ANALYSIS OF EXTRINSIC AND INTRINSIC FACTORS AFFECTING THE ADOPTION OF BIOGAS TECHNOLOGY IN MBARARA DISTRICT IN WESTERN UGANDA

A CASE STUDY OF MBARARA DISTRICT

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DEDICATION

The project report is dedicated to my Husband Mr. Ssemwogerere Kenneth for his inspiration, encouragement and moral support he provided during writing of this project. Our two children; Nakitende Kerry Hannah, and Mukungu Ndugwa Keron for their patience especially when they missed the motherly support during my study.

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LIST OF ABBREVIATIONS

ACALISE	African Center for Agro-Ecology & Livelihood Systems
ANOVA	Analysis of variance
BSUL	Biogas Solutions Uganda Limited
GHG	Greenhouse gas
MEMD	Ministry of Energy and Mineral Development
NGOs	Non-Governmental Organisations
SNV	Netherlands Development Organization
UNIDO	United Nations Industrial Development Organization

ABSTRACT

This study concentrated on the extrinsic and intrinsic factors on the adoption of biogas Technology following the fact that, Despite the enormous advantages, existing policies and abundant biogas sources, biogas energy use in Uganda still remains low as 87% of the people in rural areas relied on biomass. Thus, this study specifically undertaken to assess the effect of communities' knowledge on the adoption of biogas technology, establish the effect of decision making process about the biogas technology in the household with focus on gender, and to assess the effect of attitude of the communities' on the biogas technology adoption.

A cross sectional survey research design was adopted for the study. A total of 186 respondents participated in the study. Linear regression which measured the effect of the variables under the study was performed and results interpreted at 0.05% level of significance. The study established that communities knowledge explain 9.0% of the variance in the bio gas adoption among the farmers in Mbarara district (Adjusted R^2= .090). Decision Making Process explain 69.9% of the variance in the bio gas technology adoption among the farmers in Mbarara district and Attitude of the communities' explain 69.8% of the variance in the bio gas adoption among the farmers in Mbarara district (Adjusted R^2= .698). This shows that community's knowledge about the biogas is a significant predictor of the adoption as explained by 69.8% of the respondents.

The study concluded that that communities' knowledge about biogas technology was essential for technology adoption. This implied that the way the community understands the bio gas technology determines whether they will adopt it or not. The findings on the effect of decision making process revealed that it contributes highly and significantly to the overall adoption of biogas technology and thus a unit change in decision making process is a significant predictor of whether the households will adopt biogas technology. Lastly, the attitude of communities towards biogas technology positively significantly influences its adoption, thus if people have a negative attitude it would lead to low uptake and high uptake if its positive since in general terms attitude explains 69.8% of the choice of adoption on biogas technology.

The study recommended that since communities' knowledge influenced the biogas technology adoption by only 9% which is very low perhaps because the communities are not fully sensitized on the advantages of biogas, government through its line ministry of energy and mineral development should team up with NGOs to conduct massive sensitization of farmers to adopt biogas energy which is by far has more advantages compared to other biomass energy. It has also been seen that attitude contributes significantly to the adoption of technology adoption yet one of the challenges seen in the study was financing. Therefore, government should set up demonstration plants in communities as a means of developing positive attitude towards adoption of biogas technology.

CHAPTER ONE: GENERAL INTRODUCTION

1.0 Introduction

More than 70% of the population in Africa rely on fuel wood energy source (Matsika, Erasmus, Twine, 2013), 90% (Amankwah, 2011) from natural forests. Excessive energy consumption derived from forest resources disrupts carbon sinks, which compounds the adverse effects of climate change. This has caused droughts, flooding, land degradation, and loss of soil nutrients that directly affect livestock and crop yields *(*Riti & Shu, 2016). *Africa's* energy situation illustrates the necessity and urgency of investing in development of decentralized renewable energy technologies for rural and poor communities

Energy source in Africa is perceived as environmental friendly and has received growing attention, especially when trying to alleviate energy poverty. (Karekezi - 2003) This is generally defined as limited or lack of access to modern technology. Biogas produced from cattle, pig dung of (human excreta and kitchen waste), together with the bi-product bio-slurry can offer a solution to poor access to modern energy services and help mitigate poverty, climate change and soil fertility problems.(L Warnars - 2014) It is simple and affordable uncomplicated method of maintaining energy supply. Potential of biogas is significant in developed as well as developing countries Uganda being one of them (F Lutaaya - 2013) . Biogas consists of methane and carbon dioxide and the flame is smokeless and non-toxic. It creates employment, saves the use of tradition cooking fuels and increases the availability of clean fuels. It reduces indoor smoke and related problems such as eye infections, respiratory diseases and burns (DG Fullerton - 2008). Biogas installations reduce methane emissions since the gas is captured in the bio digester.(Warnars and Hivos, 2014)

1.1 Background of the Study

Kurchania (2012) noted that biogas digester is one of the sustainable energy alternative that has potential to provide low-cost energy without the need to harvest wood. *)* Capturing biogas during waste decomposition (Abbasi, 2010) and using it for energy can reduce the use of fuel-wood energy and hence lessens the degradation of (Harmse, 2010) local forests.

Therefore, the introduction of biogas energy sources, for instance, in China, Ethiopia (Cheng et al, 2013) and India, has effectively improved livelihoods of rural communities where it has considerably decreased the dependence on energy consumption from fossil and wood sources

Animal and crop wastes are an important source of renewable energy through the process of anaerobic digestion. Anaerobic digestion, a biological conversion process, has a number of advantages for waste conservation and is an important renewable energy source. Fresh animal or crop wastes with high moisture content (about 80%) that makes them unsuitable for most thermo-chemical processes can be easily fermented using the anaerobic digestion method (Park et al., 1998) to produce biogas. Biogas consists of between 40 and 70% methane, with the remainder being carbon dioxide, hydrogen sulphide and other trace gases (Singh and Sooch, 2004; Shin et al., 2005; Batzias, 2004).

Dependence on non-renewable energy sources is increasingly becoming unsustainable due to ecological and environmental problems and rapid depletion.(Mulinda, Hu and Pan, 2013). Land degradation is widespread and is the result of unsustainable farming and a growing fuel wood demand, demand for fuel wood decreases vegetation coverage thus causing soil erosion. Overgrazing and soil compaction too is another challenge. Bio-gas is produced from a variety of materials such as waste products. For example, wastewater sludge and municipal solid waste can be used to produce biogas. One of the major advantages of biogas is that it can be produced from agricultural waste. Soiled bedding from cattle sheds, unconsumed crop residues, fallen leaves, farmyard manure and weeds, all of which are available abundantly in farms, can be used to produce biogas. Hence, practically every farm in India is a potential producer of energy. (Anupoju *et al.*, 2015)

Biogas is processed by microbes in anaerobic digesters to produce colorless, odorless, energy-rich gas called methane. However, methane in a gaseous state is difficult to transport from the source. It is more readily conveyed from one place to another when it is highly compressed. And here is one application where air compressors have a role to play in generating and using renewable energy.(Christopher A. Badurek, no date)

Depletion of fossils fuels can have a negative effect on local environments. Making sustainable energy available in rural areas in developing countries will lead to improved living conditions and improvement of the local environment. Such factors have led to innovative global search for renewable sources of energy. Consequently some alternatives, especially renewable energy options have been explored and discovered. Feasible technologies in a wide area of solar, biomass have been discovered, tested and perfected and are under popularization, biogas is one of such options. Majority of renewable energy technologies are better eco-friendly as compared to conventional energy options, however their adoption is very slow because of various reasons such as economic constraints, lack of supply and users friendly technical know-how. Further, the use of these technologies like biogas technology is still limited to majority of the stationary operations mainly due to technological imitations and poor economics.(Sorathia, Rathod and Sorathiya, 2012)

Since fuel wood is generally harvested unsustainably, this reduction translates into the prevented release of 5.5 tons of carbon dioxide into the atmosphere annually from an average biogas digester, resulting in many environmental benefits(Naeem *et al.*, 1999) . Biogas technology has been identified as a socially, economically and environmentally sustainable solution for addressing issues of optimal sanitation, dependence on wood and charcoal for fuel, and decreasing agricultural productivity (Wilkinson *et al.*, 2009). The technology makes use of livestock waste, crop material and food waste to produce a flammable gas that can be used for cooking and lighting (Omer, 2010). Further benefits accrued to the use of biogas technologies extend to include reductions in the need for fuel wood for cooking(Wilkinson *et al.*, 2009), production of bio-slurry which is a valuable fertilizer(Bureau, Bulletin and Semestriel, 2005) .

In many African nations, biogas technology has become an important strategy to provide sustainable energy. The unsustainable use of fossil fuels has led to increased awareness and widespread research on the accessibility of renewable energy resources such as biogas (Warnars and Hivos, 2014). Biogas is a methane rich gas that is produced by anaerobic fermentation of organic material(Lior, 2008). Over 70% of the households in sub Saharan Africa use wood fuel and agricultural waste for cooking (Wilkinson *et al.*, 2009).

There are several reasons why biogas energy in particular seems an appropriate and important option to augment Uganda's conventional household energy shortages, Animal manure is widely available in most parts of the country because livestock production is an important economic activity in almost all regions of the country (Pandey et al., 2007). Biogas can be generated throughout the year because of the suitable temperature for anaerobic fermentation process in the tropics. Since Uganda lies across the equator, temperatures are fairly constant throughout the year, and always above 15°C.

Uganda is facing serious electricity shortages because of heavy dependence on few conventional unsustainable fossil and biomass energy sources (MEMD, 2018). The high prices for petroleum products and unsustainable pressure on the country's forest biomass are exacerbating the current energy crisis in Uganda. Production of biogas fuel at the household level using local, renewable resources reduces the pressures on forestry, centralized electricity production, and fossil fuel distribution networks (Pandey et al., 2007).

Smoke from cooking in the kitchen is one of the world's leading causes of premature child death, claiming the lives of 500,000 children under five annually (Jörg Langbein). Young children are particularly vulnerable for two reasons: (Jörg Langbein). First, they are usually with their mothers during the cooking process and thus inhale large loads of particulate emission. (Jörg Langbein). In a recent systematic review, it was found that childrens' particulate emission exposure is similar to their mothers'.(Toba, N. (2013)) Second, in comparison to adults, the still growing bodies of young children are more susceptible to ARI, leading to a high death rate in this age group. (Toba, N. (2013)

Animal manure is not methodically composted and integrated into farming practice in Uganda. At the same time Uganda is one of the lowest per hectare users of imported fertilizer in Africa with the largest farm area among countries in Africa certified for organic farming. Increasingly, intensive agriculture with limited return of nutrients is rapidly exhausting the soils. Biogas digesters perform the task of collectors of under-utilized dung, and with sufficient awareness through biogas energy production and utilization, fertilizer nutrients can be recycled to farms to preserve the fertility of the soil.

Source of Fuel after Biogas Adoption: It was observed that after the adoption of the biogas peoples were still using other alternates of biogas because of many reasons like, shortage of animal manure, lesser efficiency of biogas plants in winter season, overhauling of plants etc. Around fifty four percent households reported that they had not enough gas for cooking hence they used fuel wood also. While twenty percent households said they are using LPG, along with biogas and only one percent peoples were using dung cake. Twenty five percent peoples were depending only on a single source of energy i.e. biogas

Level of Satisfaction: Seventy four percent of the households said that their biogas plant was fully functioning and they were fully satisfied. Twenty two percent said that their plants were partially functional and therefore they were partially satisfied. Four percent said their plants were not well functioning and therefore they were not satisfied.

