani 2015). Rainfall averages 650-800 mm per annum with temperatures averaging around 26-29 degrees Celsius in summer (Zvigadza et al. 2010). In winter the temperatures drops to as low as 10-15 degrees Celsius. Zvigadza et al. (2010) further pointed out that frequent mid-season and unusual rainfall variations are threatening many livelihoods in some parts of the area. Vegetation is sparsely distributed with shrubs and mature trees severely subjected to deforestation. Common tree species include Julbernadia globiflora *(munondo)*, Eupaca kirkiana *(muzhanje)* and Parinari curatelifolia *(muhacha).*

1.5.3 Socio-economic Characteristics

Domboshava communal area is largely populated by people who speak zezuru, a shona dialect which is one of the main vernacular languages of Zimbabwe (Ingwani 2015). The average poverty prevalence in the area ranges between 61% and 72% according to (Zimstat, 2015). Poverty is more prevalent on the northern peripheral areas of Goromonzi District in wards 01, 02, 03, 04 and 05 which forms the huge part of Domboshava area. Major economic activities in the area ranges from market gardening, grain production and livestock rearing. In general terms it can be said that most people in Domboshava are subsistence farmers who grows groundnuts, maize and other small grains for food security. However, Zvigadza et al. (2010) mentioned that for decades families in Domboshava has been relying on market gardening activities for survival but things seems to be changing as the area is facing serious deterioration of water levels, expanding population, economic stagnation and a flooded market for some of its agricultural products.

CHAPTER TWO: LITERATURE REVIEW

2.1 Background to biogas technology

Today's use of energy in Africa and other developing countries world over is heavily represented by the use of biomass (Muriuki 2014). While modern fuels are an important enabler of socio-economic development, still over two billion people world-over rely on wood, agricultural residues and cow dung for all their daily energy needs (UNDP 2009). These resources in developing countries accounts for over 90% of daily household energy consumption (UNEP 2013). Parawira et al. (2012) warned that due to a shortage of commercial modern energy and current economic situation in most African countries, energy substitution away from biomass is less likely. This is mainly because of declining disposable incomes of most rural and urban populations. He added that, there is a high likelihood of many households switching back to traditional energy as modern energy sources becomes more and more scarce and expensive, notwithstanding corresponding extinction of biomass in some parts of the continent. Thus (UNDP 2009) explained that biomass is a very cheap source of energy, but again when used in an unsustainable way may lead to consumption beyond regenerative limits with serious socio-economic and environmental consequences. To this effect, Barnes (2005) called for concerted efforts and coherent biogas technology strategy with a view of establishing a vibrant biogas sector in Africa.

The first practical application of anaerobic digestion for energy production took place in England in 1896 when biogas from sewage sludge digestion was used to fuel street lamps. As is the case for many other renewable technologies, interests in anaerobic digestion suffered the rise of dependence on petroleum (Amigun et al. 2008). However, some developing countries largely in Asia, embraced the technology for the small scale provision of energy and sanitation services (Gautam 2009). Since then, anaerobic digestion continued to receive considerable interest to harness its waste disposal and energy producing capabilities, with municipal sewage disposal attracting the widest application in the early 21st century (Gautam 2009).

The technology has been advanced around the world as a renewable energy by various organizations and well-wishers. Currently, biogas technology is being used successfully in Asia, Latin America and some regions of East and West Africa (Laichena 2013). In Nepal for instance the use of biogas technology has been promoted by the Biogas Support Program (BSP) since 2003. Following this effort, in 2009 the program had installed 208,000 biogas plants benefitting 1.25 million people across the country (Rai, 2009). India has an estimated two million households with biogas facilities while Bangladesh has over 50 000 household digesters as of 2013 (Rao and Medy 2014). This has been attributed particularly to a thriving livestock sector as well as coordinated government policies and programmes. In China, the application of biogas technology has been experimented since 1958 (Robert 2005). Remarkably, in around 1970 China had installed over 6 million digesters in an effort to make agriculture more efficient (Robert 2005) and in the recent years the technology has been met with high growth rates.

In Europe on the other hand, the level of development greatly varies across the region. According to Adeola et al. (2009) this variation is largely a result of different legal frameworks, education schemes and the availability of other technologies. They further posted that while countries such as Germany, Austria and Sweden are fairly advanced in their use of biogas, vast potential for this renewable energy source lies rightly in the rest of the continent, chiefly in Eastern Europe. Africa has various organizations such as African Biogas Partnership Program and SNV-Netherlands actively involved in advancing the idea of biogas use in countries such as Uganda, Ethiopia, Tanzania, Kenya, Rwanda and Zimbabwe.

2.2 Biogas technology adoption and use in Africa

The interest of biogas technology in Africa has been stimulated by promotional efforts of various international organisations and foreign agencies. This has been done through active meetings, workshops, publications and demonstration centres. Parawira (2014) attested that, to date biogas technology units have been installed in several sub-Saharan African countries. These have been designed to utilise variety of wastes such as those from animal dung, industrial waste, slaughterhouses, household wastes and human excreta. Mshandete et al. (2009) cited that in most of the African countries like Ivory Coast, Burundi, Guinea Bissau, Kenya and Tanzania where the technology has been adopted, biogas is produced through anaerobic digestion of human excreta, animal dung and household wastes using the Indian floating-cover and the Chinese fixed dome digesters. Nevertheless, these has been dismissed as not reliable and of poor performance (Amigun et al. 2008) hence stimulating a negative attitude towards the technology in some of these areas. Most of these biogas plants has been operational for a very short time and were abandoned due to technical challenges. Table 2.1 gives a list of selected African countries with biogas units as of 2013.

Table 2.1: Selected sub-Saharan African countries with biogas units as of 2013

Country	Domestic / small scale biogas digesters	Institutional biogas digesters
Botswana	Several	74
Burundi	>279	21
Ethiopia	Several	107
Kenya	>900	232
Lesotho	40	4
Malawi	-	1
Rwanda	Several	17
South Africa	Several	72
Swaziland	Several	30
Tanzania	>1000	402
Uganda	Few	3
Zambia	Few	13
Zimbabwe	>425	42

Source: Parawira (2013)

Some of the first biogas plants in Africa were set up in the 1950s in Kenya and South Africa. In Tanzania biogas technology was first introduced in 1975 while in some countries even more recently for example South Sudan (2001). Presently, biogas technology has been adopted in many sub-Saharan Africa countries like Burundi, Ghana, Guinea, Nigeria, Botswana, Zimbabwe and Ethiopia (Hivos, 2015). Installed plants ranges from small scale household digesters, community, institutional and commercial plants. Various inputs are utilised such as wastes from slaughterhouses, urban landfill sites, industrial wastes, water hyacinth plants, human excreta and animal dung. The plants have been installed in various places for example health clinics and hospitals (Tanzania and Zimbabwe), commercial farms (such as dairy and chicken farms in Burundi), and also in prisons for example in Zimbabwe and Rwanda (Winrock International 2007). However, household domestic biogas digesters are by far the widely attempted model largely using animal dung (Table 2.1). This is because of the understanding that biogas technology is closely linked to poverty alleviation and of course rural development (Parawira et al. 2009). The biogas produced from these household level based system is commonly used for cooking while very few and in rare cases it is used for lighting (Mwakaje 2014).

Global experience has demonstrated that biogas technology is a simple and readily usable technology which does not require complex and sophisticated expertise to construct and manage. Taleghani and Kia (2010) proclaimed that biogas technology has been recognised as a befitting, modest and adaptable technology for Africa. There are some cases of successful biogas technology interventions in Africa, demonstrating effectiveness of the technology and its appropriateness for the region. Lessons learnt from experience in some parts of Africa suggest that biogas technology has multiple beneficial effect at household level and the nation at large. Given multifold benefits of the technology, one would hence expect that the adoption of biogas technology across the continent would be very high. Contrary to this line of thinking, a study by (UNEP 2013) revealed that the uptake of the technology have remained relatively low and is not widespread in Africa.

2.3 Biogas technology in Zimbabwe, status and prospects

Biogas production and use is not new in Zimbabwe. According to a journal published by the then Department of Energy and Water Resources, the government assisted towards the construction of more than a hundred biogas units in rural areas and tertiary institutions in the 1980s. According to Chimombe (1986), these were set to be demonstration centres where people could be taught and replicate the new technology. However, it has been concluded that the technology has never taken off as initially envisaged. It is in the recent years that the government has sought to revive the dissemination of biogas technology in a desperate need to quench the growing need of renewable energy sources in rural areas. Accordingly, over 400 biogas units has been constructed at homestead level in Hwedza, Sanyati, Chirumanzu, Gutu and Chipinge (Herald 2013). In another development, SNV in partnership with the Ministry of Agriculture, Mechanisation and Irrigation Development and the Renewable Energy Fund are actively promoting biogas to provide access to clean energy for cooking, lighting and other productive use in Insiza, Chegutu, Goromonzi and Mvuma. Furthermore, more than 70 biogas masons as well as 18 fabricators have been trained to take up the installation of biogas plants. Despite the efforts, potential and advantages of biogas technology in Zimbabwe, Mutsvange et al. (2016) stated low uptake of the technology and further reported partial adoption in households with biogas units. The reasons for this have never been adequately known and are yet to be documented.

Mshandete et al. (2009) proposed that the use of improved energy technologies in Zimbabwe has often been unsuccessful especially in rural areas. This is largely because most households do not adopt the technologies at all, and if they do, use them in ways that do not achieve the sought after level of reductions in fuel wood use and the subsequent harmful emissions. Hivos (2012) maintained that the challenge of ensuring successful uptake and proper use of improved energy technologies such as biogas in rural households of Zimbabwe stems from the twin failure of both adoption and implementation. Adoption in this context refers to the decision to acquire the new technology, while implementation refers to the households' actual use of the new technology (Karakezi et al. 2008). According to Barnes et al. (2006) these failures stems from a misunderstanding of households' decision making processes (around improved technology adoption), which are grounded in the livelihoods of the people, the social, political, cultural, economic and ecological dimensions of energy security, as well as access to alternative sources of energy to meet energy supply and demand. Biogas technology uptake and use in rural Zimbabwe could be limited by some or all of these factors. It is in the interest of this study to further investigate these factors.

2.4 Level of awareness and attitude towards biogas technology

Abdulkarim et al. (2013) cited that choice of energy sources depends largely on three major factors with knowledge on available types of energy being one of the factors. They further concluded that options of renewable energy available have to be effectively communicated to people with a view to keep them well appraised of the options they can choose from. According to Obwogi (2014), studies carried out in most parts of Africa have revealed a high degree of ignorance with regards to biogas technology particularly in Southern Africa. This stems from the observation that of all the installed small scale biogas plants in the region, over 50% of them have since been abandoned while a shocking 70% of the rural populations confessed total ignorance of the technology. Thus there is obviously very little awareness and utilization of biogas technology in the region. This is irrespective of the impression that biogas is widely known and utilized in other parts of the world (Parawira et al. 2014). In East Africa, Murphy (2014) lamented limited awareness of the availability, benefits and opportunities of biogas technology within the public domain particularly those residing in rural areas.

In Zimbabwe, despite the need to heavily promote biogas technology it is not certain if the general populace is fully aware of the technology and how it works. Mlambo (2016) content that, while some households are well aware of the technology as a best alternative to carbon based energy sources, the majority have never heard about the technology at all. In addition the few who are aware of it lacks sufficient knowledge on the positives of the technology hence some misconceptions and misperceptions attached to the technology. In this regard (Mlambo 2016) recommended that the mis-perception and mis-conception of people and their fear of biogas and its usage need to be adequately addressed so that the cultural use of fuel woods can be reduced to a minimum. Also, the assumption is that level of knowledge determines attitude and influences decision of household heads. This research henceforth seeks to establish level of awareness and attitude of people of Domboshava Ward 4 towards biogas technology.

2.5 Determinants of household energy choice and usage in rural areas

A number of studies have been carried out to identify major issues shaping the environment in which households make their decisions and choices to energy use. Such an environment can be referred to as the 'household decision environment' which represents a complex and interactive web of factors that influence behaviour (Campbell et al. 2003). Gallagher (2004) further added that literature has shown times without numbers the need to look beyond income to explain household energy choices, suggesting therefore that other than household level of affluence there are other underlying factors that influence household's choice to use a certain type of energy and in the interest of this study biogas technology.

However, income is commonly used as an indicator to distinguish households from each other and also one of the most important influencing factor related to energy choice in a household setup. A study conducted by Wayuan and Zarriffi (2008) in Bangladesh revealed that increasing levels of household income tends to result in decreasing share of biomass in total household energy consumption. The study further revealed that as income increases, many households do not only increase consumption of fuel, but they also use multiple fuels. Barnes and Qian (1992) are of the view that as income increases wood fuel does not disappear completely as households continue to increase its use thus reflecting the utility of these fuels in households. Davies (2008) asserts that irregular and variable income flows (derived from agricultural work or informal selling of goods) prohibits regular consumption of modern energy and restrict fuel transition. These results are in line with the expectation that households with a stable regular income are better able to rely on and consume commercial fuels (Barnes and Qian 1992) and in this case LPG and electricity. With regards to biogas technology adoption, a study in Pakistan by Iqbal et al 2013, revealed that family income was a primary factor influencing the decision to adopt biogas by household heads.