Although biogas energy provides promise for many African countries (Riti and Shu 2016), observed that no study had evaluated how biogas digesters influence households' energy choices. Furthermore, Melaku et al (2017) indicated that there had not been a quantitative analysis to predict when households will substitute away from traditional energy sources. Their study on factors influencing the adoption of biogas digesters in rural Ethiopia, concluded that household biogas energy use remains below expectations, even though subsidies make the units affordable for small farmers. Therefore there was a need to by this study to assess the communities' knowledge about the adoption of the biogas technology

Mengistu et al, (2015) study on biogas technology and its contributions to sustainable rural livelihood in Ethiopia found out that at a household's energy choice is influenced by various socioeconomic variables, environmental changes, demographic compositions, and social factors. However, there was no study in Mbarara district about Extrinsic and Intrinsic factors on the adoption of bio gas technology

Several gaps on biogas technology in developing countries have been identified. They include lack of long term operation studies on extrinsic and intrinsic factors that affect the adoption of the biogas technology, the communities knowledge, attitude towards the technology and also the decision making process in the household. (Rowse, 2011). The aim of this study, therefore, was to assess the factors affecting the adoption of the biogas technology projects and the factors that determine and influence the adoption and sustainability of the technology in the rural areas of Uganda. The outcome will identify under which conditions biogas technology can work best.

Biogas technology success in rural Kenya has continued to be problematic in spite of the partnerships with international organisations. Such biogas partnership organisations include Netherlands Development Organization (SNV), Netherlands Directorate General for International Cooperation (DGIS), German Organization for Technical Cooperation (GTZ), WINROCK International, International Humanist Institute for Cooperation with Developing Countries (HIVOS), Biogas Institute of Ministry of Agriculture, China (BIOMA), African Biogas Partnership Program (ABPP) (Mulinda et al., 2013), International Fund for Agriculture Development (IFAD) and Biogas International (Sovacool et al., 2015). Although biogas technology has been thoroughly studied in Europe and Asia, little effort has been made to study the same in sub-Saharan Africa (Naik et al., 2014). Lark of biogas advancement is as a result of low access, utilization and maintenance capacity. Similarly, the biogas market potential has been underexploited, despite the technology being linked to poverty alleviation and development in rural areas (Mulinda et al., 2013)

1.2 Statement of the Problem

Energy is an important ingredient for the development process of any country. Energy Consumption level is a good indicator of socio-economic development level of a country because the energy sector has strong impact on poverty reduction through income, health, education, gender and the environment linkages (Sayin et al., 2005). Biogas technology has become an important strategy (Kamp and Forn 2016) to provide sustainable energy.

Uganda has policies supportive of rural energy investments and institutional mechanisms that have been built through earlier work by the government and private sectors in Uganda, coupled with the energy crisis in the country, provide a conducive entry point for an integrated household-level biogas program in the country (Pandey et al., 2007). Further, there also exist favorable technical conditions for the production of biogas energy in Uganda. These include availability of abundant biodegradable animal and crop waste raw material, warm tropical temperatures and availability of field–tested technologies.

However, despite the enormous advantages, existing policies and abundant biogas sources, biogas energy use in Uganda still remains low (Walekhwa, 2010, Global Alliance for Clean Cook stoves (2017). For instance the rate of adoption of biogas technology is estimated at 25.8% of its potential. Worse still, Eighty-seven percent of the population who lives in rural uses unprocessed biomass to cook (GACC, 2017). In urban and peri-urban areas; kerosene is used in small portions, less than 0.5% and 0.8 percent of the population in Uganda use a mix of fuels produced from small enterprises and possibly some electricity. Lwiza et al (2017) studied the dis-adoption of biogas and found that households that dis-adopted the technology, did so within a period of 4 years after its installation, yet the lifespan of using it is estimated at 25 years. Lwiza et al (2017) looked at dis-adoption of biogas, and not adoption. On his part Walekwa (2010) acknowledged the abundance of biogas sources but did not study the extrinsic and intrinsic factors that deter the people of Mbarara from adopting biogas technology. Equally Rogers (2002) and Muvhiiwa et al (2016) observed that technology involved in having biogas operational involves heavy costs. However, they did not show by what percentage, costs affected the adoption. Therefore to fill these gaps, this study was undertaken to examine the extrinsic and intrinsic factors contributing low adoption of biogas technology.

1.3 Objectives

The main objective was to carry out an in-depth assessment of the extrinsic and intrinsic factors affecting the adoption of the biogas technology.

a) To assess the effect of communities' knowledge on the adoption of biogas technology

b) To establish the effect of decision making process about the biogas technology in the household with focus on gender.

c) To assess the effect of attitude of the communities' on the biogas technology adoption.

1.4 Research Questions

a) What is the effect of communities' knowledge about the adoption of biogas technology?

b) What is effect of decision making process about the biogas technology in the household?

c) What is the effect of attitude of the communities' about biogas technology on the biogas technology adoption?

1.5 Scope of the Study

Geographical scope

The geographical scope and my area of study was in Mbarara district that is located in the western region of Uganda. My sample was of 196 respondents. The district is subdivided into one municipal council, Mbarara Municipality, and 19 sub-counties, namely: 1. Kashari 2. Bubaare 3. Bukiro 4. Kagongi 5. Kakiika 6. Kashare 7. Rubaya 8. Rubindi 9. Rwanyamahembe 10. Biharwe 11. Kakoba 12. Kamukuzi 13. Nyamitanga 14. Rwampara 15. Bugamba 16. Mwizi 17. Ndaija 18. Nyakayojo 19. Rugando

Content Scope

This study focused on the micro-level relationships in the adoption of biogas technology and factors influencing it at the household level. The study examined how adoption of biogas technology is in part influenced by policies and institutional support services, individual socio-economic characteristics, environmental characteristics and technological characteristics. Since only one district was involved in this study, the findings are for only Mbarara district as per the scope of study area.

Time Frame

This study was conducted in a period of Four (4) months, data entry, data coding, cleaning and analysis was done in a month (1month).

Time Scope

Biogas innovation started in Uganda in 2009, the technology was being implemented by Heifer international before the project was taken over by Biogas solutions Uganda Limited (BSUL). The beneficiaries my study was focusing on a time period from 2009 – 2018 thus nine (9) years where my study scope was focusing, I collected data from beneficiaries that had and were using the technology that was 4-6 years old. This data enabled me understand the extrinsic and intrinsic factors affecting the biogas technology in Mbarara district.

1.5. Justification of the Study

Lutaaya (2012) noted that there is good potential for biogas in Uganda and its exploitation has been witnessed, investigating its low adoption in Uganda’s energy crisis was believed to pave way for environmental conservation and sustainability. Yet Biogas technology as an alternative renewable energy has been introduced in Uganda for a reasonable period of time but so far the technology is not adopted to the expected levels, resulting into the continued exploitation of forests. The need for a study that can contribute to better understanding of the root causes of low adoption rate of biogas technology was necessary.

Secondly, if the responsible government institutions and other stakeholders would adequately promote biogas technology, in a bid to save forests (deforestation) save time wasted in firewood collection and in turn increase women participation in other productive work, they must be aware of what effects communities' knowledge and attitude towards biogas have on the final decisions to adopt the technology

The adoption of biogas technology in Africa would contribute to the well-being and economic prosperity of the continent as a whole by ensuring that the communities are sensitized about the technology and its benefits. Contribution to global warming and associated impacts. Reduced carbon emissions can be quantified based on local forest pressures and energy alternatives, and these carbon credits can be sold on the global market as certified emissions reductions, generating revenue to help internalize the aforementioned positive environmental externalities. When used in institutional operations, such as with dairies or feedlots, biogas can also be economically used to generate electricity, providing a carbon neutral energy source with greenhouse gas benefits correlating with the emissions intensity of the local electricity grid, or off-grid alternatives. Biogas also can substantially reduce smoke emission from fuel wood burning, improving outdoor as well as indoor air quality, as mentioned below, and the use of biogas slurry as fertilizer, particularly when combined with composting, can help reverse soil degradation.

1.7 Significance of the Study

The findings of this study will contribute to better understanding of the root causes of low adoption rate of biogas technology

The findings of this study could be used as inputs for decision-making by the policy makers, planners, non-governmental organizations, and implementers of bio-energy technologies and other projects of similar nature. Following the establishment of the National Biogas Programme in 2008 the findings of this study could expose some areas which need improvement as far as development of biogas programs is concerned.

In addition the findings would provide additional knowledge on the present literature on bio-energy technologies about the potential of agro-forest residues to be used as raw materials for renewable energy source. It is anticipated further that the study would also stimulate interest on more researches in the field of renewable energy sources.

Efforts to encourage clean energy has resulted in more than 20 percent of global power being generated by renewable sources as of 2011. But still one in five people lack access to electricity, and as the demand continues to rise there needs to be a substantial increase in the production of renewable energy across the world. (SDGs Uganda)

The achievement of long-term sustainable economic growth in the face of climate change is a primary concern in Uganda. The climate of Uganda is its most valuable natural resource and a major determinant of other natural resources like soils, water, forests and wildlife, as well as the human activities dependent on them. However, increasing emission of carbon dioxide and other greenhouse gases are changing the earth‘s climate. (NDP-II)

1.9 Conceptual Framework

The conceptual framework in the figure 1.1 below was generated and used by the researcher to relate biogas technology and the factors that influence its adoption as an alternative source of energy. This research pursued three objectives to assess the communities' knowledge about the biogas technology, to establish the decision making process about the biogas technology in the household with focus on gender, and to assess the perception and attitude of the communities' about biogas technology.

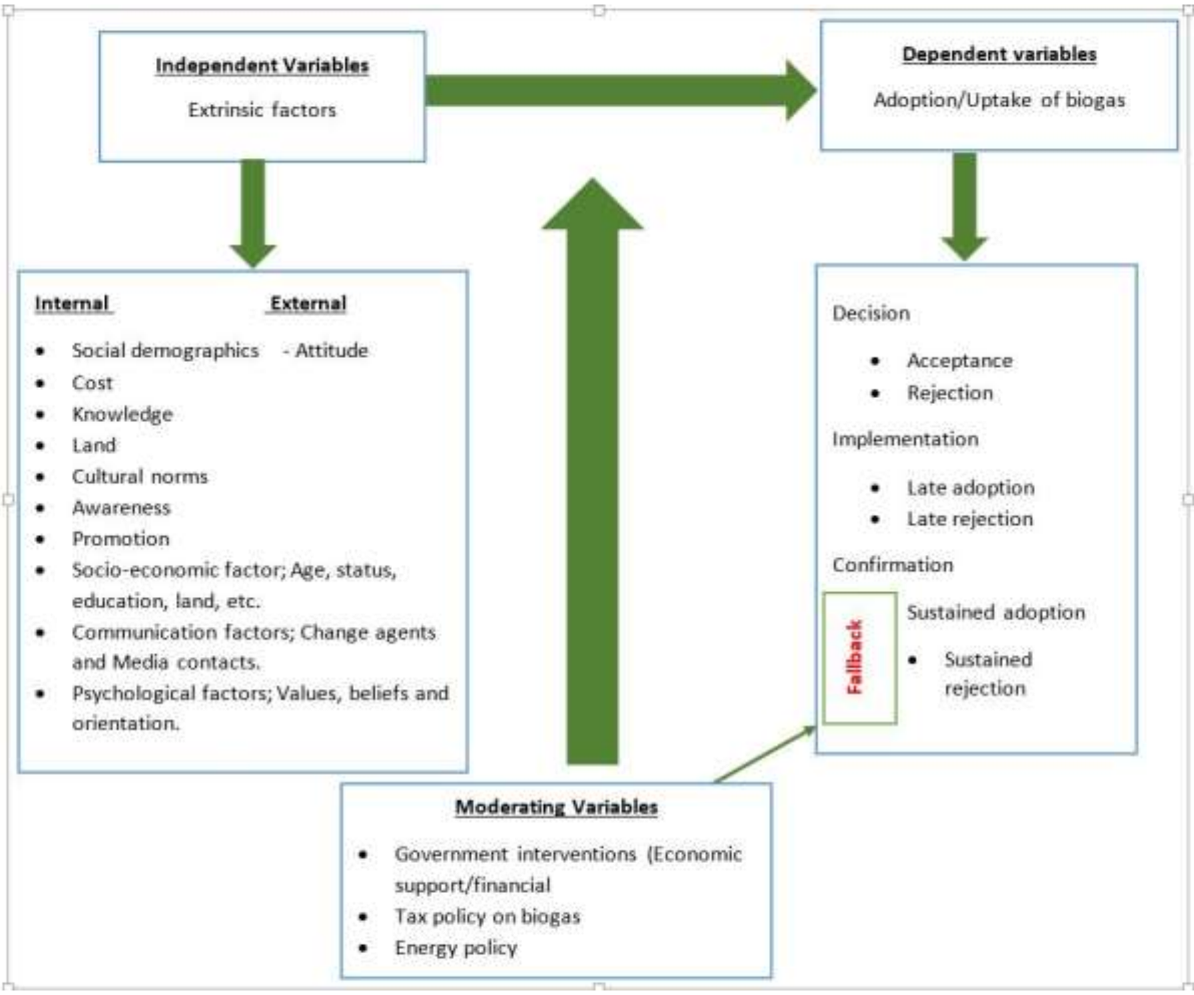


Figure 1. 1 Conceptual Framework

As demonstrated in figure 1.1 above adoption and use of the biogas technology is directly influenced by technical, economic, and social related factors. The technical factors such as installation cost of the biogas technology, cost of hire of a trained mason, maintenance of the plant and storage of the biogas energy directly influenced adoption and use of biogas technology.

Attitude and awareness towards adoption and use of the biogas technology also influence adoption and utilization of the biogas technology because it’s perceived that biogas energy is clean friendly and less costly. It was further perceived that due to the above characteristics of the biogas technology, embracing of the technology would enhance improved health, improved rainfall pattern, improved food security, improved forest cover, provision of fodder for animals and manure from Bio slurry. When people are aware and informed of the benefits of biogas technology, they may be compelled to opt for it as an alternative source of energy. As this factors play out in determining whether adoption will be there or not, there exist institutional factors such as extension, policy and regulations and credit provision.

1.10. Definition of terms

Attitudes: The opinion about biogas fuels

Biogas fuel adoption: Use of biogas fuel

Gender: the state of being male or female (typically used with reference to social and cultural differences rather than biological ones).

Extension services: Agricultural extension is the application of scientific research and new knowledge to agricultural practices through farmer education.

Kigozi et al, (2014) defines Biogas as an odorless gas produced by anaerobic digestion (AD) of biomass using microorganism. It has an approximate composition of 50-70% methane, 30-50% carbon dioxide and other trace gases depending on the nature of the biomass.

Rogers, (1995) defines technology adoption as the level at which an innovation is chosen to be used by a person or an organization.

Extrinsic Factors: These are factors that occur outside the person – these factors include physical environment, cost, knowledge, land, cultural norms, Awareness, promotion, Social economic, communication, psychological factors like belief.

Intrinsic Factors: originating with the individual - includes Attitude, decision making process, implementation.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

The chapter reviews various studies conducted in the area of biogas technology from global to local scenarios. This literature provided an overview of how biogas technology and energy is used around the world. This chapter presents what other researchers have found about the adoption of biogas technology as a source of energy**.** A literature review was done to identify any gaps that other researchers did not fill about the communities knowledge on the adoption of biogas technology, effects of decision making process in households affect the bio gas adoption and as well the effect of the attitude of the communities about biogas technology adoption were identified and filled these gaps as identified.

2.1 Bio Gas technology adoption in Uganda

Uganda being an agricultural-based country, she possesses large quantities of crop residues and animal wastes. They are largely unutilized as alternative fuel sources but to a good extent as manure. Crop residues are burnt in fields as a means of disposal while animal wastes are left to decay without control hence emitting gases such as methane, a potential greenhouse gas to the atmosphere hence contributing handsomely to global warming (Sebitt et al., 2004). Biogas energy production and utilization still do not have a foothold in Uganda and the socio-economic and environmental potential of the technology has largely remained elusive. The reasons for this trend remain by and large obscure.

Biogas energy, a clean and renewable form of energy, could augment conventional energy sources because of its environment friendliness allowing for efficient waste utilization and nutrient recycling (Bhat et al., 2001). Generally, biogas digesters have come to symbolize access to modern energy services in rural areas and are slated to considerably improve health and sanitation, and to yield significant socioeconomic and environmental benefits (Srinivasan, 2008). It is a versatile source of energy which meets several end uses, including cooking, lighting and motive power generation (Rubab and Kandpal, 1995). When used as a cooking fuel, it provides for better combustion than the less efficient cooking fuels like fuelwood. It is comparatively clean and hygienic (Jingura and Matengaifa, 2008) because bacteria and other pathogens are destroyed through anaerobic treatment.

The economic prosperity and quality of life of a country are closely linked to the level of its per capita energy consumption and the strategy adopted to use energy as a fundamental tool (Amigun et al. 2008). However, like in many developing countries, there is over-dependence on a few conventional energy sources such as biomass (firewood, charcoal and crop residues), petroleum products and grid electricity as the driver of economic development. Energy plays a central role in national development process as a domestic necessity and major factor of production, whose cost directly affects price of other goods and services (Amigun and von Blottnitz, 2007)

In his study Quality and Usage of Biogas Digesters (Lutaaya, 2012) established by 2009 Uganda Traditional biogas in Uganda was the major contributor to the energy balance of the country with over 90% of the energy needs of the country being met by traditional biomass. This was not sustainable and has led to the disappearance of the country's forest cover and draught which have left the population homeless and without food (WEO, 2009).The fuels are mainly used for heating and lighting in households and institutions such as schools and hospitals, commercial settings such as restaurants and hotels; and small scale industries such as lime, bricks and tiles making, agro based industries (tea, tobacco) and fish smoking (Sebitt et al., 2004). Most biogas systems that are built in Uganda use cow manure as the main source of substrate for the system

According to a report of the Uganda Domestic Biogas Program (UDBP, 2010) biogas technology has been present in Uganda since 1950 and by 2008 the estimated number of systems was around 800 a great improvement over the 100 that were estimated to exist in 1990. The same source also point out that the failure rate can be estimated between 15-20%, and the main causes for failure are limited skills by the constructors of the systems and an inadequate operation and maintenance by the household. The report also points out that the main barriers for the diffusion of this technology have been a lack of technical capabilities and the comparatively high upfront cost (M Ghobakhloo - 2012).

Agricultural residues have been used for generation of heat and light in Uganda through direct combustion of the solid fuels (Lutaaya, 2012) and biogas generated from anaerobic digestion processes. They are however utilized by a very small portion of the population. On contrary Sebitt et al., (2004) established that direct combustion of agricultural residues is not only inefficient but also inconveniencing because of the low fuel density and the requirement for large storage facilities yet the use of biogas is convenient, clean, fast and efficient. However, the puzzle remained in the why communities in Mbarara were not adopting bio gas thus necessity the study

Moreover, Sebina, (1998) observed that while it was very encouraging that fuel saving devices had been developed (e.g. charcoal stove), it was sad that the rate of fuel saving trails far behind the ever increasing demand for fuel resulting from rapid population growth. This meant that there will always be an inexhaustible demand of wood for fuel by the population which will lead to more destruction of forests leading to an environmental imbalance. He further noted that while tree planting has been carried out and promoted, this method alone cannot achieve the desired goals because of a lag phase between when trees are planted and when they are mature. There as a result of this phenomenon, an independent method of fuel production should be encouraged so that even deforested areas are left to regenerate

2.1. Theoretical Frame Work

The study is guided by Technology Acceptance Model (TAM). The main assumption of the TAM model is that when an individual forms an intention to act, they will be free to act without limitation (Davis, 1989). However, it is known that in real life situations there are constraints such as limited ability (cognitive, psychomotor or materials), time, environmental or even organizational Issues, and unconscious habits that will limit the freedom to act.

The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use the same. TAM helps to understand the role of perceptions such as usefulness and ease of use in determining technology adoption and holds forth that external variables influence behavioural intention to use, and actual usage of technologies, indirectly through their influence on perceived usefulness and perceived ease of use. Perceived risk is taken as a direct determinant of attitude towards adoption of technology; in relation to this, the perceived usefulness and perceived ease of use are taken as direct determinants of attitude (Davis, 1989). This model is relevant as it helps in understanding the attitude of the household as shaped by the environment they live in and how this on the other hand influences their attitude towards adopting biogas technology.

Perceived usefulness (PU) was defined by Davis (1989) as "the degree to which a person believes that using a particular system would enhance his or her job performance". The technology acceptance model has identified the role of the perceived usefulness and perceived ease-of-use constructs in the adoption process of new technology. Whereas past research has been valuable in explaining how such beliefs lead to system use, it has not explored how and why these beliefs develop. TAM represents an important theoretical contribution towards understanding usage and acceptance behaviour.

Concern Based Adoption on Model (CBAM) by George, J-I all and Stiege Ibauer (2006) postulates that individuals have certain concerns that they always feel need to be addressed as they prepare to adopt new technology. The model mainly concerned itself with change implementation at system level and not the individual. It is model that can help change agents (supervisors, change leaders) to understand the dynamic process of change particularly how individuals respond to change and how the right corrective actions are taken to facilitate the success of the change initiative. The main tenets of the model are as follows: that it is important to understand how people typically respond to, or think about change; and that change initiatives are more successful if they are implemented in a community of interested individuals (learning community), which creates a sub-culture of practitioners from whom other individuals can learn from. CBAM was selected to fill in the gaps left by TAM in that CBAM looks at the system as the main influencer for adoption while TAM looks at the individual. In this study CBAM was used to show how government policy can influence adoptions. According to this study it is assumed that the combined interaction of the two models have implications on the adoption of technology in general and the adoption of biogas technology in particular.

Contrary to the basic economic principles underlying this study stem from economic theory that attempts to estimate the economic value that individuals or households place on various goods, services and public programmes. The welfare implications resulting from households consuming a given good or service are often expressed in an index measured in monetary amounts which would need to be taken or given to the agent to keep the agent’s overall utility constant.

2. 2 Communities Knowledge about Biogas Technology

Biogas technology is considered as a sustainable renewable energy source that can be used for cooking, lighting, heating and power generation. It offers various benefits such as saving fuel wood and protecting forests as well as reduces expenditure on fuels. It further reduces household labor on time spend on cooking and housekeeping and improves hygienic conditions (Gregory, 2010) despite the enormous advantages that come with Bio gas, its uptake was low. It was important that a study was undertaken on the

While it's clearly understood that the capital costs of building a biogas plant are high, it has remained unclear why even people who can afford to pay for the technology have little or no knowledge of it and thus rely on other forms of energy such as generators, solar, kerosene and wood for their cooking and lighting needs (UDBP, 2009). Therefore there was need to carry out a survey on farmers in Mbarara to assess the effect of the communities knowledge about the adoption of bio gas. This would act as a basis for suggesting possible practical measures that could enhance the uptake of bio gas in Uganda.

Muvhiiwa et al (2016) observed that the technology involved in biogas production is fairly simple and can be implemented cheaply and efficiently by means of small-scale digesters that are easy to use and maintain. These household bio digesters can offer benefits to all spheres of society but have a particular bearing on the needs of farmers in rural areas. They can use the gas produced for cooking and lighting, for charging batteries from running biogas generators, and for fertilizing crops with the residual waste.