Human capital is also an important asset and refers to the quantity and quality of labour available in the household, including educational level, knowledge and skills. According to

Wang et al. (2012), in China biogas technology adoption is affected by family size, education level, knowledge and awareness. Education is seen as an important determinant of energy choice in a household. Studies in Kenya indicated a profound positive effect of education on the probability that educated household heads use modern commercial fuels such as LPG, electricity and Kerosene (Pundo and Fraser 2006). Wayuan and Zarriffi (2008) explained that when resident's education level is higher, they use less biomass or more commercial fuels because of the increasing opportunity cost of biomass collection. Whalekwa et al (2010) further added that a highly educated woman is likely to lack time to collect firewood and may therefore opt for firewood alternatives. Opportunity cost of time becomes an aspect of concern to highly educated household heads and therefore affects their choice to use a particular type of energy. Besides this, education positively contributes to the level of awareness of the negative health effects of using biomass and charcoal (Wawa 2012).

According to Njenga (2013) large family sizes suggest that there is abundant labour available for firewood collection, which limits the need to move to modern fuels purchased in markets or new technologies of renewables. Rao and Reddy (2007) are of the view that larger households in developing countries let alone in rural areas are often related to lower incomes, hence amplifying their limited capacity to move to modern sustainable energy sources. Pundo and Fraser (2006) further stated that in order to feed and warm a large family one requires much more fuel. Thus using fuel wood is cheaper due to its lower consumption rate per unit of time compared to kerosene and LP gas (Sathaye and Tyler 1991), prohibiting large families to change their source of energy. Similarly (Martins 2007) contends that larger households are less likely to choose modern energy sources over solid fuels.

A study by Kabir et al (2013) in Bangladesh exposed household labour economy (division of labour) as an important factor determining household energy choice and usage. In this case women are often responsible for cooking and collecting firewood hence a high share of females in a family increases available labour for cooking and firewood collection. According to Kabir et al. (2013) this in turn reduces the need to abandon time-consuming fuel wood sources in a household setup. On the other hand, (Modi 2006) is of the view that women are most directly affected by the negative effects of firewood use and switching to other energy sources can improve their livelihood situation considerably. According to Modi (2006) a larger number of females in a household translate into a better bargaining position inducing therefore power over energy choices in a household. This was further cemented by Rao and Reddy (2007) who stressed that households headed by women are more likely to choose modern fuels over traditional sources of energy. This points to the assumption that women will choose energy types that improve their collecting and cooking conditions (Modi 2006). On a sad note though, according to Barnes et al. (2006) a large share of female headed households belongs to the poorest segments of society hence limited access and capacity to use modern sources of energy. Conversely, Ouedraogo et al. (2006) could not find an effect of the share of women in a family on fuel choice. According to Ouedraogo et al (2006) families with more female members or female headed households are more likely to use either solid fuels or a mix as their main source of energy.

Besides the above mentioned factors, age of the household head is another important determinant of household energy choice and use. Heltberg (2005) concluded that age of a household head can lead to two opposing effects. On the one hand age of the household head functions as an indicator for the life cycle of the household. The further a household moves up in its lifecycle, the wealthier it becomes and the more likely it has been able to accumulate financial assets, allowing them more financial freedom (Leach 1992). On the other hand, older household heads may be more conservative, restraining them to move away from their current practices (Heltberg 2005). It is from this point of view that Kroon et al. (2013) argued that a woman's age influences energy choice through loyalty to firewood so that the older the woman (when all factors are held constant) the more likely the household will continue using firewood. This was also found to be true by Wawa (2012) who demonstrated that older household heads prefer the use of solid fuels while non-solid fuels are more likely to be adopted by the younger household heads. Ouedraogo (2006) in a study carried out in Nigeria find a positive relationship between age and the use of conventional energy sources as the main source of energy for cooking. Several other studies attest to the notion that household age is key in making decisions on household energy choices and hence affects biogas technology adoption in rural areas.

Also, preference of a given type of fuel is another determinant of household energy choice. This can also be associated with a stronger attachment to indigenous culture and traditional cooking. Attitude of people influences the choice of household fuel in that some people believe that some fuels are faster than the others while some fuels such as the food cooked using charcoal has a tasty flavour (Israel 2006) and that some fuels are dirty to use and have low efficiency.

2.6 Efficiency and advantages of using biogas technology

Renewable energy technologies provides a wide range of advantages that can be harnessed and contribute immensely to addressing vital local and global development challenges (IMF 2009). Small-scale biogas digesters in particular have great promise to contribute to sustainable development by providing a wide variety of socio-economic and environmental benefits (Heltberg 2005). These among other things include diversification of energy supply, creation of domestic industries and employment opportunities, increased crop productivity and provision of clean household energy (Arthur et al. 2011). Other indirect benefits may include improved subsistence, increased food security, and income generation.

The use of anaerobic digestion to create biogas from cattle manure and other organic wastes can reduce GHG emissions in two separate ways as out forward by (Muriuki 2014). Firstly, when used in combination with a manure management system that stores manure under anaerobic conditions, it can prevents the release of methane (CH4) (a greenhouse gas) into the atmosphere. Secondly, biogas generated by the anaerobic digestion process can replace the use of fossil fuels that generate GHGs (Ken et al. 2005). According to Muriuki (2014), each year some 590-880 million tons of methane are released worldwide into the atmosphere through microbial activity. About 90% of the emitted methane is derived from biogenic sources, i.e. from the decomposition of biomass and the remainder is of fossil origin. Unlike fossil fuel combustion, biogas production from biomass is considered to be carbon neutral and therefore does not emit additional Greenhouse Gases (GHG) into the atmosphere .Biogas energy is therefore, a clean and renewable form of energy because of its environment friendliness allowing for efficient waste utilization and nutrient recycling (Bonnke 2014).

To further on, biogas digesters have come to symbolize access to modern energy services in rural areas. According to Kroon et al. (2013) biogas digesters are related to improved health and sanitation and yields significant socioeconomic and environmental benefits. Thus (Bonnke 2014) resolved that biogas technology is a versatile source of energy which meets several end uses such as cooking, lighting and power generation. A study by (Muriuki 2013) in Kenya revealed further that when used as a cooking energy, it provides better combustion than less efficient traditional energy sources like firewood. Lettinga (2004) attested to the notion that biogas technology is comparatively clean and hygienic mainly because bacteria causing disease and other pathogens are destroyed through anaerobic treatment.

Socially, Brown (2006) believes that biogas digesters contribute to improved health and reduction in medical expenditure by substantively reduce labour for women and indoor smoke and resultant optical and respiratory infections. Replacing firewood with biogas would have a positive effect on deforestation as well thus improving the local environments, ecosystems, problems with erosion and mitigate greenhouse gases (Brown, 2006). Bonnke (2014) concluded that, biogas offers many advantages in terms of health, cost, and sanitation at individual level. The absence of smoke in biogas eliminates smoke discomfort and significantly reduces health problems. Biogas is a convenient source of efficient fuel for domestic energy needs because it is cost effective and easy to use and maintain (Parawira et al. 2012).

Furthermore, developing and using biogas as alternative energy source for household delivers enormous advantages at national level. Parawira et al. (2012) is of the opinion that widespread implementation of biogas technology can meaningfully reduce deforestation and its results such as soil erosion, floods, climate change and degradation. Biogas also offers economical advantage for the nation by reducing domestic consumption of commercial energy as it enables the government to divert commercial energy for industrial uses and also subsequently saving foreign currency (Parawira et al. 2012). More so, it is an important point to note that the use of dung and human excreta as biogas digester inputs immensely helps to improve sanitation, reduce air and water pollution (Mshandete et al. 2009).

In the face of all these economic, social and environmental benefits of biogas technology (Lettinga 2004) is of the view that the benefits will be significant if uptake of the technology is accelerated. Yu et al. (2008) estimated socio-economic and environmental benefits of biogas digesters in China in a study which revealed a reduction of 45.59 x 106 tonnes of CO2 equivalent per annum between 1991 and 2005 in rural China and other related advantages as explained above. Up to date however, only a few studies have been done to assess and ascertain the said benefits in the African context. A systematic study to bring together and ascertain benefits of biogas digesters particularly in the Zimbabwean context is needed like never before. This henceforth partly forms the basis of this study from biogas technology user’s standpoint.

2.7 Challenges to biogas technology adoption in Africa

While it is true that the adoption of biogas technology has the potential to mitigate a wide spectrum of environmental problems and proffers many socio-economic benefits at household level, Omer and Fadalla (2013) attested that the number of biogas plants in existence in all sub-Saharan African countries is almost insignificant. Parawira et al (2012) is of the opinion that, the implementation of the biogas technology on large scale may be prevented or slowed down by a number of constraints grouped as political, socio-cultural, financial, informational, institutional, technical and training.

In sub-Saharan Africa Parawira et al. (2012) cited lack of a coherent biogas technology strategy and this is despite high prices of conventional energy types. He further cited that the main contentious problem of biogas acceptance in the region relates to economics and political will and many site-specific issues. These issues include dynamics of local perceptions influenced by personal, social and cultural beliefs, as well as internal conflicts, due to perceived environmental, social and ecological risks, that were aggravated by miscommunication and lack of understanding (Omer and Fadalla 2013).

In a study carried out for sub-Saharan Africa (Lettinga 2004) concluded that the investment cost of even the smallest of the biogas units is prohibitive for most rural households due to extreme poverty in the region. Ni and Nyns (2006) reported that biogas technology is more accepted by upper and middle-income small scale farmers in China. Ni and Nyns (2006) are of the view that the obvious effect of individual income is the ability to install a digester system and above all to maintain its operation. Thus according to Parawira et al. (2012) there is need for subsidy-led programmes which will be demand-driven and market-oriented to increase the adoption of biogas plants at household level.

In addition, lack of coordination among institutions and conflicting interests has been cited as other obstacles inhibiting good penetration of biogas technology into the African market (Laichena 1997). Similarly, Campbell et al. (2003) recapped that there are weak linkages between institutions involved in development and promotion of biogas technology thus making it difficult in decision making. Thus Amigun et al. (2008) maintains that most of the stakeholders involved have weak capacity to carry out their devolved functions due to inadequate information for planning and policy formulation as well as limited finances and human resources. Davidson (1992) is of the view that constant persuasion and active campaigns by fully resourced organisations can help reduce resistance to adoption of biogas technology.

Some potential users are reluctant to try biogas technology out of concern about sanitation. Use of human wastes and animal dung for biogas production and the subsequent digested sludge as a source of fertiliser faces cultural and health resistance in Ghana (Amigun et al. 2008). Even though the anaerobic digestion process naturally reduces the pathogen load, handling biogas feedstock particularly human excreta and using biogas slurry as fertiliser does pose some risk of infection (Brown 2006). Also, there is usually lack of enough supply of manure for efficient and sustainable biogas production. Parawira et al. (2012) revealed that liquid manure is preferred for most biogas plants, but households may not be accustomed to storing and handling it. People also find it difficult to collect, store and deliver fresh manure to the digester. Bonnke (2014) concluded that the effort of maintenance and control on biogas plants often does not meet the level of literacy skills of the rural populace. Therefore handling and storing manure for the digesters requires additional education and training to ensure sustainability. Also, problems include that animals must be penned for effective collection of animal dung and the initial costs for the required infrastructure may be deterrent (Parawira et al. 2012).

Lack of knowledge about biogas technology is often cited as a reason for non-adoption of biogas in some countries in Africa. In a study of biogas technology adoption in rural areas of Kenya, Bonnke (2014) observed that outside installation expenses, many consumers are hesitant to adopt the technology, thus reflecting a dismal lack of public awareness of the relevant issues. He stressed further that in areas where people have installed biogas plants, problems of bad quality of the installed units and poor operations and maintenance capacity of users have led to poor performance and even abandonment of biogas digesters. A survey in Zimbabwe of about 200 existing plants in 2007 reported only 97 out of 200 functional and 103 out not functional or never finished (Hivos 2012). According to the authors, major problems linked inadequate design and construction, poor maintenance and generally poor social acceptance. To date, this combination of factors has largely stifled the use of biogas technology in the country and Africa at large.

2.8 Knowledge gap

While a remarkable number of studies have been carried out on the feasibility of establishing a vibrant biogas sector in Zimbabwe, little has been done to document the advantages and challenges of adopting biogas technology at household level. In Zimbabwe, many studies carried out has been concentrating much on institutional biogas technology adoption side-lining household level and users perceptions on the technology. Also, previous studies and reports available have been focusing on institutional capacity and the promotion factors which includes marketing and coordination of stakeholders. However, institutional support services should have a direct link with public awareness hence the feeling that the promotion factor has never been fully explored by existing studies. In addition, since the technology has been faced with limited success in terms of uptake in rural areas, it is crucial to have a closer look at challenges of biogas technology adoption at household level in rural areas of Zimbabwe. Minimal analytical studies have carried out to ascertain people's attitude as well as level of awareness on biogas technology with particular reference to rural areas where there is acute challenge of renewable energy. As such, it is in the interest of this study to explore further and cover up gaps that were not addressed by other scholars.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research design

Research design refers to a blueprint or a framework mapping how the study is going to be conducted. Creswell (2009) defined a research design as a plan and procedure for research that stretches decisions from broad assumptions to detailed methods of data collection and analysis. Thomas (2010) wrote that a research design is a logic or master plan of a research specifying how all parts of the research study work together in an attempt to address research objectives. This research utilised mixed research design which combines both quantitative and qualitative research techniques, methods, approaches and concepts into a single study (Thomas 2010). Mixed research design offered the researcher a chance to compensate for in-built method flaws, capitalise on method strengths and offset inevitable method biases (Greene 2007). Thus the design assisted in obtaining complimentary data on level of awareness, efficiency of biogas technology in comparison with other sources of household energy and constraints to biogas technology use and adoption.