Education helps in improving beliefs and habits which in turn creates favorable mental attitude for acceptance of new practices (Omer & Fadalla 2003). Education also increases information acquisition ability thereby providing awareness knowledge to new technologies and beneficial practices. Despite the fact that formal credit markets are becoming increasingly accessible to farmers, illiterates may find the complicated borrowing process and paperwork a major disincentive (Vien, 2011). Awareness about the technology also plays a major role in technology adoption. Arthur et al., (2011) acknowledged that lack of knowledge about the technology in Ghana greatly led to low uptake. Success or failure stories of previous installations can positively or negatively affect uptake. According to Gitonga (1997) information from satisfied users on how well their systems are functioning is enough to convenience other potential users to install their own. Where the systems malfunction, uptake will be low since other individuals who may be willing to install will get discouraged and shun away from such technology

The relationship between level of education and biogas adoption in a study by Mwirigi, Gathu and Muriuki (2018) about Key Factors Influencing Adoption of Biogas Technology in Meru County found out that the majority of adopters household heads (82%) were those that had attained post-secondary education and were literate enough to manipulate the bio gas system. The study further established that an increase in education level was positively (B = 0.451; p = 0.000) associated with adoption of biogas. This can be explained by the fact that education helps in improving beliefs and habits which in turn creates favorable mental attitude for acceptance of new practices. The study concluded bio gas knowledge also enhances analytical capability of information and knowledge necessary to implement new technology. In a similar way Mwakaje (2008) that the likelihood of adoption of biogas energy increased with more years of formal education of the household head in Tanzania. However Mwanje’s study tended to dwell more on the formal education as a precursor of the adoption of the bio gas. There was a need to study the communities’ knowledge.

Once people are aware of the technology and accumulate knowledge on its benefits they develop a positive attitude towards the technology. In the case of biogas technology the benefits include clean energy and reduced workload of firewood collection for women and instead are involved in more productive work. In addition there is light for the house and refrigeration and others that improve life of rural people. Decreased deforestation is another expected benefit due to reduction of wood cutting for firewood consumption and charcoal making. Other benefits include decreased costs of energy requirements since there are monetary savings from purchasing kerosene and other costive energy, waste management and improved soil fertility by the use of bio slurry.

Accordingly, various organizations are trying to speed up the installation of biogas plants. Information about behavior, attitudes, and knowledge through regular surveys is essential to disseminate any technology to end user (SNV 2018). This is even more important for a country like Bangladesh where education level is very low and information pathway is very weak. (HIVOS 2018) Unfortunate, there is no information about livestock farmers' thinking on biogas plant in Bangladesh. Therefore, the present study was conducted to know the livestock farmers knowledge, perceptions and attitudes, toward biogas plant and compare it with people who are not involved in farming activities

Njoroge et al (2014) quotes a study by the Shell Foundation in 2007 cited several challenges facing the adoption of biogas technology that included poor management and maintenance emanating from lack of proper knowledge as intrinsic factors. For optimal production, a certain level of management both for the zero-grazing units and the digesters was needed but with so many competing uses for rural farm labour, management of the digesters was bound to suffer as an extrinsic factor. The findings indicated that households were content to get 'acceptable' and not' optimal' levels of production from their investments in the biogas technology.

In their study about the Social-Economic Factors Influencing Biogas Technology Adoption among Households in Kilifi County- Kenya, Momanyi, Ong'ayo and Okeyo (2016) as extrinsic factors and found out the low adoption of Biogas was attributed to low technical knowledge of both users and non- users. The study findings were similar to those reported by Rajendran, Solmaz and Mohammed (2012) who noted that lack of community knowledge as an extrinsic factor had hindered biogas dissemination and adoption. The problem of lack of technical knowledge as an extrinsic factor was also noted to have contributed significantly to failure of biogas plants in Ghana (Bensah & Hammond, 2010).

He further suggests that the lack of technical services as an extrinsic factor may be an indication of poor training by biogas promoters or lack of interest as an intrinsic factor from the respondents to learn more on the same. This is further expounded by Ngigi et al. (2010) who notes that without proper technical expert to help in the design, construction and maintenance of biogas digesters the technology may become difficult to embrace. Ngigi et al. (2007) further argues that neighbors are attracted by functional biogas digesters and attempt to build their own. However, it is imperative to note that biogas digesters are not as simple as they look. They must be properly designed and constructed by qualified personnel. An attempt by unqualified person only exposes the investor to losses and this discourages potential investors

Bensah and Hammond, (2010) observed that users of biogas plants had little or no knowledge of the functions of the biogas plant and this contributed more than any factor to the breakdown of most biogas plants in Ghana. Those who showed interest in this technology also lacked the technical support on construction and maintenance matters or any information they would have liked to know as a result of an extrinsic factor.

Nhembo, (2003) Education level is associated with greater access to information and enhanced capacity for creativity, so educated individuals are expected to be more aware of and have more knowledge on a new technology. According to Akinola and Young, (1985) knowledge reduces uncertainty and thereby induces adoption. However some skills are not correlated with years of schooling. Senkondo *et al.,* 1999 in their study found that adoption of rainwater harvesting technologies in western Pare was not significantly explained by education but rather by other factors like experience in farming and perceived technology benefits.

Panwar (2011) noted that Biogas has been acknowledged as being simple and cheap technology; it does not require imported knowledge or components and also is suitable for family and/or village scale use. Information dissemination is a key process in bringing awareness about the presence of a new technology. After being aware of a new innovation, people would accumulate knowledge and then test the innovation and adoption is expected to happen after people become satisfied with the results of the test

Furthermore awareness alone is not enough to influence the adoption of an innovation. According to Rogers (1995), awareness is just the first stage of adoption process, and it has to be followed by accumulation of knowledge which in turn induces the perception of people on the technology. The accumulation of knowledge is a result of continuous efforts of acquiring information concerning the introduced innovation. Responding to household interviews on knowledge of biogas technology

2. 3 The decision making process about the biogas technology in the household with focus on gender

Bakul *et al* (2014) indicated that the need for reliable and renewable energy sources is increasing day by day and with it is the revived interest in the biogas technology, especially when addressing rural cooking and lighting energy needs. However, there is no documentation available on how the models are approved thus, leaving the choice of model to the end users. This has resulted in promotion of the models based on the organization’s (governmental and non-governmental) expertise in constructing certain models rather than the informed choice of the end user. One of the answers to these questions, is a multi-criteria decision making tool which can aid in the promotion of different biogas technologies on the basis of several socio-economic-environmental criteria may be able to address these question

Unbiased decision making in modern times is guided by the development of models by decision makers commonly referred to as Decision Support (DS) tools Kirby and Mavris (2000). DS tools are usually presented in the form of computer programs into which data variables are fed to yield results that aid the decision making process. Organisations apply DS tools in acquisition of assets, recruitment, and risk analysis among others. Technology designs are most often probabilistic in nature and the evaluation criterion is multi-dimensional therefore the decision making on technology selection calls for complex decision support tools that can capture all the dimensions of a decision problem hence the employment of project specific techniques

Continuous social pressure on the farmers channel the decision--making process towards an investment in biogas. Capacity building of the sector's key stakeholders, and creation and capacity building of additional service companies is key for further scaling in the market, as well as for demand and high quality supply creation. This includes awareness raising activities to assist the commercial sector in creating demand.

Chai , Liu and Ngai (2012) noted that decision making process could take Multiple-criteria Decision Analysis (MCDA) approach or Multiple criteria Decision Making (MCDM) is an approach where decision makers, make recommendations from a set of finite seemingly similar alternatives based on how well those alternatives rate against a pre-defined set of criteria. In MCDM, six steps are followed during the selection procedure. They are as follows: Definition of the problem and its alternative solutions, Identification of the stakeholders, Definition of selection criteria, and Selection of the technique of preferences aggregation, Evaluation of solutions in respect to each selection criterion and, Search for a consensual solution

Although international organizations and communities are striving hard to provide clean energy to the impoverished households in developing nations, but still the future of these technologies is uncertain. According to Rogers 2002, even after the adoption the technology passes through the complex stage of implementation and confirmation. In particular, the biogas technology, which though has benefits, has been expensive at rural household level. So, it is essential to understand the adoption decision of biogas by not only taken into account the household demographic and socio-economic characteristics but also how this process affects the adoption of biogas technology.

A study on Development of Biogas Energy and its Impact on Users in Rural Nepal by Tulasi (2013) shows that households decision making on plant installation, toilet attachment and site and company selection were always discussed between male and female before commissioning the biogas plants however, males had played the leading role. Women's sub-ordination and their passive role in decision making process of plant installation, company selection, and other pre plant installation activities were evident. Very few women had access to the activities like marketing and decision making for the installation of biogas plants. The decisions made on biogas plant installation were male dominated. Female participation and their role was higher in site selection (40 percent), and toilet attachment (42.5 percent), in comparison to other activities. This study gave a hint on what could have been a limiting factor on the adoption of the biogas technology in Uganda

Adoption of technology at household level is a complicated process and there is no theoretical basis to select the independent variables which affect the decision to adopt or not (GACC 2011). The size of a household may influence the adoption decision because maintenance of biogas is labour intensive (Walekhwa, Mugisha and Drake 2009). A big family with many children and a few adults are less likely to adopt biogas for lack of manpower.

In a study by (Muzamil and Akhtar 2008) in India, it was established culturally that a woman does not play any significant role in decision-making such being an intrinsic factor. This is natural in the context of rural areas in India where important decisions are usually taken by the males in a family (Muzamil and Akhtar 2008). Equally so, the study by Daisy, Kishor and Atanu (2017) on who adopts biogas in rural India which found out it has been found that wealthy people are more likely to adopt biogas compared to the marginalized section of the society, contradicts the findings of Walekhwa, Mugisha and Drake (2009) which shows that women are not refrained from adoption of biogas in a different way in Uganda. The researcher thus wondered if then the women were not refrained from biogas technology adoption, who could be adopting technology and whose decision is it a household level. This gap could only be filled through such a study.

According to Simon (2006) after the initial stage of awareness and knowledge the potential adopters are still faced with the decision whether or not to adopt a technology. In the case of biogas technology the decision is influenced by various factors including socio-economic factors such as education level, age, household size, income level gender and the main economic activity of the household head. These characteristics are determinants of the individual’s ability to receive information, knowledge and perception towards the technology benefits which in turn influence one’s decision to adopt the technology or not.

The awareness level as a result of continuous knowledge influences peoples’ attitude towards the new technology. Attitude is a crucial element in implementation of the technology and it can be a powerful activator or a barrier towards adoption of a technology (Abukhzam and Lee, 2010).

Another attitude response from discussions above is perception differences in the uses of biogas technology between men and women as discussed under gender Section. Men perceived biogas technology as a modern energy source to supply electricity for electrical appliances like lamps for lighting, pressing iron, refrigerators for running small business while women perceived it as alternative energy for cooking to relieve them from firewood collection. This difference in perception has an implication on decision-making about adoption of biogas technology.

Kabir Yegbemey and Bauer (2013) point out that income, academic qualification, number of cattle and female-headed household significantly affect the decision of biogas plant installation. In addition to all such factors, cooking energy services may sometimes be affected by taste and preferences (Masera and Naviat 1997).

Similar results are found by Horst and Hovorka (2008) which show that traditional energy use is not driven by poverty. Rather, it is the result of active decision-making based on individual preference and broader/diverse lifestyle consideration. A group of social scientists finds that the success of projects related to biogas is determined to a great extent by the social mindset besides income. It is so because social perception may deter them from using a technology which uses wastes and excreta in sub-Saharan Africa (DFID 2012).