According to Yin (2011) qualitative research is a system of enquiry which attempts to gain an understanding of the underlying reasons and motivations for actions and establish how people interpret their experiences and the world around them. In this study, qualitative research was instrumental in gaining a clear understanding of people's views, attitudes and interpretation of the introduction of biogas technology in Domboshava. The approach also allowed the researcher to make an in-depth synthesis of variables related to adoption and non-adoption of biogas. Therefore, a combination of interviews, observations, document review and a questionnaire survey was employed. Interviews were directed to relevant key informants from stakeholders selected purposively because of the knowledge they are perceived by the researcher to possess. Similarly open ended questions were asked to both biogas adopters and non-adopters using a structured household questionnaire. These instruments were particularly instrumental in collecting data on factors that are affecting adoption of biogas technology among Domboshava residents, challenges and constraints being faced in adopting and using biogas and opportunities being realised by the adopters.

Furthermore, quantitative approach to data collection and analysis also played a critical role in the study. Quantitative research is premised on numeric expression of data, thus making it liable to statistical analysis (Creswell 2009). In this case, quantitative data was collected using closed ended questions within questionnaires. It involved measuring the frequency of fuel wood collection, quantities consumed per week, and changes of fuel wood consumption before and after biogas adoption. Moreover, quantitative research captured data on demographic characteristics of various households surveyed, awareness, attitudes and perceptions on adoption of biogas. Data collected from the field was then analysed to establish the level of awareness, efficiency of biogas from the users' perspective and people's attitudes on the technology.

In light of the above explanations, mixed research design was best suited for the study as it ensured that quantitative and qualitative data obtained from closed and open ended questions respectively, provided the much needed description and explanations for the problem under study. The approach allowed the use of both numbers and words in solving the problem as well as further combining inductive and deductive thinking (Creswell 2007).

3.2 Target population

Prabhat and Pandey (2015) referred to population as the totality of subjects or the entire cluster of people or objects that conform to a set of specifications that are of interest to the researcher. Consequently, target population has been defined as a unit of the population to which the researcher seeks to make inference (Yin 2011). With these definitions, the target population for the study was primarily biogas technology adopters in Ward 4 of Domboshava Communal area. These households were chosen by the researcher because they have first-hand information critical for making conclusions on challenges and opportunities that are arising from biogas technology adoption and use.

In addition, the researcher also targeted the Director of Renewable Energy from the Netherlands Development Organisation (SNV) and Project Coordinator of Environment Africa respectively. These are vital key stakeholders playing a critical role in the promotion of biogas in Zimbabwe. Information sought included challenges and constraints to biogas dissemination among rural communities in Zimbabwe, level of awareness and critical areas for improvement in the quest for sustainable energy in Zimbabwe. Moreover, Director of Environmental Projects from Environmental Management Agency (EMA) became of importance in acquiring information pertaining to the impacts of the current energy consumption patterns in Zimbabwe. Moreover, the Director of Environmental Projects from EMA was instrumental in providing information on major problems arising from over reliance on biomass as a source of energy among the rural communities.

The researcher also targeted the Department of Renewable Energy in Zimbabwe Energy Regulatory Authority. This was done in order to get insight and data on technical challenges commonly faced by biogas adopters and also policy framework guiding the use of renewable energy in Zimbabwe. Similarly, the chairperson of the Domboshava Community Development Association assisted to shed more light on why there is the need to shift from using biomass as a source of energy and also constraints restraining adoption of biogas technology among residents in Ward 4. Lastly, selected village heads and the Ward Councillor chronicled the problem of energy in Domboshava, problems arising from continued reliance on biomass, need for alternative energy sources and factors limiting adoption of biogas by many households in the area.

3.3 Sample size determination and selection

Sampling involves the selection of a number of study units from a defined study population. Polit and Beck (2008) defined research sample as a subgroup of a population from which data is collected and generalisations are made. Accordingly, total enumerative method (census) was adopted mainly because of the small number of biogas adopters in the study area. A census study is a survey of every unit, everyone or everything in a population targeted (Creswell 2013). According to Creswell (2013), if a study population is small or less in number, it is most preferable to do a census of everyone in the population rather than a sample. This approach has a high level of accuracy and provides a complete statistical coverage. As a result, 56 biogas adopters drawn from all villages making up Ward 4 of Domboshava Communal Area became the research sample. The use of a census study was indispensable as it allowed the researcher an opportunity to have an intensive study on the level of awareness, attitude, efficiency and challenges of biogas technology adoption and use from the adopter's perspective. The idea of sampling the whole of Ward 4 in Domboshava Communal area was influenced mainly by the realisation that biogas adopters are not found in only one village but are rather scattered in the entire Ward. Purposive sampling was used in the selection of key informants who participated in the interviews. These included Ward 4 Councillor, Director of Environmental Projects from EMA and Director of Renewable Energy SNV among other interview participants. These were critical informants in the research for example the Ward Councillor informed the researcher on the level of awareness and attitude towards biogas technology within the study area.

3.4 Research Instruments

3.4.1 Questionnaires

A questionnaire was designed and administered to 56 biogas adopters in Ward 4 of Domboshava Communal Area (Appendix 1). Prabhat and Pandey (2015) defined a questionnaire as a research instrument consisting of a series of typed questions serving the purpose of gathering information from respondents. The researcher opted for a questionnaire survey since it allows large amounts of information to be collected from a large number of people in a short period of time and in a relatively cost effective way. The questionnaire design consisted of both open ended and close ended questions ranging from information on household socio-economic characteristics, attitude and perceptions towards biogas technology, level of awareness in the community and efficiency of the biogas technology. Close ended questions collected data mainly on household sizes, level of education of the household head, age, and the number livestock owned per each household.

Similarly, open ended questions were crucial to the researcher as they give respondents freedom to freely express themselves (Gwimbi and Dirwai 2003) giving answers in their own words and be able to clarify issues pertaining to fuel wood shortages, options available and challenges of adoption and use of biogas technology. The questionnaires were self-administered to the selected households in order to give clarifications where needed. Respondents had the pleasure to fill questionnaires in any language they understand best, although the questions were all in English. In instances where respondents could not understand English, the researcher had to translate to Shona which is a local language in Domboshava.

3.4.2 Key Informant Interviews

According to Yin (2011) a key informant is a person with profound knowledge and experience with a particular phenomenon. Key informant interview has henceforth been defined as a qualitative in-depth discussion with a resourceful person who has profound knowledge of the issue in concern (Attride-Stirling 2001). The researcher opted for key informant interviews to supplement data obtained from questionnaires and partly due to its cost effectiveness and its strength of capturing empirical data in both informal and formal settings (Prabhat and Pandey 2015). Semi-structured interviews were contacted with various key informants using an interview guide consisting mainly of open ended questions (Appendix 2-7). Open ended questions were ideal for the collection of detailed and explanatory data on participants' opinions and preferences on energy, options available in Ward 4, Domboshava and their related environmental problems. Similarly, they were designed to capture information on respondents' attitudes and perceptions on the adoption and use of biogas.

Targeted key informants for the study included Director of Renewable Energy from Netherlands Development Organisation (SNV), Project Coordinator of Environment Africa and the Technical Adviser from the Department of Renewable Energy of Zimbabwe Energy Regulatory Authority (ZERA). Also the Chairperson of the Domboshava Community Development Association was targeted as an important key informant. Information with regards to technical challenges of biogas digesters was sought from the senior Technician of SNV and Hivos International. The researcher has to make prior arrangements through a mobile phone with the respondents and also introduce to them the objectives of the interview. This follows the realisation that some of the key informants are always busy and also to avoid fruitless endeavours in cases of absence.

The interview method adopted proved to be useful as it allowed one on one interaction with respondents allowing the researcher to read their behaviour, attitude and expressions towards biogas technology issue. Also the interview method was very flexible as it allowed the researcher to adjust questions and provide clarifications wherever it was needed. A note book was used to record answers to the interview questions and also the researcher has to use an audio recording device to capture the conversation. This was mainly to ensure coverage of the entire interview and make sure no data is missed.

3.4.3 Direct Observations

Apart from administering questionnaires and conducting key informant interviews, direct observations were used to evaluate the existence of the biogas plants, designs and inputs used to generate biogas. Observations also enabled the researcher to establish those households with functioning and non-functioning biogas plants amongst biogas adopters. Thus Yin (2011) pointed out that direct observations helps the investigator to observe things as they happens. The researcher was able to notice and approximate quantities of fuel wood piles at each household, distances travelled to collect fuel wood, vegetation cover in the area, storage, use and general handling of slurry from the digester. Observations enabled the researcher to bridge the gap between data obtained in questionnaires and that from interviews. A camera was used to capture some objects of interest to this study which include the biogas plants and piles of fuel wood. Moreover, direct observations were aided by an observation checklist (Appendix 8) that has been prepared by the researcher prior to the field work.

3.4.4 Secondary Data Sources

Secondary data refers to the information that has been collected for other purposes. The researcher targeted reports from various Non-Governmental Organisations promoting renewable energy to establish distribution of biogas plants in the study area, proportion of the population using traditional biomass for energy and the electrification rate in rural areas of Zimbabwe. The data can be historical or contemporary and can be qualitative or quantitative collected to serve other purposes thus De Vaus (2011) reiterated that the data requires adjustments and validation before put into use by the researcher. The researcher found secondary data sources useful in complementing primary data obtained through questionnaires, observations and key informant interviews.

3.5 Data Analysis and Presentation

Data analysis is a methodical application of statistical and logical techniques to describe, categorise, illustrate, summarise and evaluate data obtained from the field work (Yin 2011). All data collected in the field was organized and analysed based on the study objectives, thus a detailed statistical analysis was carried out to establish relationships between variables and draw conclusions. Descriptive statistics and qualitative content analysis were used to analyse findings from the questionnaire survey and interview response data respectively. In this case, descriptive statistical approach was useful in the conversion of qualitative data to frequencies, arithmetic mean and percentages. This was done by converting the qualitative data into numerical data through coding with numeric and string options available in the Statistical Products and Services Solution (SPSS version 20). Age, household size, education level, occupation and gender of the respondents were some of the variables coded for analysis. Percentages, frequencies and arithmetic mean were therefore calculated to make comparisons on socio-economic characteristics of the surveyed households. Chi-square tests of significance were also carried out to determine relationship between biogas adoption, employment status, level of education and affordability of biogas plant installation. The data was then presented in the form of tables, graphs and pie charts.

Similarly, qualitative data from interviews, observations and open ended questions were also converted into meaningful descriptive information using qualitative content analysis approach. Content analysis involves coding and categorising of verbal or behavioural data in a manner that differences and similarities can be recognised. In this manner, the researcher had to firstly arrange text data with the same meaning and then encode them with numeric values. SPSS and Microsoft excel was then used to generate relationships, frequencies, percentages of the data.

The analysis targeted expressions, attitudes and perceptions of the respondents and the key informants as obtained during data collection. Thus data obtained through qualitative means was used to explain factors that influence adoption and use of biogas as well as challenges and constraints to biogas technology adoption among rural communities. Analysed data was then presented in the form of pie charts, tables, bar graphs and frequency tables generated from Microsoft Excel and SPSS.

3.6 Ethical Considerations

Ethics refers to a set of acceptable moral principles developed by individuals or groups to govern conduct of a research with particular reference to sample population and other stakeholders involved (Gwimbi and Dirwai 2003). Thus Yin (2011) postulated that the research should be designed, undertaken and reviewed to ensure integrity and quality. Accordingly, the researcher acquired permission first from the Netherlands Development Organisation (SNV) which is a key institution implementing biogas projects in Domboshava. This was done at the same time as seeking permission to include their personnel as respondents as well. More so, arrangements were made with interviewees prior to the interview for approval. The researcher find it imperative to seek permission of entry in the area from the Ward Councillor and Village Head prior to data collection.

Furthermore, prior to participants' engagements, the researcher had to obtain a consent letter from the Department of Geography and Environmental Studies which highlighted research information as well as asking for permission from the targeted participants. Confidentiality remained a priority in the research and rights to self-determination, anonymity and informed consent were keenly observed throughout the research. In this manner, the researcher had to explain and guide participants in completing questionnaires basing on the realization that some of the participants could fail to understand well some of the terminology used. Further, no name of the participating household appeared on the questionnaire. For semi-structured interviews, permission was sought first and upon agreement the researcher had to stress the purpose of the research first before engaging in asking questions. Scientific honesty was highly observed by clearly recording answers from the informants honestly without manipulation.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Response rate

The study targeted a research sample of 56 households who have adopted biogas technology in Ward 4 of Domboshava Communal Area. However, 45 questionnaires were successfully administered yielding a response rate of 80%. The remaining questionnaires could not be administered owing to incessant rains which coincided with field work and hence some households could not be accessed due to a flooded stream. In addition to the remaining questionnaires, three household respondents could not respond to the questionnaires as they cited political insecurity and kept on saying they are not fully convinced with the aim of the research. Nonetheless, Mugenda (2003) cited that a response rate of 72% and over is considered very good and adequate for analysis and reporting. In light of this assertion, 80% response rate is therefore excellent and satisfactory to make conclusions for this study.

Table 4.1: Number of targeted households and response rate per village

Villages	*Number of targeted households*	*Number of questionnaires issued*	*Response rate*
Parirehwa	14	14	100%
Chirodza	11	9	82%
Zimbiru	7	5	71%
Chogugudza	4	4	100%
Chinamhora	6	4	67%
Murape	12	7	58%
Mungate	2	2	100%
Total	**56**	**45**	**80%**

4.2 Characteristics of the household respondents

Table 4.2 gives a summary of demographic and socio-economic characteristics of the sampled population within the study area. The researcher considered these characteristics due to their supposed influence and linkage with biogas technology adoption (Wawa 2010). Further, these characteristics were subjected to a detailed descriptive analysis in section 4.4 with a view to examine their influence on the adoption of biogas technology in Ward 4 of Domboshava Communal Area.

Table 4.2: Demographic and socio-economic characteristics of the respondents

Variable	Frequency	Percentage %
Gender		
• Male	24	53.3
• Female	21	46.7
Age		
• 21-30	6	13
• 31-40	11	24.5
• 41-50	18	40
• 51-60	7	15
• 60+	3	6.6
Education		
• Primary	2	4.4
• Secondary	31	68.9
• Tertiary	11	24.5
• None	1	2.2
Household Size		
• <4	8	17.8
• 5-7	18	40
• 8-10	18	40
• >11	1	2.2
Main source of livelihoods		
• Formal employment	12	26.7
• Farming	16	35.5
• Casual labour	15	33.4
• Pension	2	4.4

Results in table 4.2 indicates that most of the households with biogas digesters (53.3%) are male headed compared to 46.7% female headed households. Furthermore, the results also shows that all the respondents were above the age 20 years (Table 4.2). This implies that most of the people adopting biogas technology are within the economically active age group mainly ranging from 31 years to 60 years old.

Education level of the respondents was also considered as it relates to level of awareness and capacity to access information. Results from the study show that almost all questionnaire respondents were literate with 93% have reached at least secondary level education. On household size, the research established that many household respondents had family sizes above five members (82.2%) with those with family members less than 4 claiming on 17.8% of total respondents. Large households implies labour availability for the operation of the plant and for casual labour hence capacity to meet costs of biogas plant construction.

Further, the results indicate that a considerable number of respondents (35.5%) are surviving on farming as their main source of livelihoods. This comes not as a surprise since Domboshava area is known for intensive small scale farming specialising particularly in vegetable production (Dailynews 2014). In addition, the general trend however as indicated in Table 4.2 is that respondents are almost equally distributed between formal employment, casual labour and farming while very few (4.4%) mentioned pension as their main source of livelihood. With farming being one of the key sources of survival for the people in the study area, biogas technology is hence forth promising and very suitable for the area.

4.3 Level of awareness and attitude towards biogas technology

Knowledge and awareness towards a certain technology may have an influence on its adoption. By measuring level of awareness and understanding of biogas technology by users in the community helped the researcher to ascertain the future of the technology in terms of continuous use and adoption by households in Domboshava. To do this, the researcher initially identified channels of information pertaining to biogas technology and then assess the respondents' level of awareness on biogas technology usage and their opinion on general level of biogas technology awareness in Domboshava Communal Area.

Plate 4.1: One of the respondent explaining how a biogas plant works and is maintained
Source: Field Survey (March 2017)

4.3.1 Source of information about biogas technology

The study identified channels of information that had helped sensitizing the public on the importance, advantages and efficiency of the biogas technology. As indicated in Figure 4.1, NGOs (33.3%) and existing biogas adopters (friends/neighbours) 40% served as the main sources of information about biogas technology. Only 13% of the biogas users have heard about the technology from government while less than 12% mentioned media publications. This relates to the findings of (Wawa 2010) in Tanzania where she acknowledged that NGOs are more active than government in the promotion and awareness raising of biogas technology. In addition, existing biogas users with the largest representation stands to be tools for biogas technology promotion and use in Domboshava. Muriuki (2014) highlighted that potential users are able to see the real benefits derived from biogas technology and thus inspired to replicate. The role of media (12%) is not much visible given location of the study area in the outskirts of urban areas which hence inhibits access to information and media publications. The Project

Coordinator from Environment Africa revealed that, in as much as media and other communication lines are critical in raising awareness, the public also requires demonstrations hence most adopters are finding it easy to learn from their neighbours and friends. He further elaborated that most renewable energy programmes communicated through media are not accessible to the poor people in rural areas. Asked to comment on sources of information on biogas technology in Domboshava Communal Area, the Ward 4 Councillor highlighted that the media has minimal role to play given the rural set up of the area. She revealed that many people are engaged in agricultural activities during the day and when they come back home in the evening they are tired to give attention to a radio, reading a newspaper or watching television. How, she appreciated the role of NGOs for raising awareness as well as pioneering construction of biogas digesters where other potential adopters are replicating from.

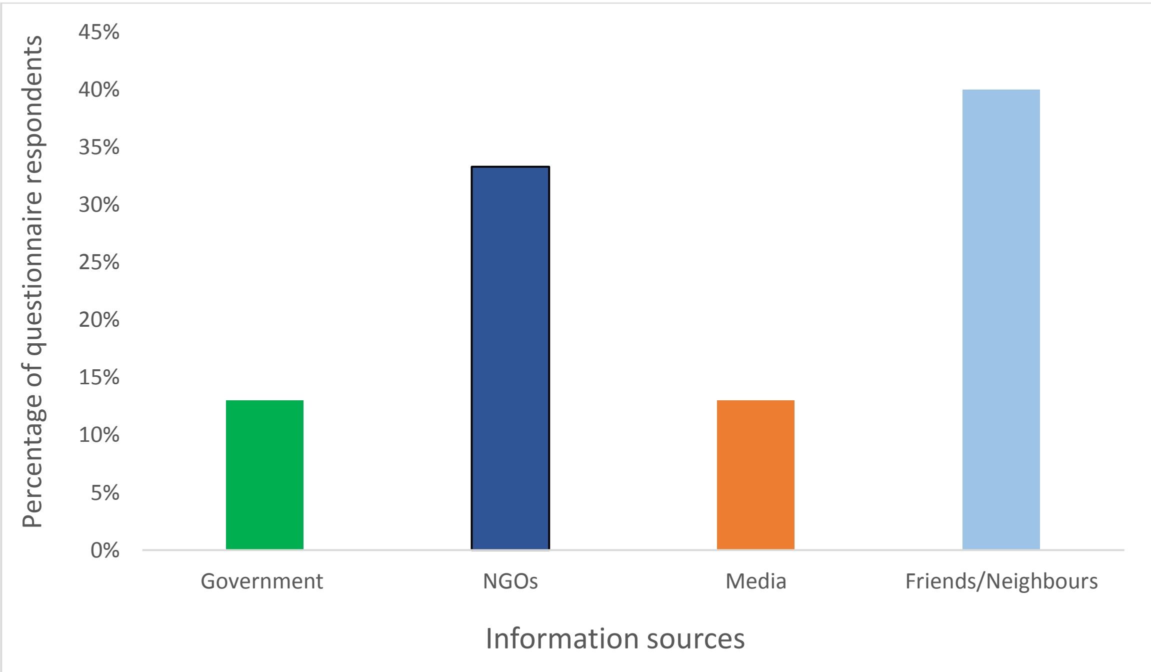

Figure 4.1: Sources of information on biogas technology in Ward 4 of Domboshava Communal Area

4.3.2 Awareness on biogas technology

Furthermore, to ascertain the general level of awareness on biogas technology in the study area, the researcher learnt from the biogas technology adopters themselves. In this regard, respondents were asked to specify whether people are well aware of biogas technology or not. A statement claiming that people in Domboshava are well aware of the biogas technology was designed for respondents to answer. The responses were based on a five point Likert scale rated as; Strongly agree with a score of 1; Agree with a score of 2; Undecided with a score of 3;

disagree with a score of 4 and lastly strongly disagree with a score of 5. The items were presented to the respondents whose responses were analysed and presented in Table 4.3.

Table 4.3: Responses on the level of awareness on biogas technology in Ward 4, Domboshava

Level of agreement	Frequency	Percentage
Strongly Agree	4	8.9
Agree	6	13
Undecided	10	22.2
Disagree	25	55.6
Strongly Disagree	0	0

The findings in table 4.3 reveal that a few of the adopters' neighbours, friends and relatives in the Domboshava community are well appraised of biogas technology. Most household respondents (56.6%) were in disagreement with the statement that people in Domboshava ae well aware of the biogas technology. In addition, while 22.2% of the questionnaire respondents are not sure (undecided) of the level of biogas technology awareness, only 13% holds to the view that people knows about the technology. However, it is not clear whether the knowledge encompasses both existence, operation, maintenance and efficiency of the technology since awareness of the existence of the technology does not point to the technical awareness of the technology itself.

Wawa (2010) proposed that awareness of biogas technology should encompass people getting to know finer details of the technology, that is; what it is, how it functions, its services and financial aspects for it to be able to influence people's decision on adoption. Thus, information on the level of awareness on biogas technology was enhanced by determining whether the respondents have ever attained any training, attended meetings or workshops before they adopted and started using biogas technology. In this regard, respondents were required to indicate yes or no and if yes further mention frequency they had attended meetings or received training.

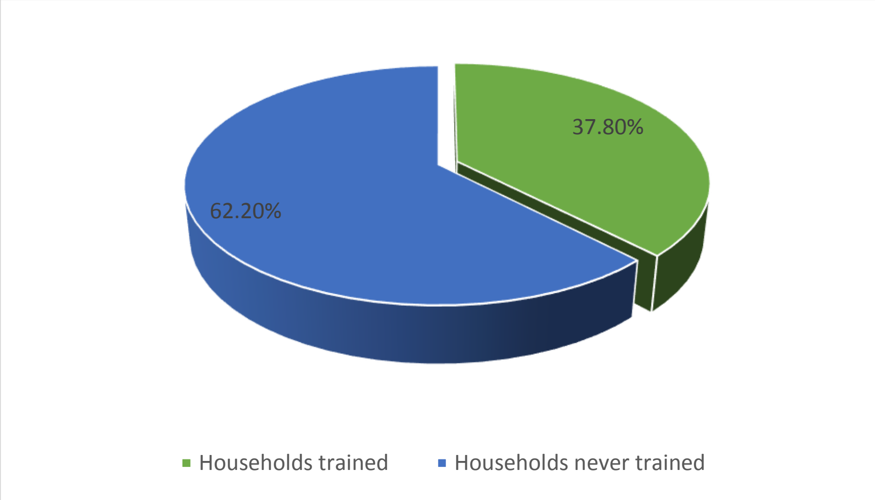

Figure 4.2: Proportion of trained and non-trained biogas adopters before biogas technology adoption

Findings from the study indicated that only 37.8% of the respondents had received training on biogas technology (Figure 4.2). The other 62.2% of the respondents indicated that they have never received some form of training or attended a meeting on biogas technology. This relates with the discovery that a substantial number of the respondents have learned about biogas technology from their neighbours and/ friends. However, the implication of the result is that biogas adopters who have never attended meetings or receive some form of training on biogas technology may fall short of the adequate knowledge on the benefits, operation, maintenance and services offered by the technology hence low awareness.

4.3.3 Attitude towards biogas technology

The researcher contents that awareness level influences people's perception towards a new intervention brought to the community. According to Abkhuzam and Lee (2010), attitude is an important element in the implementation of a new project and can be a strong activator or an obstacle towards full realisation of the expected goals. In this regard respondent's attitude towards the use of biogas technology was examined by asking respondents to respond to a set of statements inclined to various positive aspects of biogas technology. The underlining position of the researcher was that if respondents find biogas technology useful, they will automatically have a positive attitude towards the technology. Thus, agreement to the statements asked was taken to infer positive attitude while disagreement points to negative attitude. Statements developed measured attitude based on whether respondents strongly agree, agreed, disagreed or are undecided to the statements raised. Questionnaire respondents have a positive attitude towards biogas (Table 4.4);

Table 4.4: Respondents attitude towards biogas technology

Statement	SA	A	UD	D
1. Biogas will reduce the rate of deforestation	**15** (33)	**25** (56)	**4** (10)	**1** (2)
2. Biogas will relieve women workload	**7** (15)	**16** (36)	**15** (33)	**5** (11)
3. Biogas will save time spend on fire wood collection	**12** (27)	**20** (44)	**8** (18)	**4** (10)
4. Biogas will reduce inhalation smoke	**9** (20)	**11** (25)	**17** (38)	**9** (20)
5. Biogas technology will help improve soil fertility	**13** (29)	**31** (69)	**4** (10)	**0** (0)
6. Biogas is recommended as the best alternative energy source	**33** (73)	**9** (20)	**2** (4)	**1** (2)
7. Benefits of biogas overweighs its weaknesses	**5** (12)	**18** (40)	**13** (29)	**9** (20)

(Bolded figures indicates frequency and those in brackets is the percentage frequency)

Key: **SA** Strongly agree; **A** Agree; **UD** Undecided; **D** Disagree

The general trend indicated that, the majority of the technology users have a positive attitude towards biogas technology. Scores for strongly agree and agree are higher than those of disagree, undecided and strongly disagree combined together. This is a clear indication that overally respondents have a positive attitude towards biogas technology. However, further enquiries indicates that many people were not very sure (undecided) if the technology can help reduce smoke inhalation given higher frequency (38%) of neutral responses. Also, high frequency of neutral responses were noticeable on the ability of biogas to relieve women workload (33%) and outweighing its weaknesses (29%). This points to low awareness and the reason mighty be that adopters have not yet fully utilize all the benefits offered by biogas technology. However, on a general note, neutral responses could not dilute the general trend of a clear positive attitude towards biogas technology expressed by the household respondents.

4.4 Factors influencing adoption and use of biogas technology for household energy in Ward 4, Domboshava Communal Area

The uptake of biogas technology in Domboshava Communal area is influenced by a number of factors ranging from socio-economic and non-economic factors. Some of the factors are push factors while others are pull factors. All these factors combined plays an important role in determining the future of biogas technology adoption in Domboshava (Table 4.5).