More fundamentally, critics also argue that a democratic process of decision making is not al ways compatible with local decision making practices (Pardhun, 2011).

2.4 Attitude of Communities about Biogas Technology Adoption

Eagle, and Chai ken (1993) noted that Attitudes are theoretically conceptualized as either "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" or as the strength of the memory association between a given object (to be understood in a broad sense) and a summary evaluation (in terms of liking) of the object. The former definition is limiting as it relates the term attitude to any momentarily activated evaluative response, which can typically be expressed to most objects. The latter definition focuses on memory associations, which means evaluative knowledge represented in memory. Then, just as one can associate “nurse” with “white”, a farmer can be expected to associate “compost” with “soil fertility” (among other objects).

According to Campbell (2006) attitudes and their associated behaviours are inseparable aspects of the same latent disposition. A farmer working hard towards the goal of improving soil fertility conditions is then anticipated to have a strong positive attitude towards technology. Moreover, a farmer with a strongly expressed attitude (behavioural disposition) towards ISFM is anticipated to carve out a set of ISFM behaviours consistent with their disposition. Behaviours in that case are a “transitively ordered set of means to implement different levels of attitudinal goals”

This study was undertaken to assess the effect of Attitude of Communities about Biogas Technology Adoption. Ghimire, (2013) observed that Biogas benefits include time and money saved, reduced workload, health and quality of life. Equally Sovacool et al., (2015) found out that women are the main beneficiaries within a family of biogas technology. In the rural areas, 90% of energy is used for cooking. Women are normally responsible for cooking (Rowse, 2011). When rural households use biogas, firewood consumption decreases on average by 53% (Rowse, 2011). With these findings, and in respect to the low adoption of bio gas technology it was worthwhile taking a study.

Biogas plants do not require big capital to set up and offer solutions to existing environmental problems and many unexpected benefits besides (Drabez et al., 2009). In other studies, a critical factor for rural communities in order to adapt to climate change effects is to develop human and financial capacity through the delivery of energy that is both affordable and reliable (Casillas and Kammen, 2010).

One of the variables measured in this research is the attitude of the rural population towards biogas technology. It is instructive to note that attitudes are evaluative statement either favorable or unfavorable concerning objects, (Njoroge et al, 2014) people or events. Attitude reflect how one feels about something. A person acquire attitude in the course of his or her experience and maintains them when they are reinforced. Thus, attitude are learned and not inherited and can be acquired in one or more ways, including direct experience with a particular object, which generates an attitude based on whether or not such experience was rewarding or punishing.

Biogas fuel is described as an excellent tool for improving life among local communities (Raskovic et al., 2009) and is investment, advanced one of many biomass energy sources which require more technology and resources than basic bio-digesters provide (Jury et al., 2010). This technology is a very good solution to local energy needs and provides significant benefits to human and ecosystem's health. The technology is also considered as a means leading to rural development (Raskovic et al., 2009).

Attitudes may also form by associating an object with another about which attitudes had been previously formed; or through learning from others. According to the social theory, an individual tends to comply with other referees' opinion (Bagozzi and Lee, 2002), thus, developing a positive attitude towards adoption of technology. Generally, attitudes which are acquired through personal experience tend to be more resistant to change than those learned from association or from others.

Adopting a technology in keeping with (Abukhzam & Lee, 2010) depends on numerous elements which purpose a targeted user to adopt or reject. They include; perceived usefulness and ease of use, facilitating conditions e.g. availability of government support and managerial support, technology readiness and social influence. These factors can make a positive or negative contribution towards technology adoption. Customers may also reject some technologies due to the fact that technologies are not in line with their values, beliefs and past experiences. Davis et al., (1989) argues that the successful implementation of any innovation is primarily determined by users' attitude. However, factors such as technology characteristics (e.g. perceived usefulness and ease of use, compatibility, reliability, security), organizational and managerial characteristics have been found to be key instrumental factors affecting users' attitude towards adoption or rejection of a particular technology.

Moreover awareness alone is not sufficiently adequate to induce adoption decision. Rogers (1995), defines technology awareness as just the first stage of adoption process followed by accumulation of knowledge which in turn influences peoples" attitude on technology. Knowledge accumulation is a continuous process of acquiring information on how the introduced innovation functions and its financial aspect

2.5 SUMMARY

In this chapter research work done by various researchers was reviewed and various information gaps revealed intended to be addressed. There seemed to be limited or no studies carried out in Mbarara district on biogas and therefore the study was intended to contribute to filling this information gap about the extrinsic and intrinsic factors affecting biogas as a technology in Mbarara district, this is a district that has a lot of cows so it's expected to have a lot of these technologies other than Karamoja with the highest number of cattle keepers / grazers. This study is to find out how extrinsic factors and intrinsic factors affect a technology from being adopted in terms of community's knowledge, attitude, and decision making process in a household that is with female or male headed.

CHAPTER THREE: METHODOLOGY

3.0 INTRODUCTION

In this chapter, the procedures used in conducting the study are presented. They include the study area characteristics, research design, target population, sample and sampling procedures, research instruments, validity and reliability of instruments, data collection and data analysis procedures.

3.1 Research design

The design used in the study was a cross-sectional survey. Cross sectional research design is a popular design that is widely used by researchers. Such a design allows collection of data on different groups of respondents at one point at a time. The design has greater degree of accuracy and precision in social science studies than other designs (Casley and Kumar, 2013). In this type of design, either the entire population or a subset thereof is selected, and from the sample population, data are collected to help answer research questions of interest.

Cross-sectional survey was suitable for this study because of its flexibility and its simplicity in collecting many types of information related to the use of various data collection methods. The design is also economical in terms of costs and time due to its ability to draw generalization about large population on the basis of representative sample (Krishna swami and Ranganathan, 2005). Data can also be used for simple descriptive interpretations using inferential statistics as well as determining the relationships between variables at a particular point at a time. In the case of this study data was collected from different groups including households, government officers and biogas project officers.

Cross-sectional studies provide a 'snapshot' of the outcome and the characteristics associated with it, at a specific point in time. Unlike the experimental design where there is an active intervention by the researcher to produce and measure change or to create differences, cross-sectional designs focus on studying and drawing inferences from existing differences between people, subjects, or phenomena.

3.2 Area of Study

This study was carried out in Mbarara district. The location of Mbarara districts in western Uganda is as shown on Map 3.2 and its profile as presented below. Mbarara is about 290 kilometers (180 mi), by road, southwest of Kampala, Uganda's capital and largest city. Mbarara is an important transport hub, lying west of Masaka on the road to Kabale, near Lake Mburo National Park. The coordinates of the Mbarara central business district are 00 36 48S, 30 39 30E (Latitude:-0.6132; Longitude: 30.6582). In 2002, the national census estimated the population of the town at 69,400. The Uganda Bureau of Statistics (UBOS) estimated the population at 82,000 in 2010. In 2011, UBOS estimated the mid-year population at 83,700.In August 2014, the national population census put the population at 195,013. Soils, Generally Sandy, clay and slightly laterite loams. Vegetation, Generally grassland and woodland savannah with patches of forest mineral resources.

Figure 3: Map Showing Mbarara District study Area

Mbarara District is part of the Ankole sub-region. The districts that comprise Ankole include: (a) Buhweju District (b) Bushenyi District (c) Ibanda District (d) Isingiro District (e) Kiruhura District (f) Mbarara District (g) Mitooma District (h) Ntungamo District (i) Rubirizi District (j) Sheema District.

The area covered by the above districts constituted the traditional Ankole Kingdom. In 1967, Milton Obote abolished the traditional kingdoms in Uganda. When Yoweri Museveni re-established them in 1993, Ankole did not re-constitute itself.

Mbarara district consists of one municipality (Mbarara Municipality), and nineteen rural sub-counties, organized into two counties. Mbarara District covers a land area of 1,778.4 square kilometers (686.6 sq. mi), with an average elevation of about 1,800 metres (5,900 ft.) above sea level. The district receives an average annual rainfall of 1,200 millimetres (47 in). Temperatures range between 17 °C (63 °F) and 30 °C (86 °F).

The district is subdivided into one municipal council, Mbarara Municipality, and 19 sub-counties, namely: 1. Kashari 2. Bubaare 3. Bukiro 4. Kagongi 5. Kakiika 6. Kashare 7. Rubaya

8. Rubindi 9. Rwanyamahembe 10. Biharwe 11. Kakoba 12. Kamukuzi 13. Nyamitanga 14. Rwampara 15. Bugamba 16. Mwizi 17. Ndaija 18. Nyakayojo 19. Rugando

The relevance of this study was to find out the extrinsic and extrinsic factors affecting the adoption of biogas in Mbarara district in Western Uganda since the district has many cattle keepers.

3.3 Study Population

The target population of the present study was the households for they are the potential adopters of biogas technology. The study population included farmers rearing cattle and banana growers totaling to 384. It is from this population that the sample was calculated to represent the entire population in the study area. The district was selected because of the biogas technology being implemented by SNV and Biogas solutions Uganda Limited (BSUL) program interventions: one Subcounty was selected for quantitative (using structured questionnaires) and qualitative interviews (FGDs and KIIs) while other sub counties in the district where the program had just commenced its activities was selected and targeted for collection of qualitative data.

3.4 Sampling Procedures

Sampling is the procedure a researcher uses to gather people, places or things to study (Orodho 2005).

A multi-stage sampling technique (combination of stratified and simple random sampling) was used in this study. The multistage sampling is a complex form of cluster sampling in which the population was divided into groups (4) then the required information was collected from sample elements within each group. The choice of this technique was guided by the following reasons;

The technique was convenient for studying large and geographically dispersed populations as well as populations whose list of the actual individuals to be studied is not available. It is easier to administer respondents as opposed to most single stage techniques mainly because the sampling frame under multi-stage is developed in partial units.

From the list of non-adopters of biogas technology given by parish chiefs, 10 names of heads of household were drawn in order to obtain a fair representation of the population under the study. Simple random sampling was employed to select households that are non-adopters of biogas technology. This was done by listing all the names of head of households on pieces of paper and randomly selecting 10 names for interview in each selected village within the district

3.4.1 Study population and Sample Size

Selecting the appropriate Sample size remained important for this study to ensure obtaining accurate results for generalization. However, there was lack of information on the accurate population size of the farmers that used biogas within the district. Hence, the researcher calculated the projected population size to facilitate determining the sample size for the study. The calculation of the projected population size based on the following elements. a) Margin of Error (Confidence Interval) —margin of error of +/- 5%, b) Confidence Level —the most common confidence intervals are 90% confident, c) Standard of Deviation — 50% and lastly Z-Value of 1.96. These procedures follow below.

i. Population Study

$$\boldsymbol{N = (Z - Score)^2 * SD * \frac{(1 - SD)}{(ME)^2}}$$

Where:

N= required population size (?)
Z= 1.96
Standard Deviation (SD) = 0.5 or 50% of the population proportion
Margin of Error (ME) = 0.05
Confidence level 95%

$$N = (\ 1.96)^2 * 0.5 * \frac{(1 - 0.5)}{(0.05)^2}$$
$$N = (3.8416\ ) * 100$$
$$N = 384$$

ii. Sample size (n) estimation

$$\textbf{True Population } \boldsymbol{TS = \frac{(n * N)}{(n + N - 1)}}$$

Where:

TS= True sample size (?)

n=Sample size (assumed same as N = 384
N= Study population (384)

$$TS = \frac{(n * N)}{(n + N - 1)}$$

$$TS = \frac{(384 * 384)}{(384 + 384 - 1)}$$

TS= 196

3.4.2 Sampling Techniques

The researcher used both probability and non-probability techniques

Table: Sample size and Selection Technique.

Category	**Target population**	**Sample size**	**Sampling technique**
Local leaders	30	5	Purposive sampling
Cattle farmers	122	80	Simple Random Sampling
Crop growers	100	80	Simple Random Sampling
Businesses	112	27	Simple Random Sampling
Key Informants	20	4	Simple Random Sampling
Total	**384**	**196**	

Data Source: Mbarara Local government

3.5 Data Collection Methods and Instrument

3.5.1 Methods

Primary data was collected using focus group discussion interviews to a target population using different methods of data collection like use of the questionaires. Primary data related to respondents' and study area characteristics, analysis of biogas technology such as adopters and practicing, adopters and not practicing, and those not adopted and not practicing. Factors influencing adoption and non-adoption, and people's awareness and attitude towards bio-gas technology. Also data relating to promotion of biogas technology in the study area by the government and other stakeholders was collected from the respondents during the household survey.

Secondary data was collected from various sources such as government officials at district and national levels and from NGOs reports, libraries, institutions and websites, journals and then used to complement information obtained from respondents. Secondary data collected was provide background information on energy situation in the country, on biogas technology, policy issues related to adoption of biogas technology, factors affecting adoption and non-adoption; and promotion of biogas technology.

Both qualitative and quantitative approaches were employed due to the nature of the study. The study involved assessing attitudes and behaviors of individual households that assumed to have influence adoption of biogas technology. The qualitative approach was to enable the researcher make an in-depth investigation of the variables related to adoption and non-adoption of biogas technology.

A combination of methods was used to collect both qualitative and quantitative data. This included structured and semi structured interviews, checklists for focus group discussions and field observations. The use of a combination of methods in data collection was due to diversity of information that the study required to achieve the objective of the study.

The method of interviewing involved oral questioning, and face to face interaction between the researcher and selected staff to collect data which could not have been got from questionnaires. Interviews were used because they both have the advantage of ensuring and probing more information, clarification and capturing facial expression of the interviewees (Amin 2005).

Interviews were used because it was easy to fully understand someone's impressions or experiences, or learn more about their answers to questionnaires. According to Mugenda

(1999), interviews were advantageous in that they provide in-depth data which is not possible to get when using questionnaires. All the tools were pre-tested using a near by district.

3.5.2 Data Collection Instruments

Questionnaires

A questionnaire is a series of questions asked to individuals to obtain statistically useful information about a given topic. The questionnaires were used because the respondents fill them at their own convenience and are appropriate for large samples. Some questions for the study were close ended.

Respondents were required to respond to the statements by indicating whether they strongly agree (SA), agree (A), were undecided (UD), disagree (D) or strongly disagree (SD). The responses were assigned to a like scale. In this case the individual positivism or negativism was indicated by one's agreement or disagreement with the statements. For easier assessment, responses of "strongly agree" and "agree" were combined to show the agreement therefore positive towards the technology while responses "disagree" and strongly disagree" were combined to show disagreement therefore negative towards biogas technology. Responses of 'undecided" were included in the analysis and were considered to indicate the lack of knowledge or disability to weigh advantages and disadvantages of biogas advantages hence ignorance which will be assumed to contribute to non-adoption of biogas technology.

Apart from the afore-mentioned descriptive statistics, more focused empirical investigation was employed to confirm the existence of the relationships among variables. The logistic regression model and multiple linear regression model was used to predict and determine the factors affecting adoption and non-adoption of biogas technology. The main motivation of using multiple linear regression model is that the model is commonly used by researchers to analyze adoption problems due to rational behavior of the households which leads to the discrete nature of management decisions Based on rational behavior, households are confronted with a decision whether to adopt a technology or not. In the present study households with positive reactions towards adoption of bio-gas technology was classified as “adopters” while those with negative reactions was classified as “non-adopters”. The observations were coded “1” for adopters and “0” for non-adopters and will be used as a dependent variable.

The statements were designed to capture respondents’ opinions on the advantages and disadvantages of biogas technology. The assumption was that if the respondent was knowledgeable and recognized the advantages of biogas technology; his or her attitude towards biogas would be positive and would adopt the technology.

3.6 Quality Control

To ensure the appropriateness of the research instruments, content validity index was determined at 0.79 a value that exceeded the threshold of 0.7, suggested by Amin (2005), for instruments acceptance. A panel of judges attested to the content validity of the instrument (Sekaran2003:2006) especially the supervisor. Content validity refers to the test which actually measures or is specifically related to the traits for which it was designed. It shows how adequately the instruments sample the universe of knowledge, skills, perceptions and attitudes that the respondents were expected to exhibit.

Reliability is the degree to which measures are free from error and therefore yield consistent results (i.e. the consistency of a measurement procedure) (Kimberlin and Winterstein, 2008). To ensure reliability, the researcher carried out a pre-test of the instruments on some selected respondents

3.7 Data Management and Processing

Data was collected coded and entered into the Statistical Package for Social Sciences (SPSS) versions 20.0. The data was collected using questionnaires were listed, coded and compiled in accordance with the study objectives to ensure completeness, and the questionnaires filled to harmonize the findings

3.8 Data Analysis

Both descriptive and inferential statistics techniques was used to analyze the data. A substantial part of the analysis was based on descriptive statistics such as frequencies, cross-tabulations, These statistics were used to determine and to assess the following aspects: respondents' characteristics, their awareness and attitude towards bio-gas technology, factors influencing adoption and non-adoption of biogas technology, probability that someone will adopt to biogas technology, and assessment of the adequacy of strategies for promoting adoption of bio-gas technology in the study area. The statistics were used to assess people's opinions, knowledge and insights regarding biogas technology,

Furthermore an analysis of decision making process and attitude at household level in regards to biogas uptake was undertaken in order to estimate the level of decision making and attitude towards biogas technology, sampled population were asked to indicate whether they find biogas technology beneficial or not.

Using linear regression which measured the level of influence of the variables under the study was performed and results interpreted at 0.05% level of significance

3.9 Measurement of variables

The measurement instrument serves as reliable sources for the design of questionnaires (Welman and Kruger 2004: 142-148). The researcher developed questions scales for each of the variables from the conceptual framework based on the literature reviewed. A nominal scale was used to measure the variables requiring yes or no responses.

3.10 Ethical Consideration

The researcher followed the ethical standards to plan, collect, and process and interpret data in line with conventional research norms. The researcher took ethical concerns about the copy rights respect and ownership of intellectual property to avoid plagiarism. This was very vital while making references to other people's studies. Seeking consent from interviewees is the confidentiality of information received.

3.11 Limitations of the Study

The limitation of the study is its cross-sectional design. Therefore, firm conclusions about the directions of causality implied in the model cannot be drawn. Thus, relationships among variables must be interpreted with caution. True causal inferences can only be drawn testing models using longitudinal data. This is especially important for a subject like adoption that is not static but a process that changes over time.

The present study relied largely on quantitative methodology of data collection (though qualitative methodology was used to a limited extent) and is therefore restrictive. Therefore, more of qualitative methodology of data collection should be undertaken in future to provide wider perspective to the present study. For instance, the research design can employ case study methodology or content analysis to provide a holistic picture to the given subject.

The results from the analysis were limited to the one study district of Mbarara and therefore may not be generalized to all other districts in western Uganda. The respondents selected generated information only related to their respective district. Since the selected district was located in the western region of Uganda, its findings may not be generalized to all other districts in the region. The researcher found that there was very little on adoption of biogas technology and therefore the findings of the study will enhance awareness of the technology among the communities in Mbarara district.

CHAPTER FOUR: RESULTS AND DISCUSSION

4. 0 Introduction

This chapter presents the findings, analyses and discuss them in accordance with the literature review. The chapter presents the findings of the study, and the discussion in accordance with the objectives of the study which were as follows;

a) To assess the effect of communities' knowledge on the adoption of biogas technology

b) To establish the decision making process about the biogas technology in the household with focus on gender.

c) To assess the perception and attitude of the communities' about biogas technology

The respondent's opinion on adoption and utilization of biogas energy in Mbarara district was assessed in terms of the Extrinsic and Intrinsic Factors on the Adoption of Biogas Technology as a Source of Energy.

The chapter is divided into two major parts; the first part presents the bio data of respondents and the second part presents the findings on each objective.

4.0.1 Response rate

The response rate was computed to establish whether it was adequate for the generation of the required data. Out of a sample size of 196 respondents, 186 (95%) managed to respond to the questionnaire instrument, while 10 respondents, that is 5% Failed to get time to answer questionnaires. According to Amin (2005), a response rate of over 80% is adequate enough to facilitate a research study.

4.1 Background information of the respondent

4. 1 Table showing respondents Bio data

Respondent's distribution by gender (N=186)	**Frequency**	**Percent**
Male **Female**	71 115	38.2 % 61.8%
Respondent's distribution by age group (N=186)		
18 to 35	35	18.8
36 to 49	107	57.5
50 to 63	33	17.7
Above 64	11	5.9
Respondent's distribution by Level of Education (N=186)		
Primary	27	14.4
Secondary	93	49.7
Post-Secondary	66	35.3

Source: Primary data, 2018

4.1.1 Gender of respondents

The female to male ratio was high that is 61.8% of respondents was female compared to 38.2% female. This was partially because one-third of households are headed by women (GACC, 2017) and more so, the bio gas being used for cooking, women were more available to respond to the study compared to men. More so as Walekhwa, Mugisha and Drake (2009) observed, women are not refrained from adoption of biogas in Uganda. However, the study equally generated responses from men as well. This was to ensure that opinions of both males and females inform the findings of this study.

4.1.2 Respondent's distribution by age group (N=186)

Age was an important factor in this study. As (Walekhwa, Mugisha and Drake 2009) noted, a family with many children and a few adults are less likely to adopt biogas for lack of manpower. For this study the findings indicated that the majority respondents (57.5%) were aged 36-49 years compared to 18.8% respondents who were aged between 18 and 35. On the other hand, 17.7% were aged between 53 to 63 years and 5.9% were above 60 years. The findings show that this study drew respondents from both the youth, adults and senior citizens. This was done following the observation by Simon (2006) who noted that the case of biogas technology the decision is influenced by various factors including socio-economic factors such as education level and age. Therefore, it was important to draw respondents from various age groups to allow the blend of ideas from the various categories of respondents about the extrinsic and intrinsic factors for adoption of biogas technology.

4.1.2 Respondent's distribution Education level (N=186)

Education level was a key factor to enable the researcher capture opinions of respondents in two ways; first to ensure that the respondents were literate enough to comprehend the items in the questionnaire and make sure that different levels of education give their opinions. This was in line with Mwirigi, Gathu and Muriuki (2018) who established that an increase in education level was positively ($B = 0.451$; $p = 0.000$) associated with adoption of biogas and that 82% of the Adoption of Biogas Technology in Meru County was made possible by post-secondary education holders.

In this study, 93 (50%) respondents representing the majority of the respondents were secondary school certificate holders while 66 (35.5%) of the respondents were post-secondary level and 27(14.5%) were at primary level. Nhembo (2003) observed that education level is associated with greater access to information and enhanced capacity for creativity, so educated individuals are expected to be more aware of and have more knowledge on a new technology. The findings of this study are by no means contrary to the observations of (Nhembo, 2010) since respondents were literate enough to appraise the study.