4.4.1 Motivation for biogas technology adoption

Firstly, the questionnaire respondents were asked to give their main reasons behind acceptance and implementation of biogas technology. It was established that motivation from promoters and other users in the area, environmental, economic and health considerations were the main crucial factors mentioned. Results of the findings are summarised in table 4.5.

Table 4.5: Respondents' motivation for biogas technology adoption

Motivation	Responses		
	Frequency	(F) %	Rank
Motivation from promoters	41	91	1
Motivation from other biogas users	31	69	2
It cooks quickly	27	60	3
It save firewood	27	60	4
Provides clean energy	23	51	5
Health benefits	13	28	6
Environmental benefits	8	18	7
Non-availability of cheap fuel sources	4	9	8

Table 4.5 depicts that almost all the respondents acknowledged motivation from biogas promoters (91%) and biogas adopters (69%) as their main source of motivation for the adoption of biogas technology. This relates to the findings that friends and neighbours were also crucial sources of information in terms of awareness in Ward 4, Domboshava Communal Area. Ability of the technology to cook quickly, produce less smoke and the associated health benefits received an overwhelming support from 60%, 51% and 28% of the respondents respectively.

It is also worth note that only a minority (9%) were inspired by the non-availability of other cheap sources of energy. This points to the conclusion that despite availability of other types of energy, there would be other superior reasons for people to opt for biogas technology. When asked to compare their preference of biogas in relation to firewood, a substantial 48% of the respondents acknowledged that biogas does not produce smoke therefore creating a very friendly and healthy environment for cooking. A further 45% of the respondents reported their preference for biogas technology as a source of energy that offers multiple services other than energy for cooking.

In an interview, the Environment Officer for Goromonzi District from EMA argued that outside some inhibiting factors, people are lured into biogas technology because of the need to have an alternative source of energy which is sustainable, environmentally friendly and cost effective in nature. The results of the study are in agreement with studies carried out in Kenya where people's involvement in biogas technology was mainly due to the need to enjoy multiple services that it provides. According to Waqa (2012), about 30% of the users were motivated by time and energy savings, 45% provision of clean energy and 73% by economic reasons. In Ghana, improved sanitation was seen as the main motivating factor for the adoption of biogas technology (Wawa 2010).

4.4.2 Cost of biogas digester installation

The opinion of the biogas technology adopters on the cost of installing a biogas digester was tested to establish if installation cost was one of the factors influencing biogas technology uptake within the study area. In this regard, respondents were asked to respond to a question based on whether the construction of a biogas plant is cheap; reasonably affordable; expensive; or very expensive. Results obtained from the field were summarised and presented in Table 4.6.

Table 4.6: Views of the questionnaire respondents on the cost of biogas technology adoption.

Variables	Frequency	Percent	Valid Percent	Cumulative Percent
Cheap	0	0	0	0
Reasonably affordable	23	51.1	51.1	79.6
Expensive	15	33.3	33.3	93.5
Very expensive	7	15.6	53.6	100.0
Total	108	100.0	100.0	

From the results obtained in the field, while a significant number of respondents (45%) are of the view that the installation process is reasonably affordable, at least 63% contends that it is expensive. According to the Chairperson of DCDA and the Director of Renewable Energy from SNV, estimated cost of installing a domestic biogas digester and its appliances ranges from US$600.00 to US$ 1500 depending with the size of the plant. A huge percentage of questionnaire respondents seeing biogas technology as expensive is expected of the rural communities given their sources of money and livelihoods. A substantive number of household heads expressed that the cost of acquisition and installation of the technology was high and they find it very difficult to raise the required funds in time. This implies that cost of biogas technology is an important influencing factor with high initial cost of installing the technology being a limiting factor in Ward 4, Domboshava. This is also related to an observation by Barnes et al (2007), who finds out that in most developing countries high initial costs of access to modern energy sources are often exorbitant and inhibitive for poor rural populations. The results therefore indicates that while biogas technology maybe expensive as expressed by the biogas adopters, people are motivated by other factors superior than the expensive nature of the technology. The general conclusion being that while installation costs are comparatively high, the long term benefits overrides the initial costs. However, it should not be forgotten that the cost of biogas construction may be a barrier towards its adoption in rural communities as said by (Barnes et al 2007).

4.4.3 Socio-economic characteristics of respondents and biogas technology adoption

The researcher considered socio-economic characteristics of the household respondents as one of the factors having an impact on the decision to adopt biogas technology in Domboshava Communal Area. Resultantly, a study was carried out on various demographic and socio-economic aspects of the respondents which include but not limited to gender, age, family size, education level and employment status.

i. Gender of household respondents

Gender of the household heads was considered important as decision making and priorities varies between male and females in a household setup. The research findings in Table 4.7 reveals that male headed households (53.3%) embraced biogas technology more than female headed households (46.7%).

Table 4.7: Distribution of respondents based on gender

Sex	Frequency	Percentage
Female	24	53,3%
Males	21	46.7%
Total	**45**	**100%**

The higher proportion of males adopting biogas technology may be attributed to patriarchal system in most societies where men are the household heads and hence dominate in decision making processes. Equally important is the proportion of females at 46.7% and their presents might have been caused by deaths, unmarried women or divorced women. This study was carried out in light of gender responsibilities and involvement in energy activities at household level which is assumed to have an impact on decision to the adoption of biogas technology.

Interview with Ward Councillor and the Chairperson of the Domboshava Community Development Association (DCDA) confirmed that women are the ones mainly responsible of ensuring availability of household energy compared to men. However, it was revealed that decision making with regards to biogas adoption is mainly done by men. This is in line with the findings of Ngwandu et al. (2009) who indicated that traditionally men dominates decision making and ownership of resources. This implies that if men are not convinced, chances of adoption are limited. Findings from the interviews further implies that women being responsible for the provision of household energy, may be willing to adopt biogas technology as an alternative source of energy, but unfortunately the decision is finalised by men who are not directly affected by energy problems as much as women do.

The Director of Renewable Energy from SNV during an interview stressed that men are usually the ones attending to village meetings, seminars and workshops. The implication of this is that women are less knowledgeable about the technology thus lack of confidence and interest on the technology. Since the results indicated an almost fair distribution of both sexes, it is therefore evident that outside the dominating factor of men, women have a higher chance of making positive decision on biogas technology.

ii. **Age of household respondents**

The researcher was of the view that age variation is an important aspect that have a bearing on the adoption and usage of biogas technology. This is so because various age groups in a population are engaged in different economic activities for example aged people are the ones normally found in rural areas engaged in agricultural activities while economically active people migrates to urban centres for employment opportunities. In light of this, respondents were asked to give their ages and results are illustrated in Figure 4.4.

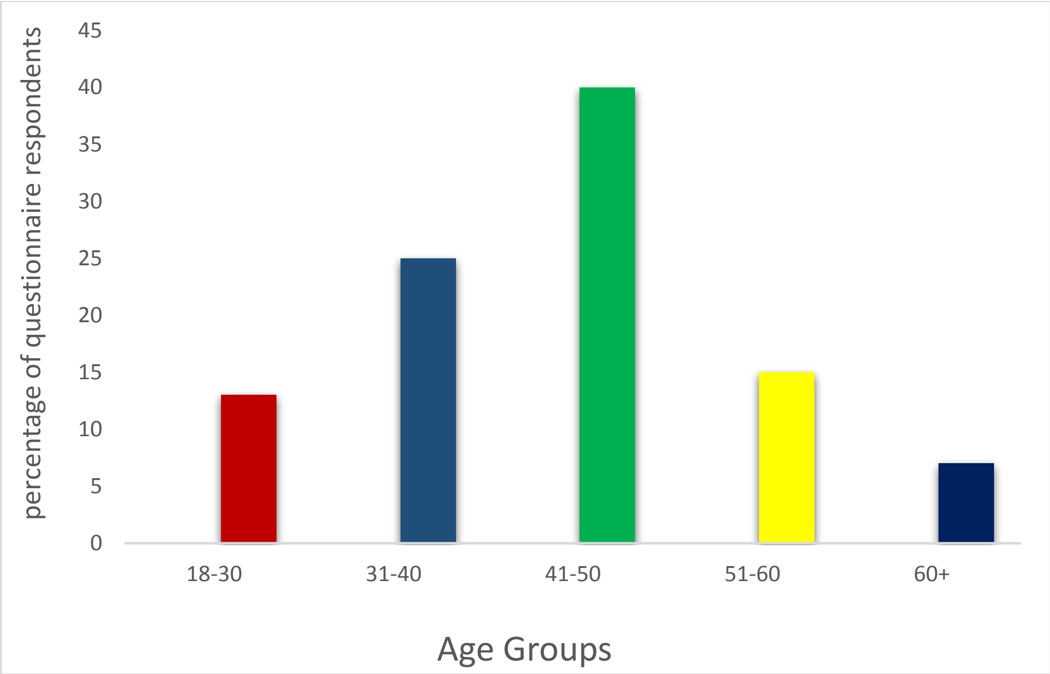

Figure 4.3: Age distribution of respondents

Figure 4.3 reveals that many biogas technology adopters are within the economically active age group (31 – 60 age groups combined) while the aged and youthful were very few. The youthful (18-30 years) had 13% frequency while the elderly; above 60 years (6.6%) seems uninterested in the new technology as indicated by lower percentages. More biogas adopters are in the age group 41-50 and 31-40 years and this can be related to the argument that this is a productive age in the society comprising of people who are likely to be employed in the formal and informal sectors and hence can afford installation costs of a biogas plant. Wawa (2010) in a study in Tanzania, reasoned that high frequency of biogas technology adopters who are above forty years of age is mainly because of financial stability. She supports the notion that the further a household moves up in its lifecycle, the wealthier it becomes and the more likely it has been able to accumulate more financial assets as put forward by Leach (1992). This is the same trend revealed by this study in Domboshava.

While young people may be in schools still pursuing education careers and employment opportunities, elderly people of the community may be reluctant to take risks and hence lower likelihood of them embracing the new technology. Very older people are considered to be very conservative and may not easily leave their old way of cooking opting for new technology. And also young couples may not yet have establish their households sufficiently well to experiment in new technology. The age trend indicated in fig 4.4 relates to the conclusions made by Sufdaret et al (2013), who reported that the likelihood of biogas adoption increases with age up to around 60 years where descending of the probability begins. This is also anchored by the findings of Ouedraogo (2006) who find a positive relationship between old age and the use of conventional energy sources in Nigeria.

iii. Education level

More than often, education level detects how individuals access information, internalise new interventions and of course embrace new technologies. As a result, education level for the household heads was found paramount by the researcher and hence investigated to ascertain its influence on biogas technology adoption. The results in Figure 4.4 indicates that the majority (68.9%) of household respondents in the study area attained secondary level of education with a few (24.5%) highly educated up to tertiary level. Very few household heads (4.4%) mentioned primary level education as the highest they attained and this may correspond with the age of the household heads who may be in 60 years and above age bracket. The researcher discovered that these aged respondents attended "standard school" which can be considered equivalent to primary school education. The general trend indicates that many household heads who have adopted biogas technology in the study area are literate with over 93% of them having at least attained secondary education. The assumption however is that, even those who attained primary level education only have the requisite capacity to know the importance of biogas technology and hence adopt it accordingly. The conclusion from the results is that education level is an important influencing factor on biogas technology adoption. Results of the study are similar to those of (Ndereba 2013) who confirmed a positive link between education and biogas technology adoption. Mary et al (2010) further postulated that low levels of education affects adoption of biogas technology negatively as it affects ability of people to interpret and perceive information and hence they remain ignorant of the new trending interventions.

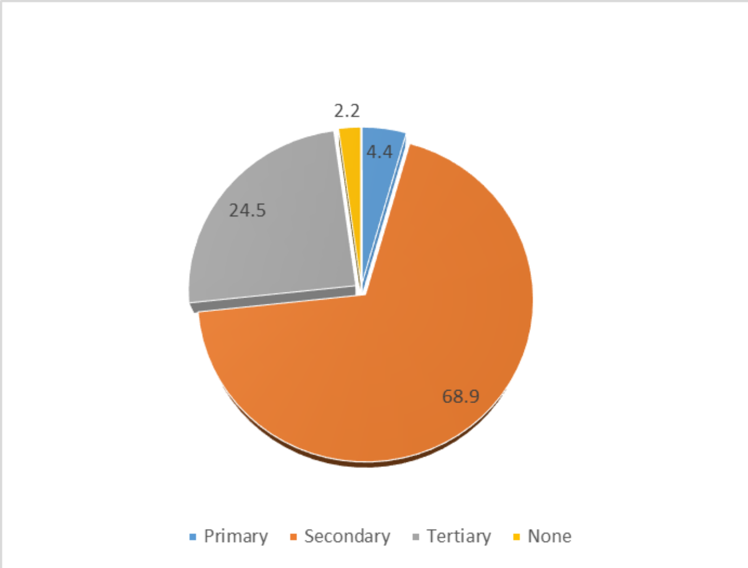

Figure 4.4: Level of education attained by biogas technology adopters in Ward 4 of Domboshava Communal Area.