4.2 Findings on Study objectives

In this section, the researcher presents the findings on the extrinsic and intrinsic factors affecting the adoption of the biogas technology. The specific objectives were threefold; to assess the effect of communities' knowledge on the adoption of biogas technology, establish the decision making process about the biogas technology in the household with focus on gender and to assess the perception and attitude of the communities' about biogas technology. The findings generated from the respondents are hereunder presented, analyzed and discussed

4.2.1 Communities Knowledge about Biogas Technology as an extrinsic factor

The first objective of the study was to assess the effect of communities' knowledge on the adoption of biogas technology. This was conceived on the grounds that Biogas technology is considered as a sustainable renewable energy source that can be used for cooking, lighting, heating and power generation. It offers various benefits such as saving fuel wood and protecting forests as well as reduces expenditure on fuels. It further reduces household labor on time spend on cooking and housekeeping and improves hygienic conditions (Gregory, 2010) despite the enormous advantages that come with Bio gas, its uptake was low. It was important that a study was undertaken to assess the communities' knowledge about the bio gas technology so as to assess whether knowledge had an influence on the adoption of the biogas technology.

To gauge the respondents' knowledge about the biogas technology, they were asked if they knew bio gas technology as here presented

4. 2 Table showing Respondents answers to having knowledge about Biogas

	Responses	***Frequency***	***Percent***
	No	***33***	***17.7***
	Yes	***153***	***82.3***
	Total	***186***	***100.0***

Source: Primary data, 2018

The findings presented in table 4.2 show that 153(82.3%) respondents representing the majority affirmed that they knew biogas technology this concurs with Muvhiiwa et al (2016) who observed that the technology involved in biogas production is fairly simple and can be implemented cheaply and efficiently by means of small-scale digesters that are easy to use and maintain. Therefore having more respondents agree implied that bio gas was a technology that was known to them. However, it was paradoxical that despite having majority respondents knowing the technology, there were low adoption as indicated by the onsite visits by the researcher.

Only 17.7% of the respondents did not have knowledge about Biogas being an alternative source of energy for cooking. This is contrary to Rubab and Kandpal, (1995) who concluded that bio gas is a versatile source of energy which meets several end uses, including cooking, lighting and motive power generation known to many farmers. Therefore those who did not know the technology were not embracing it hence the cause for low adoption.

Although only 82.3% knew that Biogas is an alternative source of energy for cooking, when respondents were asked to tell what bio gas is to them, 184 (98.9%) were able to define it and only 2(1.1%) were unable to define what biogas is as shown in table 4.3 below

4. 3 Table showing Respondents Definition of about Biogas

Responses	**Frequency**	**Percent**
No response	2	1.1
Gas that is generated from decomposing organic materials	166	89.2
Gas used for cooking and lighting	18	9.7
Total	186	100

Source: Primary data, 2018

From the findings presented above, 166(89.2%) respondents knew biogas as gas that is generated from decomposing organic materials while 18(9.7%) respondents showed that biogas is that gas used for cooking and lighting. The findings concur with Abukhzam and (Lee, 2010) who noted that when the people's awareness level is high as a result of continuous knowledge, it influences peoples' attitude towards the new technology. However, on contrary it should be stated that majority of the respondents who knew biogas were not equally adopting it. More over majority (92) representing 49.5% had not seen a biogas plant as opposed to 54(29%) respondents and 40 (21.5%) did not commit themselves which is interpreted to mean that they equally had not seen it.

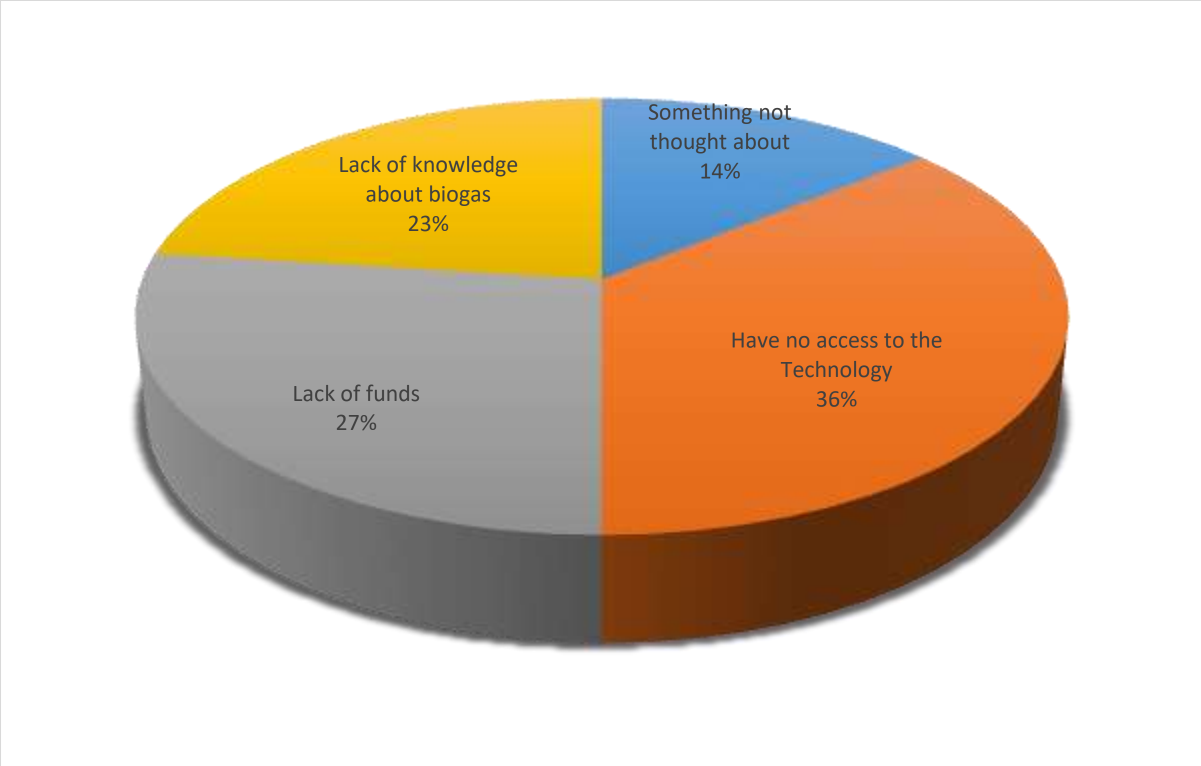
4. 4 Table showing Respondents that had ever seen a biogas plant

Responses	Frequency	Percent
No Response	40	21.5
No	92	49.5
Yes	54	29.0
Total	**186**	**100.0**

Source: Primary data, 2018

The findings contradict the observations by (Drabez et al., 2009) who showed that biogas plants do not require big capital to set up and offer solutions to existing environmental problems and many unexpected benefits besides. If this was true, then it would have been possible in Mbarara that over 70% of the respondents as shown above had not seen the biogas plant

Asked why they did not have biogas plants, 36% respondents showed that they have no access to technology while 27% indicated that there was a limitation of funding which concurs with (UDBP, 2009) who noted that it clearly understood that the capital costs of building a biogas plant are high, compared to other forms of energy such as generators, solar, kerosene and wood for their cooking and lighting needs



4.1 Figure showing reasons for not having biogas

Furthermore 23% of the respondents that they had negative attitude about the biogas and 14% attested that biogas is something they have not yet thought about. It is because of these

Despite the above reasons, given that most responds had knowledge about what biogas is about, the study intended to establish whether this knowledge affected the adoption of the technology since the study established that only 47.3 % of the respondents attested that they their communities had embraced it.

4. 5 Table showing how the community embraced the biogas technology?

Responses	**Frequency**	**Percent**
No response	1	.5
Very few have it	88	47.3
None	97	52.2
Total	**186**	**100.0**

Source: Primary data, 2018

The findings above indicate that the rate at which the community embraced biogas technology was adopted by 47.3% compared to 52.2% who did not have it. Given that fact that 82.3% knew about biogas but only 47.3% responded in affirmative that very few communities have it contradicts what Arthur et al., (2011) acknowledged that lack of knowledge about the technology in Ghana greatly led to low uptake. Therefore, it is seen that other than knowledge there are others limiting factors to the uptake of the biogas

However when the respondents were asked to show if **biogas would save them some time,**

4. 6 Table showing respondents who think having biogas would save some time

Responses	**Frequency**	**Percent**
No response	50	26.9
No	28	15.1
Yes	108	58.1
Total	186	100.0

Source: Primary data, 2018

The findings above show that 108 (58.1%) respondents were aware that biogas would save them some time. This showed that the respondents were aware of what biogas can do what it was thus important that a linear regression analysis was done to ascertain by what percentage this knowledge affected the adoption of bio gas technology

Table 4.7: showing model summary about communities knowledge

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.309[a]	.095	.090	1.37004
a. Predictors: (Constant), Communities Knowledge				

The linear regression model summary above indicates that communities knowledge explain 9.0% of the variance in the bio gas adoption among the farmers in Mbarara district (Adjusted R^2= .090). This shows that community's knowledge about the bio gas is significant predictors of the adoption as explained by 9% only. The adjusted R^2 provides an idea of how well the model generalizes the study variables and every researcher would like the Adjusted R^2 values to be the same as or close to R^2. For this study, the difference for the model is (0.095 – 0.090 = 0.005). The shrinkage of .005 (0.5%) means that if the model was derived from the population rather than a sample, it would account for approximately 0.5% less variance in the outcome.

The findings above show that the *r value* is only .309[a] with Adjusted R^2 of only .090 which show a low percentage. This is in agreement with Amigun and von Blottnitz, (2007) who noted that in many developing countries, there is over-dependence on a few conventional energy sources such as biomass (firewood, charcoal and crop residues), petroleum products and grid electricity as the driver of economic development. It is evident that whereas there was knowledge of the community about biogas this being an extrinsic factor was still high contrary to Arthur et al., (2011) Momanyi, Ong'ayo and Okeyo (2016) and Rajendran, Solmaz and Mohammed (2012) who found out the low adoption of Biogas was attributed to low technical knowledge of both users and non- users. This study ushered in a new set of knowledge which indicated that whereas the communities had some knowledge, it only explained 9% of biogas adoption, it means 91% was explained by other factors

The ANOVA table which reports how well the regression equation fits the data (i.e., predicts the dependent variable) indicates that the regression model predicts the dependent variable significantly well

4.8 Table showing Analysis of Variance (ANOVAa)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	36.354	1	36.354	19.368	.000[b]
	Residual	345.372	184	1.877		
	Total	381.726	185			
a. Dependent Variable: Biogas technology Adoption						
b. Predictors: (Constant), Communities Knowledge						

The above results indicate the statistical significance of the regression model that was run. Here, P=.000[b], which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable.

4.9 Table showing Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.664	.516		9.035	.000
	Communities Knowledge	-.058	.013	-.309	-4.401	.000
a. Dependent Variable: Biogas technology Adoption						

The above table provides the necessary information to how communities knowledge predicts the adoption of biogas technology , as well as determine whether contributes statistically significantly to the model shown by the constant (P=.0000) and predictor variable (P=.000<.0.05).

4.2 Decision making process about the biogas technology in the household as an intrinsic factor

The second objective of the study was to establish the effect of decision making process at household level on the adoption of biogas technology with a focus on gender. As noted (GACC, 2017), one-third of households are headed by women and it was established 85 % of Ugandans use unprocessed biomass and charcoal alone accounts for 13% of the population, mainly in urban and peri urban areas. Equally, Lutaaya (2012) noted that there is good potential for biogas in Uganda and its exploitation has been witnessed, but still its adoption was low and one of the challenges identified was decision making process to adopt it (Chai , Liu and Ngai ,2012). Therefore it was necessary to conduct this study to establish by what percentage decision making process at household level influenced the adoption of bio gas technology in Mbarara district

Both descriptive and inferential statistics were used to present and analyze the findings of the study as hereunder; this study was interested in establishing who makes decision making about space utilization at home.