The research findings were further augmented by semi-structured interviews carried out with various stakeholders involved in the promotion of biogas technology in Zimbabwe. In an interview with the Director of Renewable Energy from Netherlands Development Organisation (SNV), it was revealed that a literate person is better placed to adopt biogas technology since he/she is able to understand technical language than an uneducated person. All interviewed stakeholders from Environmental Management Agency (EMA), Environment Africa and the Ministry of Energy and Power Development (MoEPD) strongly felt that literacy puts one in a better position to adopt biogas technology. Interestingly though, it is critical to mention that the research findings contradicts those of Walekwa (2010) who postulated that biogas technology is viewed as the technology of the poor by highly educated people in Uganda.

iv. Employment status

The respondent's employment status was essential for the researcher to understand how households of varying economic statuses respond to biogas technology thus testing if employment status of household heads influenced decision to adopt biogas in Ward 4, Domboshava. As a result, respondents were requested to indicate their employment status (Figure 4.5).

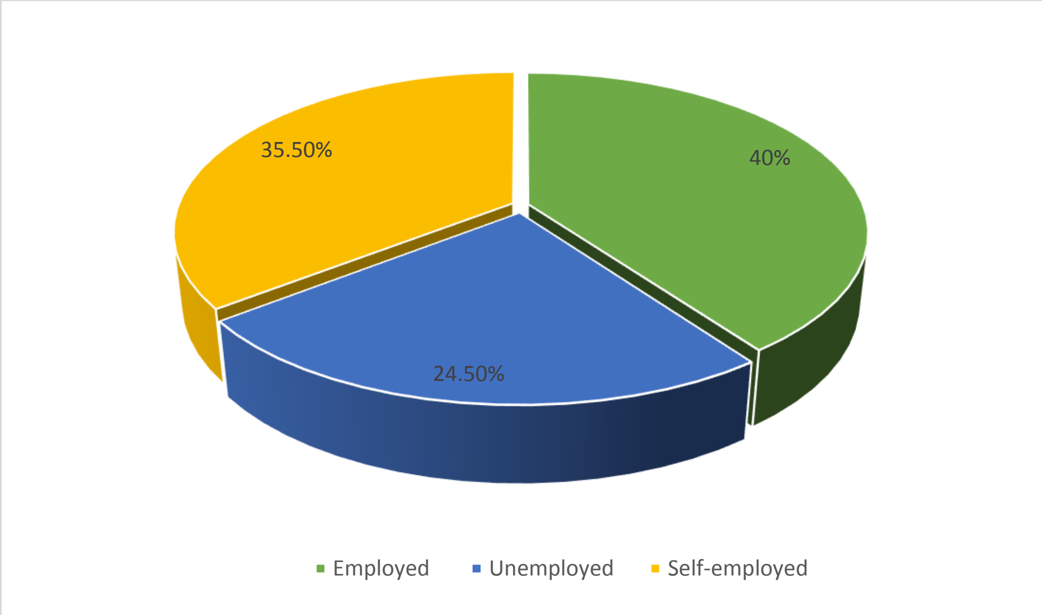

Figure 4.5: Employment status of the respondents

Findings from the study sample established that a larger segment (40%) of the population was employed formally while 24.5% are unemployed. A further 35.5% of the sampled respondents indicated that they are self-employed.

Table 4.8 : Chi-Square test results for employment status and affordabitity of initial costs of a biogas plant

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	48.962[a]	4	.000
Likelihood Ratio	55.587	4	.000
N of Valid Cases	45		

4 cells (44.4%) have expected count less than 5. The minimum expected count is 1.71.

Chi-square test results revealed that there is a relationship between employment status and affordability of installing a biogas plant (p=0.000) (Table 4.8). This indicates that people who are employed are better positioned to adopt biogas technology in Domboshava than those who are unemployed. Employed household heads can afford initial installation costs of biogas technology and also they are advantaged in terms of access to information when they migrate to various urban centres in pursuit of their occupations. Equally important is the significant proportion of household heads who are not employed (24.5%) but still adopted biogas technology. This can be explained in terms of main source of livelihood which can be farming.

Ngoroje (2009) established that in Kenya a larger proportion of biogas adopters depends on farming as their main source of livelihoods hence a higher likelihood of them adopting biogas. Chances are also high that those unemployed are the aged and retired members of the community who might have settled and invested already. The general observation is that employment status of a household head in Ward 4 of Domboshava is not a major influencing factor of biogas adoption since both the employed and unemployed have fairly equal chances of embracing biogas technology.

v. Main source of livelihood

To get more information on the determinants of biogas technology adoption, the researcher find it imperative to investigate further on the main sources of livelihoods for the respondent households (Table 4.8).

Table 4.9: Main source of livelihoods for the respondents

Variables	Frequency	Percent	Valid Percent	Cumulative Percent
Formal employment	12	26.7	26.7	69.4
Farming	16	35.5	35.5	84.3
Casual labour	15	33.3	33.3	98.1
Pension	2	4.4	4.4	100.0
Total	45	100.0	100.0	

Table 4.8, shows that a larger segment of the sampled population (35.5%) cited farming as their main source of livelihood while only 26.7% indicated salaries. While a larger proportion of the population maybe employed as indicated in Figure 4.5, it is understandable that the majority cited farming as their main source of livelihood given the current economic hardships in the country and also given that Domboshava is in a rural setup known as a hotspot of intensive small scale farming. Wawa (2010) established that slightly more than half of non-biogas adopters in Ghana depended sorely on salaried employment as their main source of income, suggesting therefore that farming might be a major enabler of biogas technology adoption than employment. Casual labour scored higher (33.3%) than salaried employment emphasising therefore that formal employment is not a major and only influencing factor driving adoption of biogas technology in Ward 4 of Domboshava Communal Area.

vi. Household Size and biogas adoption

The researcher assumed that size of a household would have a significant influence on the adoption of biogas technology since different households' sizes may require energy in a different manner. As a result, the respondents were asked to state their household sizes (Figure 4.6).

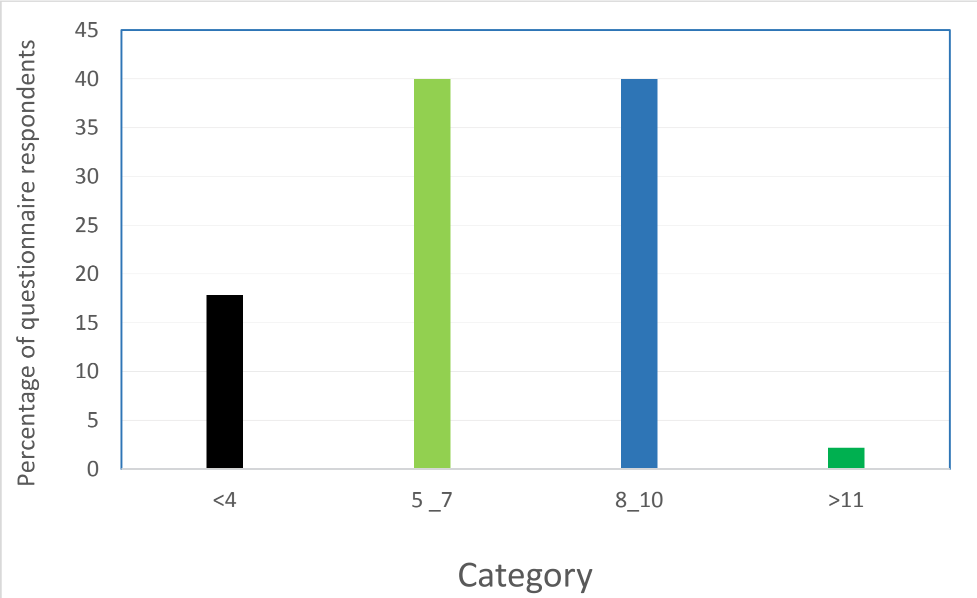

Figure 4.6: Household sizes of sampled biogas technology adopters in Ward 4, Domboshava Communal Area

Figure 4.6 reveals that households with many family members 8-10 (40%) embraced the technology than small families of less than 4 family members with a proportion of 17% only. Equally important is the range 5-8 which also scored higher (40%) in comparison with the <4 category. However, only 2.2% of the respondents had family members going beyond 11 members. The general impression as indicated by figure 4.6 is that larger households are embracing biogas technology more than smaller families in Domboshava. This can be explained by labour availability for the plant operation in terms of daily plant feeding, cow dung collection among other things. Also, because of division of labour, larger families may have their family members engaged in informal contracts and various income generating activities hence availability of disposable income to meet costs of biogas plant installation. However, the results are not in tantrum with those of Ndereba (2013) in Tanzania where biogas technology uptake was found to be greater in households with fewer members. She further argued that small households have more disposable income than larger families which may need more money to send their children to school and meet other needs for more people.

4.5 Effectiveness of biogas technology

The researcher assessed the effectiveness of biogas technology from the users' perspective and in relation to other sources of energy particularly fire wood. Effectiveness of the technology was assessed in terms of its sufficiency in meeting daily household energy needs as well as reducing time spend sourcing fuel wood. Benefits accruing from using biogas technology were also used as another important attribute giving biogas technology an upper hand over other locally used sources of energy. In this regard, biogas adopters were asked to rank services they get from using biogas. Also, respondents were asked if biogas technology was the best alternative source of energy in Ward 4, Domboshava Communal Area.

4.5.1 Adequacy of biogas for daily energy needs

Questionnaire survey results revealed that few adopters (32.2%) stated that biogas produced from their digesters was enough for their daily energy needs, whereas the majority (67.8%) pointed on its inadequacy. The difference is agreeable given that adequacy may vary with household size. Most households mentioned that they still need to supplement their biogas plants with other energy types and the majority showed that they are still using firewood to supplement biogas (Fig 4.8). Asked to qualify the continued use of firewood and other energy sources, respondents were quick to mention inadequate power due to little gas produced and inability to last for long. Furthermore, interview with the Chairman of DCDA revealed that the cookers were small to support large cooking utensils required for larger families (Plate 4.1). As a result, it was reported that fast cooking with biogas is only possible for simple meals like porridge, vegetables and tea. For heavy meals and especially for larger families, most biogas technology adopters are reportedly resorting to firewood.

Interviews carried out with the Chairperson of Domboshava Community Development Association (DCDA) revealed that most people in the area are surely energy stressed. This was further augmented by sparse vegetation and distances travelled to the nearest forest observed during field work. The Chairperson acknowledged government efforts that has been aimed at connecting rural households to the national grid through rural electrification programs. However, it emerged that not all segments of the population benefited from this initiatives with majority still languishing in energy stress. Commenting on the side-lines of biogas technology, it was stressed that the patterns of household energy demand in Domboshava revolve around daily energy end uses such as cooking, heating and lighting. However, results from the survey indicated that nearly all the households use biogas for cooking alone. One of the elderly biogas adopter in the community revealed that when he first heard of biogas technology, it was said the technology will provide energy for cooking, heating, lighting, ironing as well as refrigeration. However, this has never been the case as most households, if not all rarely use biogas for other uses except cooking.

Plate 4.1: Self purchased biogas cooking stove (A) and SNV sponsored cooking stove (B)

Source: Field Survey (March 2017)

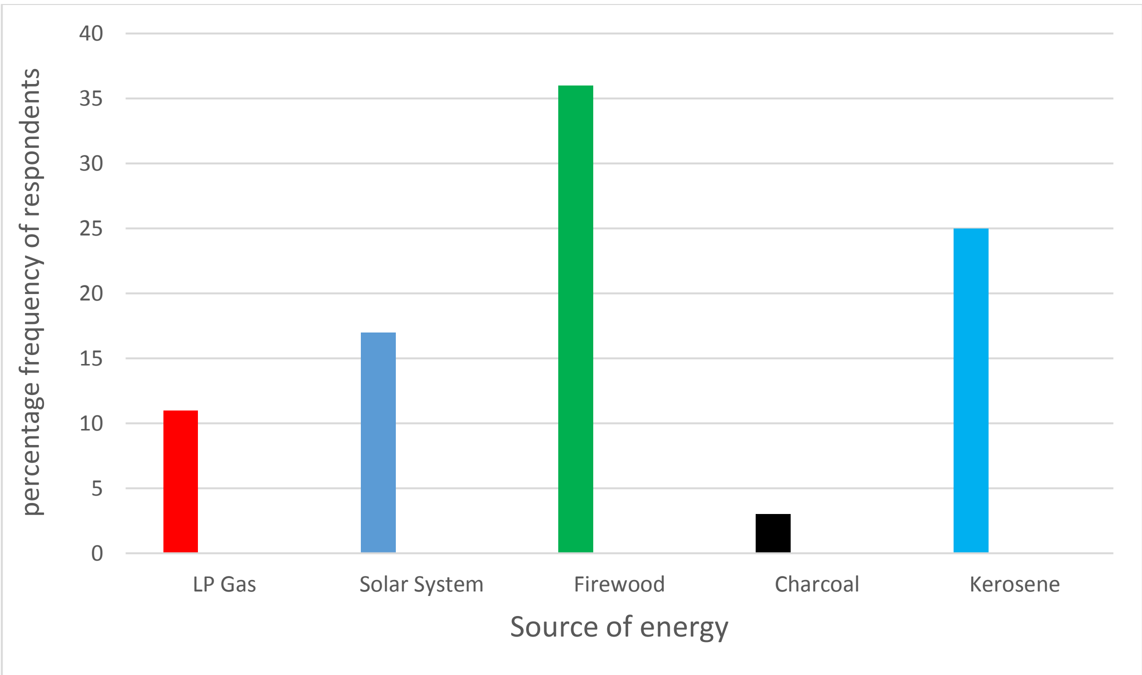

Figure 4.8: Energy types being used together with biogas by adopters

Although there are a number of energy sources being used, firewood scored highest frequency (36), followed by kerosene (25) definitely used for lighting. Other households has since secured and installed solar systems as observed during field work although it registered a low frequency due to its expensive nature and hence cannot be afforded by low income households. Due to the proximity of Domboshava to Harare, it emerged that some households are using liquefied petroleum gas (LPG) for some of its household energy needs although they are very few owing to issues of affordability as highlighted before. The Ward 4 Councillor defended the continued use of other energy sources as she stated that despite biogas being the best alternative source of energy in the area, people still needs warmth during cold seasons and also lighting services.

4.5.2 Benefits of using biogas technology

Despite some short comes displayed and presented above, there are also some benefits that are being realised from using biogas technology which points to its effectiveness. Almost all the respondents acknowledged that the technology cooks fast, provides clean energy, and of course reduce frequency of fire wood collection in the forest. Most household respondents were overwhelmed by the fact that biogas cooks fast (60%) with limited smoke (51%). Responses also showed that people were in agreement that biogas saves firewood (60%). Muriuki (2014) find a positive correlation between biogas use and reduction in firewood consumption. Interview with the Ward Councillor also revealed that biogas technology is an effective source of energy as it offers multiple services at household level. Besides provision of gas for energy, it was learnt that biogas technology provides well rotten organic manure that is free from pests and diseases. Maize and beans grow very well from this organic fertilizer and is claimed to have increased crop production for biogas adopters in Domboshava Community.

Questionnaire survey results also show that the time spend collecting firewood has been reduced significantly as shown in Table 4.9. This implies a reduction in deforestation levels in the area, reduced indoor air pollution and of course subsequent reduction in emission of carbon dioxide into the atmosphere.

Table 4.10: Comparison of time spend collecting firewood before and after biogas technology adoption

Variables	Frequency	Percentage%
Less time	39	86.6
More time	0	0.0
Same time	7	15.6

The study identified that a minority (15.6%) are still using same time after installing a biogas plant. This is despite a majority (86.6%) noting that they are seeing a difference between times spend collecting fire wood before and after adopting biogas technology. The Ward Councillor highlighted that reduced frequency of firewood collection is mainly because biogas is now used for warming bathing water and cooking. Firewood is only required for warmth in the evening and for cooking heavy meals like beans. Some adopters also explained further that despite reduced frequency to firewood collection still there is need to supplement biogas especially in winter when temperature are low therefore causing low biogas production. The proportion of those not seeing difference in terms of frequency of firewood collection before and after adopting biogas technology may be explained in terms of differing family sizes and an engraved culture of being used to firewood as a parent source of firewood. Further, the researcher observed quantities of firewood piles per each household and make comparisons. The general observation is that firewood quantities seems to correlate with household sizes although they clearly show signs of infrequent use. Less quantities of ashes pointed to reduced use of firewood as observed during field work. The Chairperson of DCDA further acknowledged that there are a few people who have just recently adopted biogas technology and they are yet to realise reduced frequencies of firewood collection.

4.6 Challenges and constraints to biogas use and adoption

Questionnaire survey results revealed a number of challenges affecting adoption and use of biogas technology in Domboshava area. Table 4.10 indicates highlighted reasons for low biogas production which is one of the problems faced by biogas technology users in Domboshava.

Table 4.11: Reasons for low biogas production

Reasons	Frequency	Percentage
Small digester	15	33.3
Shortage of cow dung	10	22.2
Construction defects	6	13
Maintenance	0	0
Operational defects	5	11.5
Seasonal changes	9	20
Inadequate appliances	16	35.5

Table 4.10 revealed that inadequacy and inefficiency of appliances (35.5%) being used by the adopters is one of the major problem causing low biogas production. The researcher noted that shortage of appropriate appliances is constraining households from diversifying the use of gas produced. It was further learnt from the survey that most households are using biogas for cooking alone despite other potential services of the technology like lighting, heating and refrigeration. In an interview with the Ward Councillor, it was revealed that the required appliances for the biogas technology like lighting mantles and efficient cooking stoves are far beyond the reach of many people due to their expensive nature. This hence forth explains the reason why many people are finding it difficult to switch completely to biogas technology. The Chairperson of DCDA elaborated further that people are currently facing challenges to tap all the benefits of the technology due to inefficient appliances at their disposal, although with time things shall be able to work for the good of people.

Size of the digester also appeared as one of the challenges causing inadequacy of biogas. A high positive correlation (0.02, $p \leq 0.05$) between biogas plant size and adequacy of biogas for daily energy needs was revealed. This means that the bigger the plant size the higher the chances of getting adequate biogas sufficient to meet daily energy needs. However, it was revealed through the research findings that the majority of people have $4m^3$ plant sizes which are much incapacitated to provide for larger families (Table 4.11).

Table 4.12: Biogas digester sizes in Ward 4

Size (m^3)		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	31	30	66.7	66.7	66.7
	9	10	22.2	22.2	88.9
	3	3	6.7	6.7	95.6
	2	2	4.4	4.4	100.0
	Total	45	100.0	100.0	

Construction of large digesters was limited by lack of resources as the majority could not afford constructing large digesters. Those with large digesters are at liberty to use gas for different purposes given the amount produced. However, the Director of Renewable Energy from SNV is of the view that size of a biogas plant should not be a major problem. She maintained that if all things are held at constant, a $4m^3$ plant digester should be able to support a family of about 6-10 people. The challenge therefore as revealed by the interviewee is that of failing to feed the plant as persistently and constantly as required. This hence points to lack of understanding on the operation and maintenance of the plant by adopters.

Constant need to ensure sufficient supply of cow dung for the digester was also raised by other respondents as labour intensive although the proportion is low (22.2%) in comparison with the issue of appliances. This is despite many households acknowledging that the task is easy when compared with collecting firewood. The researcher observed that this challenge was raised by those households without cattle. One of the household respondent who had no cattle mentione that they wake early morning daily to collect dung at a nearby shopping centre where straying cattle normally moves around during the night. The other commonly raised issue is the need to remove impurities from the dung as well as applying correct mixing ratios of water and dung. Interestingly, all the respondents rejected the researchers' probe that is if biogas technology brings more workload to the household.

In one of the informal discussion conducted during questionnaire administration, it further emerged that besides cooking, of all benefits promised by promoters, only lighting and rich manure for farming was appreciated. Lighting was however discredited owing to high costs of additional lamps which were reported to be out of reach for the most of rural people in the area. Promises for lighting services was seen as a reprieve for purchasing high cost kerosene and solar power. Some of the villagers who have adopted biogas in Domboshava also expressed that promise on refrigeration has been seen as an opportunity to venture into small scale businesses like selling soft drinks hence anchoring household economy. These unrealised potentials of biogas technology can be feared to affect people's attitude towards the technology and hence fanning low adoption of the technology.

Table 4.13: Constraints to biogas technology adoption in Ward 4 of Domboshava Communal Area

Constraints to biogas technology adoption	Frequency	% Frequency
Ignorance	43	95.5
Lack of required resources	41	91.2
Additional labour	7	17
No cattle	35	77.8
Lack of technical personnel	17	37.8
Lack of post installation support	21	46.7
High technological failure rate	2	4.4

Two major issues which are lack of adequate information (95.5%) and lack of money (91.2%) dominated the respondents' answers. Both these factors were stated and indicated by nearly all respondents. This generally gives an impression that major constraints to biogas technology adoption in Domboshava is none other than lack of money and lack of adequate information. In support of this notion, the Ward 4 Councillor of Domboshava interviewed related biogas technology with high initial costs of installation. When asked to describe households owning biogas, she was quick to characterise them as well up families. Furthermore, through mere observation, the researcher was able to conclude that households with biogas digesters are richer in comparison with other households in the area. The findings are similar to those of Waqah et al. (2013) who proposed that households that are relatively rich have higher likelihood of adopting biogas than low income earners households.

Furthermore, interviews with the local Ward Councillor revealed that available information to the people is insufficient to convince people to thoroughly consider opting for biogas. This was attributed to lack of awareness raising efforts and unclear channels of communication to the public. Lack of information by the public was also attributed to failure by the biogas adopters themselves to understand the technology. In addition to what was raised by the Councillor, one of the biogas technology adopters mentioned that there are no trained experts, fabricators and building masons in their proximity to assist with information to both biogas users and potential adopters. In the face of this challenge, the Councillor henceforth pressed for more training of some individuals who stays within the proximity of many people in Domboshava and also the need for more information on the side of biogas technology services, maintenance and operation.

In support of the Ward Councillor's observation the questionnaire survey revealed that the almost all the household respondents (95.5%) are of the view that ignorance is one of the major constraining factor to biogas technology adoption. The Director of Renewable Energy from SNV confirmed further that much is yet to be done in terms of raising awareness on biogas technology in rural areas. Correspondingly, the Chairperson of DCDA expressed the need for more information to reach the potential biogas users. Lack of adequate information on biogas technology was found paramount by (Wawa 2010) who cautioned that lack of awareness compromises people's attitude towards a new technology.

Another important issue raised in the field was lack of cattle for the provision of sufficient dung required for gas production. As indicated in Table 4.12, 77.8% of the respondents are of the view that adoption of biogas technology is being hindered by lack of cattle for the supply of cow dung. Ward 4 Councillor consented that many households were left without cattle in the past two years following an outbreak of a deadly disease that forced many households in Domboshava to close their pens. Also, lack of technical personnel for the construction of the digesters is one of the problems raised as faced by potential adopters of biogas technology. In Table 4.12 lack of technical personnel registered a substantial frequency of 37.8% indicating that a sizeable number of biogas technology adopters could have faced this challenge in the process of biogas installation. In an interview, the Director of Renewable energy from SNV admitted that little has been done in terms of training many builders as the task requires knowledgeable personnel to avoid unnecessary plant failure. One of the biogas adopters in the study area lamented that it took him more than twelve months for his plant to be constructed as the builder had other projects to complete in Gokwe.

Moreover, there were very few cases of technological failure although it scored 4.4% frequency. However, 21% of the respondents highlighted lack of post installation support as a challenge faced and threatening sustainability of the technology in the area. This relates to the findings of (Parawira et al 2010) where they mentioned that most biogas units installed in the early 1980s in Zimbabwe were left dormant following the withdrawal of the promoting donors. This was mainly because the biogas units were left in the hands of people with no proved technical competence in the face of a challenge (Parawira et al 2010). Additional labour is another issue raised as a deterring factor although with a very low frequency (17%). Majority of people contends that biogas operation requires less labour in comparison with firewood collection.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The research set out to examine challenges and opportunities of biogas technology adoption for sustainable household energy in Ward 4 of Domboshava. In spite of a noticeable positive attitude of people towards biogas technology, the research revealed a worrying lack of biogas technology awareness in the area. Awareness of the technology is very critical since it determines attitude as well as influencing decision making of household heads. Lack of a clear understanding of the goodness of the technology in terms of efficiency, operation and services provided drives unnecessary misperceptions and misconceptions (Mlambo 2016) hence the need to raise awareness on the technology.

Furthermore, socio-economic factors with greater influence as revealed by the research findings are age and gender of the household head, family size as well as sources of livelihoods. Other influencing factors included motivational factors particularly the role played by biogas promoters and users and the benefits provided by the technology itself like its ability to cook fast, save firewood and health benefits. In addition, the study revealed that biogas is effective in terms of saving firewood, quickness in cooking, less smoke, cost effective and reduced time spend collecting firewood.

Notably, the research findings revealed multiple services provided by biogas technology which are critical for the conservation of the environment as well as the provision of sustainable household energy. In this case, the study revealed significant reduction of frequency of firewood collection by many households with biogas digesters. This points to reduced cases of deforestation, expenses on other fuel sources and amounts of emitted gases from burning wood. Above all biogas technology adopters appreciated effectiveness of organic manure, an end product of the technology which is said to be equivalent to Compound D fertilizer.

Even so, the research further reflected on some of the loopholes of biogas technology adoption and use in Domboshava. Ignorance and lack of required resources were the major contraints inhibiting adoption and use of biogas. The challenge of meeting initial costs of biogas plant installation as linked to lack of required resources was widely pronounced by the respondents. It was learnt that people may be willing to adopt biogas technology, but due to high installation cost they think otherwise. With regards to challenges of biogas technology use, research findings revealed that many households are failing to diversify the use of biogas due to financial constraints. The researcher noted that many households with biogas digesters lack efficient appliances such as cooking stoves, lighting and storage of gas hence resorting to firewood and other energy types as a supplement to biogas.

5.2 Recommendations

In light of the results and conclusion of this study the researcher recommends the following:

- There is need for a coordinated approach to conduct massive awareness campaigns spearheaded by the Ministry of Energy and Power Development (MoEPD) together with other currently involved stakeholders particularly NGOs. This implies establishment of efficient information flow and coordinated channels to link up with every person irrespective of gender in rural communities.
- The government through the Ministry of Energy and Power Development together with NGOs must install at least five demonstration biogas plants in each Ward for rural households to replicate and learn from.
- MoEPD in partnership with the Ministry of Higher and Tertiary Institutions, Science and Technology Development should provide funds for more research on biogas technology to generate more innovative ideas on efficiency.
- The Renewable Energy Fund offered by the MoEPD should also be used to subsidize construction of biogas plants for the rural people and the government should facilitate subsidized credit facilities for people who want to install biogas plants.
- Biogas programmes should emphasise on training local builders and technicians to ensure proximity of maintenance and repair services within a reasonable radius for potential biogas adopters and those who have already adopted the technology.
- Lastly, the Government must set standards for biogas technology appliances and construction to ensure quality, sustainability and longevity of the biogas digesters.

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APPENDICES

Appendix 1: Questionnaire for biogas technology adopters

MIDLANDS STATE UNIVERSITY
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

QUESTIONNAIRE SURVEY ON: CHALLENGES AND OPPORTUNITIES TO BIOGAS TECHNOLOGY ADOPTION FOR SUSTAINABLE HOUSEHOLD ENERGY IN RURAL AREAS OF ZIMBABWE: A CASE OF DOMBOSHAVA COMMUNAL AREA

My name is Shingirai Sakarombe, a student with Midlands State University undertaking a Bachelor of Science Honours Degree in Geography and Environmental Studies. Results obtained from this survey are for academic purposes only and will not prejudice anyone involved in the survey. It is my special request that you spare part of your time to provide all the information as required.

Ward…………………………………………… Village……………………………………………

Questionnaire Number ☐

Date …………………………………………………….

SECTION A: BACKGROUND INFORMATION ***(tick where appropriate)***

1. Gender of the respondent Male ☐ Female ☐
2. Age 18-21 ☐ 22-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ < 60 ☐
3. Education level attained

a. Primary	
b. Secondary	
c. Tertiary	
d. None	

4. Employment Status: Employed ☐ Self-Employed ☐ Unemployed ☐
5. Household Size: >4 ☐ 5-7 ☐ 8-10 ☐ <11 ☐
6. Main source of Livelihood:

a. Formal employment	
b. Farming	
c. Casual labour	
d. Farming	
e. Pension	

7. Biogas plant size ☐
8. Livestock owned and their numbers

Livestock	Number
Cattle	
Chickens	
Goats	
Sheep	
Pig	

<u>SECTION B: LEVEL OF AWARENESS AND ATTITUDE TOWARDS BIOGAS TECHNOLOGY</u>

9. How do you came to know about biogas technology? Government ☐ NGOs ☐ Media (radio, newspapers, Television etc.) ☐ Friends/Neighbours ☐ Others *(specify)*…………………………………..
10. Has any member of your family received training on biogas technology: Yes ☐ No ☐
11. Do you agree that this community is well aware of the biogas technology and its importance as a source of household energy? (*tick where applicable)*

    Strongly agree ☐ Agree ☐ Undeceided ☐ Disagree ☐ Strongly disagree ☐
12. What is your opinion on the construction of the biogas plant?

    It is cheap ☐ It's reasonably affordable ☐ It's expensive ☐ it's very expensive ☐
13. (a.) When did you install the biogas plant?:……………………………………………………….

    (b.) How long did it take to complete construction of the plant:

    > 3 months ☐ 3-6 months ☐ 6-9 months ☐ < 9months ☐

    Explain:………………………………………………………………………………………

    ……………………………………….……………….............…………………………………

    ……………………………………………………………………………………………….
14. (a) What is the source of substrate required in the digester for biogas production:

Source	Yes	No
Cow dung		
Animal wastes		
Household wastes		

Plant residues		
Garden wastes		
Human excreta (toilet)		

15. How would you rank adequacy of the substrate that you use in the digester for biogas production? **(use the following keys; 1 – adequate, 2 –moderately adequate, 3 – inadequate)**

a) Adequate ☐ b) Moderately adequate ☐ c) Inadequate ☐

16. Is biogas a best alternative source of energy? Yes ☐ No ☐

Explain…………………………………………………………………………………………

…………………..………………………………………………………………………………

…………………………………………………………………………………………………

17. What are your future plans with regards to biogas use? ***Please tick where appropriate*** Increase use ☐ Maintain use ☐ Reduce use ☐ Diversify ☐ Abandon ☐

<u>SECTION C: FACTORS INFLUENCING ADOPTION AND USE OF BIOGAS TECHNOLOGY</u>

18. What was your source of energy before you switched to biogas? (*can tick more than one)*

Energy type	Yes	No
Electricity		
Firewood		
Charcoal		
Coal		
Cow dung		
Crop residues		

19. What motivated you to construct a biogas plant ***(can tick more than one)***

Non-availability of cheap fuel sources	
Health benefits	
Environmental benefits	
Motivation from providers	
Motivation from other biogas users	
It saves fuel wood	
It's a clean energy (produces less smoke)	
Affordable	
It cooks quickly	

SECTION D: EFFICIENCY OF BIOGAS TECHNOLOGY

20. What fire system were you using before biogas installation?

    Open firewood system ☐

    Charcoal ☐

    Electricity ☐

    Others specify…………………………………………………….

21. In comparison, which system makes more smoke biogas or your old system?

    Biogas ☐ Old System ☐

22. Are you using same, less or more time fetching firewood after installing biogas? **(please tick where applicable)**

    Less time ☐

    More time ☐

    Same ☐

23. What other energy sources are you using together with biogas:…………………………………………………………………………………………..............
    …………………………………………………………………………………………………
    ………………………………………………………………………………………………….

SECTION E: CHALLENGES AND CONSTRAINTS TO BIOGAS USE AND ADOPTION

24. (a) Is gas provided by the plant enough for all your daily energy needs that is cooking, heating and lighting? Yes ☐ No ☐

(b) If your answer to the above question is NO, then what are the reasons

Small digester ( )
Shortage of substrate ( )
Construction defections ( )
Maintenance ( )
Operation defects ( )
Less gas produced due to seasonal changes ( )
Others…………………………………………………………………………………………
…………………. …………………………………………………………………………….

22. Is operation, maintenance and servicing of the digester laborious? Yes ( ) No ( )
    Explain………………………………………………………………………………………
    …………………………………………………………………………………………………
    ………………………………………………………………………………………………..

(c) What do you use slurry from the biogas digester for?

Sell to others ( )
Farming ( )
Irrigation scheme ( )
Give to others ( )
Dispose ( )
Others:………………………………………………………………………………………………

………………………………….

23. What are the major constraints of adopting biogas technology……………………………………………………………………………………..
…………………………………………………………………………………………………
………..………………………………………………………………………………………
…………………………………………………………………………………………………

THANK YOU

Appendix 2: Semi-structured interview guide for Netherlands Development Organisation (SNV)

Objective 1: Level of awareness and attitude towards biogas technology in Domboshava

1. What are the promotion strategies and support services are offered by this organization to biogas projects and communities to speed up the uptake of biogas technology?
2. What awareness strategies are in place to motivate people in rural areas to switch to renewable energy technologies?
3. In your opinion, what do you think is the current level of awareness on biogas technology in Domboshava?
4. From your experience, what is the attitude of rural households towards biogas technology as an alternative source of energy in Domboshava?

Objective 2: Factors that influence the adoption and use of biogas technology for household energy in Domboshava

5. What are the determinants of biogas technology adoption in rural communities?
6. What do you are the factors influencing biogas technology adoption in Domboshava?

Objective 3: Efficiency of biogas technology in comparison with other household sources of energy in the area

7. Is biogas an efficient source of energy for rural communities compared to other traditional sources available in this area?
8. What benefits are being derived at household level from using biogas technology in Domboshava?

Objective 4: Challenges and constraints to biogas technology adoption and use at household level in Domboshava.

9. Why the biogas sector in Zimbabwe has failed to yield meaningful results since the initiation of efforts to disseminate the technology in the 1980s?

10. What are the major constraints inhibiting several households in Domboshava from adopting and using biogas?
11. What are the challenges normally faced by households who have adopted biogas technology?
12. What are the institutional challenges faced in an effort to disseminate biogas technology among rural communities?
13. Is the government of Zimbabwe doing its best to increase adoption and use of biogas in rural areas?
14. What are the policy recommendations can you propose for Zimbabwe to have a vibrant biogas sector?

End of the interview, thank you for your participation

Appendix 3: Semi-structured interview guide for Environment Africa Projects Coordinator

Objective 1: Level of awareness and attitude towards biogas technology in Domboshava

1. What awareness strategies are in place to motivate people in rural areas to switch to renewable energy technologies?
2. In your opinion, what do you think is the current level of awareness on biogas technology in rural areas?
3. From your experience, what is the attitude of rural households towards biogas technology as an alternative source of energy?

Objective 2: Factors that influence the adoption and use of biogas technology for household energy in Domboshava

4. What are the determinants of biogas technology adoption in rural communities?
5. What do you think are the factors influencing biogas technology adoption in Domboshava?

Objective 3: Efficiency of biogas technology in comparison with other household sources of energy in the area

6. What are the major problems that are arising from over reliance on biomass especially firewood in rural areas?
7. Is biogas an efficient source of energy for rural communities compared to other traditional sources available in this area?
8. What benefits are being derived at household level from using biogas technology?

Objective 4: Challenges and constraints to biogas technology adoption and use at household level in Domboshava.

9. Why the biogas sector in Zimbabwe has failed to yield meaningful results since the initiation of efforts to disseminate the technology in the 1980s?
10. What are the major constraints inhibiting rural people from adopting and using biogas?
11. What are the challenges normally faced by households who have adopted biogas technology?
12. What are the institutional challenges faced in an effort to disseminate biogas technology among rural communities?
13. What are your recommendations at policy level with regards to the promotion of renewable energy technologies?

End of the interview, thank you for your participation

Appendix 4: Semi-structured interview guide for the Department of Renewable Energy - Ministry of Energy and Power Development

Objective 1: Level of awareness and attitude towards biogas technology in Domboshava

1. What are the promotion strategies and support services are offered by the Ministry to biogas projects and communities to facilitate the promotion of biogas technology in Zimbabwe?
2. What is the approximate cost of constructing a medium size digester for an ordinary household in a rural area?
3. In your opinion, what do you think is the current level of awareness on biogas technology in rural areas?

Objective 2: Factors that influence the adoption and use of biogas technology for household energy in Domboshava

4. What are the determinants of biogas technology adoption in rural communities?
5. What do you think are the factors influencing biogas technology adoption in rural areas?

Objective 3: Efficiency of biogas technology in comparison with other household sources of energy in the area

6. Is biogas an efficient source of energy for rural communities compared to other traditional sources available in this area?

Objective 4: Challenges and constraints to biogas technology adoption and use at household level in Domboshava.

7. What are some of the technical challenges associated with biogas technology and commonly raised by biogas adopters and users?
8. Why the biogas sector in Zimbabwe has failed to yield meaningful results since the initiation of efforts to disseminate the technology in the 1980s?
9. What are the major constraints inhibiting rural people from adopting and using biogas?
10. What are the challenges normally faced by households who have adopted biogas technology?
11. What are the challenges facing the Ministry in its efforts to promote renewable energy technologies particularly Biogas Technology?

End of the interview, thank you for your participation

Appendix 5: Semi-structured interview guide for the Environmental Management Agency

Objective 1: Level of awareness and attitude towards biogas technology in Domboshava

1. What is the role of this organisation in the promotion of renewable energy technologies (RET) particularly biogas technology?
2. What awareness strategies are in place to motivate people in rural areas to switch to renewable energy technologies?
3. In your opinion, what do you think is the current level of awareness on biogas technology as an alternative source of energy in rural areas?

Objective 2: Factors that influence the adoption and use of biogas technology for household energy in Domboshava

4. What are the factors driving people to look for alternative sources of energy other than firewood in Zimbabwe?

Objective 3: Efficiency of biogas technology in comparison with other household sources of energy in the area

5. Is biogas an efficient source of energy for rural communities compared to other traditional sources available in this area?

Objective 4: Challenges and constraints to biogas technology adoption and use at household level in Domboshava.

6. What are the major problems that are arising from over reliance on biomass especially firewood in rural areas?
7. What are the major constraints inhibiting rural people from adopting renewable energy technologies?
8. What are the challenges normally faced by households who have adopted biogas technology?
9. What are the challenges facing this organization in its efforts of promoting renewable energy technologies particularly Biogas Technology?

End of interview, thank you!

Appendix 6: Semi-structured interview guide for the Chairperson of Domboshava Community Development Association (DCDA)

Objective 1: Level of awareness and attitude towards biogas technology in Domboshava

1. Is this community well aware of the biogas technology?
2. What is their attitude and perceptions towards biogas technology as a source of energy?

Objective 2: Factors that influence the adoption and use of biogas technology for household energy in Domboshava

3. What are the reasons pushing other households in this community to adopt and use biogas?
4. What are the reasons for low uptake of the technology in this community?

Objective 3: Efficiency of biogas technology in comparison with other household sources of energy in the area

5. Is biogas an efficient source of energy for rural communities compared to other traditional sources available in this area?

Objective 4: Challenges and constraints to biogas technology adoption and use at household level in Domboshava.

6. What are the major problems that are arising from continued use and reliance on firewood as a source of household energy for heating, cooking and lighting?
7. What are some of the challenges faced by those who have adopted biogas technology?

End of the interview, thank you for your participation

Appendix 7: Semi-structured interview guide for Ward 4 Concillor in Domboshava

Objective 1: Level of awareness and attitude towards biogas technology in Domboshava

1. Is this community well aware of the biogas technology?
2. What is their attitude and perceptions towards biogas technology as a source of energy?

Objective 2: Factors that influence the adoption and use of biogas technology for household energy in Domboshava

3. What are the reasons pushing other households in this community to adopt and use biogas?
4. What are the reasons for low uptake of the technology in this community?

Objective 3: Efficiency of biogas technology in comparison with other household sources of energy in the area

5. Is biogas an efficient source of energy for rural communities compared to other traditional sources available in this area?

Objective 4: Challenges and constraints to biogas technology adoption and use at household level in Domboshava.

6. What are the major problems that are arising from continued use and reliance on firewood as a source of household energy for heating, cooking and lighting?
7. What are some of the challenges faced by those who have adopted biogas technology?

End of the interview, thank you for your participation

Appendix 8: Observation checklist

What the researcher sought out to observe	What was actually observed
Household level of affluence	
Vegetation cover	
Distance to the nearest forest	
Firewood quantities per household	
Storage and handling of biogas plant outputs	