4. 10 Table showing the decision maker about space utilization in a household

responses		**Frequency**	**Percent**
	Both	132	71.0
	Husband	52	28.0
	Wife	2	1.1
	Total	**186**	**100.0**

Source: Primary data, 2018

It was established that in most cases, (71%) both wife and husband make decisions about space utilization. This greatly concurs with Tulasi (2013) who showed that that household's decision making on plant installation, toilet attachment and site and company selection were always discussed between male and female before commissioning the biogas plants however, males had played the leading role. Indeed from the table above it is seen that 52(28%) of the respondents agreed that it was the husband who took most of the decisions about space utilization. In case the women needed to adopt biogas technology they had therefore to seek the approval of the husbands and it thus, if the husbands delay, and or do not approve, then the biogas technology adoption would be low.

Moreover a very small number of respondents (1.1%) indicated that women took decisions on space utilization which evidently agrees with Tulusi (2013) who concluded that women's play a passive role in decision making process of plant installation, company selection, and other pre plant installation activities. The decisions made on biogas plant installation were male dominated. It noted that similar results came from respondents about who takes decisions to buy materials

4. 11 Table showing the decision maker of buying materials and managing the digester

Responses		**Frequency**	**Percent**
	Both	132	71.0
	Husband	52	28.0
	Wife	2	1.1
	Total	**186**	**100.0**

Source: Primary data, 2018

The findings above show that 71% of the respondents agreed that in most cases both wife and husbands decide to buy and manage the digester materials together, however in some cases, it is entirely the husband's responsibility compared to only 1.1% of the women who make decision on material purchasing and consequent management of the digester. Having women however they are in taking decisions is contrary to the conclusion by (Muzamil and Akhtar 2008) in India that a woman does not play any significant role in decision-making. This was basically looked at in the context of rural areas in India where important decisions are usually taken by the males in a family. However, some of the observations of Muzamil and Akhtar (2008) are very evident in this study because men take 99% of the decisions related to biogas technology.

The findings above, both on space utilization, purchase of materials, and digester management show that at least women take part which is in agreement with Walekhwa, Mugisha and Drake (2009) who observed that women are not refrained from adoption of biogas in a different way in Uganda. Therefore, both husbands and wives were responsible for deciding where, and when to purchase the materials as well deciding who should manage the digester.

The study was further interested in establishing how often the discussion on biogas is done at the house hold level. It was established that very often, the discussion always took place as seen by the majority respondents below

4. 12 Table showing the frequency of discussions about biogas acquisition in the household as a family

Responses	Frequency	Percent
Always	133	71.5
Never	9	4.8
Weekly	29	16.6
Monthly	15	8.1
Total	**186**	**100.0**

Source: Primary data, 2018

From above table, 133 (71.5%) respondents agreed that at house hold level, there are always discussion about biogas acquisition in the household among families as much as they have not seen the technology but they discuss about the technology from what they hear on radio adverts. On the other hand 29 (16.6%) respondents indicated that there are weekly discussion within families as opposed to 15(8.1%) respondents who showed that they talk about it on monthly while 9(4.85) respondents had never talked about biogas technology.

The above findings are a clear indicator that several times, at house hold level, there is a discussion. However, it is also seen that actualization of the discussed matters takes months and months. The findings concur with technology acceptance theory by Davis (1989) who observed individuals from attention before they finally act and in this case to act is to embrace technology itself. Therefore the attitude that family members develop from the technology discussions at house level is an influencing factor that shapes the final decision to adopt biogas technology.

From the above, it was worthwhile to analyze the effects of decision making process on biogas technology adoption

4.13 Table showing the model Summary about decision making process

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.837[a]	.701	.699	.78822
a. Predictors: (Constant), Decision Making Process				

The linear regression model summary above indicates that Decision Making Process explain 69.9% of the variance in the bio gas technology adoption among the farmers in Mbarara district (Adjusted R^2= .699). This shows that community's knowledge about the bio gas is significant predictors of the adoption as explained by 9% only. The adjusted R^2 provides an idea of how well the model generalizes the study variables and every researcher would like the Adjusted R^2 values to be the same as or close to R^2. For this study, the difference for the model is (.701 - .699=0.002). The shrinkage of .002 (0.2%) means that if the model was derived from the population rather than a sample, it would account for approximately 0.5% less variance in the outcome.

The findings above show that the *r value* is only. 837[a] with Adjusted R^2 of only .699 which show a high effect means that the decision making process has a high effect on bio gas technology. This highly agrees that with Rogers (2000) who concluded that even after the biogas technology adoption passes through the complex stage of implementation and confirmation. So, it is essential to understand the adoption decision of biogas is by far a great factor that affects the adoption of biogas technology

The study by Tulasi (2013) had indicated that in Uganda, female participation and their role was higher in site selection (40 percent), and toilet attachment (42.5 percent), in comparison to other activities. This study clears the air and makes clearer that despite at household level, the process to finally adopt biogas explains 69.9%. Therefore the longer it takes the fewer the farmers adopting it.

When the study by Tulasi (2013) is up held, it would have meant that Women's sub-ordination women play a passive role in decision making process of plant installation, company selection, and other pre plant installation activities were evident and so the reason for low adoption. However this study shows that it is the entire household level decision making process that affect the uptake of biogas technology.

The ANOVA table which reports how well the regression equation fits the data (i.e., predicts the dependent variable) indicates that the regression model predicts the dependent variable significantly well

4.14 Table showing Analysis of Variance (ANOVAa)

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	267.410	1	267.410	430.414	.000[b]
	Residual	114.316	184	.621		

	Total	381.726	185			
a. Dependent Variable: Biogas technology Adoption						
b. Predictors: (Constant), Decision Making Process						

The ANOVA analysis above shows a statistical significance of the regression model that was run. Here, P=.000[b], which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable. Therefore a unit change in decision making process significantly affects biogas technology adoption at 0.05% level of significance

The findings are contrary to (GACC 2011) who concluded that adoption of technology at household level is a complicated process and that there is no theoretical basis to select the independent variables which affect the decision to adopt or not. It is clear that when the decision making process is done, its effect is significant

4.15 Table showing Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.749	.067		26.263	.000
	Decision Making Process	.084	.004	.837	20.746	.000
a. Dependent Variable: Biogas technology Adoption						

The above table provides the necessary information about how decision making predicts the adoption of biogas technology , as well as determine whether it contributes statistically significantly to the model shown by the constant (P=.0000) and predictor variable (P=.000<.0.05). Therefore, it its cleat that the beta value of .837 with P=.000<.0.05 show a high significant relationship between decision making and biogas technology adoption.

4.3 Attitude of the communities about biogas technology as an intrinsic factor.

The last objective of this study was to assess the effect of attitude of communities about biogas technology and how this attitude in turn affects the adoption. As Eagle and Charken (1993) noted, attitudes are theoretically conceptualized tendencies expressed by individuals through evaluation of a particular entity with some degree of favor. Therefore, the researcher too was driven by the same conviction that perhaps the communities do not have positive attitude towards use and thus the adoption of biogas. This is because as Campbell (2006) noted, attitudes are associated with behavior towards something which is an inseparable aspect of latent disposition.

4. 16 Table showing communities' attitude and opinion about biogas technology

Statements	Strongly Disagree %	Disagree %	Agree %	Strongly Agree %
It's easy, fast, and comfortable cooking			91.9	8.1
It saves money (No need to purchase charcoal)		7.0	82.3	10.8
It Liberates from collecting firewood from jungle (Saves time and efforts)			85.5	14.5
A very reliable energy source		3.3	93	3.2
Improvements in health and hygiene			87.6	12.4
Cattle Stable remains clean			99.5	.5
Saves Chemical Fertilizer			97.8	2.2
Reduces Tree cutting			97.8	2.2

This study established that communities have various attitudes about biogas for instance 186 (100%) respondents agreed strongly that biogas is easy fast and comfortable for cooking which greatly concurs with Sovacool et al (2015) and Rowse (2013) that among the other factors which contribute to the choice of biogas is that is conveniently available for cooking. It is easy to use and operate.

Moreover, biogas did not only prove an easy and comfortable way of energy use but it equally saved money. This was revealed by 93.1% of the respondents as seen above. The findings concur with Kabir, Yegbemey and Bauer (2013) that after installation, the digester user needs not to incur additional money to finance the undertaking.

Furthermore Gamire (2013) observed that biogas save both money and time and as well the work load. Therefore if farmers and communities have such an attitude it becomes a clear cut roadmap that their decision to adopt such technology is one time a possibility.

However, there were 13 (75%) respondents who disagreed that biogas saves money indeed biogas is capital intensive to the level of farmers in rural setting since it cannot be constructed at less than a million. Therefore, if farmers and other community members have such an attitude, it will be difficult to adopt technology. This is in line with Rodgers (2002) who indicated that in rural setting biogas is seen as an expensive venture.

More so Muvhiiwa et al (2016) observed that technology involved in having biogas operational involves heavy costs. This could in any way deter communities from swiftly adopting technology.

When respondents were asked to show whether biogas helps communities the hassle of collecting fire wood, 100% agreed the findings concur with Abukhzam and lee (2010) who noted that biogas relieves communities from bothering to collect fire wood. Moreover the researcher believes that biogas is at home and operates within the realm of organic items and thus communities use only those items at home and not putting pressure on the firewood from forests which in turn would have led to deforestation.

On a good note, 179 (96.2%) respondents agreed that biogas is a reliable energy source. This concurs with Kammen (2010) Ren 2017), Wilkinson et al (2009) as well as Bakul et al (2014 that biogas is a reliable and renewable energy source.

Therefore, having this attitude is good for adoption on contrary 7 (3.8%) respondents disagreed. This was indicator that such category of persons could not take up biogas since they do not see it as either renewable. Much as 100% of the respondents affirmed that it is healthy keeps cattle stable clean and saves chemical fertilizers. Also 100% of the respondents agreed that it reduces free cutting.

From the respondent's attitude above, it was worth while establishing the effect of this attitude on adoption of biogas technology. The analysis was done by linear regression and results presented here:

4.17 Table showing Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.837[a]	.700	.698	.78906
a. Predictors: (Constant),Attitude of the communities'				

The linear regression model summary above indicates that Attitude of the communities' explain 69.8% of the variance in the bio gas adoption among the farmers in Mbarara district (Adjusted R^2= .698). This shows that community's knowledge about the bio gas is significant predictors of the adoption as explained by 69.8% only. The adjusted R^2 provides an idea of how well the model generalizes the study variables and every researcher would like the Adjusted R^2 values to be the same as or close to R^2.

The findings above show that the *r value* is only .837[a] with Adjusted R^2 of only .698 which show a high effect of the predictor variable. This is clear that Attitude and awareness towards adoption and use of the biogas technology also influence adoption and utilization of the biogas technology. This study concurs with Technology Acceptance Model by (Davis, 1989) who noted that perceived risk is taken as a direct determinant of attitude towards adoption of technology; in relation to this, the perceived usefulness and perceived ease of use are taken as direct determinants of attitude (Davis, 1989).

As Eagle, and Chai ken (1993) noted attitudes are theoretically conceptualized as either a "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor". or as the strength of the memory association between a given object (to be understood in a broad sense) and a summary evaluation (in terms of liking) of the object as seen above 69.8% of the choice to adopt biogas is showed by the attitude of the communities

Equally (Omer & Fadalla 2003) noted that favorable mental attitude for acceptance of new practices is very important before it can be fully embraced. Accordingly it is seen that attitude accounts for a relatively high percentage of influence on biogas technology adoption.

Once people are aware of the technology and accumulate knowledge on its benefits they develop a positive attitude towards the technology.

The ANOVA table which reports how well the regression equation fits the data (i.e., predicts the dependent variable) indicates that the regression model predicts the dependent variable significantly well.

4.18 Table showing Analysis of Variance (ANOVAa)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	267.163	1	267.163	429.093	.000[b]
	Residual	114.563	184	.623		
	Total	381.726	185			
a. Dependent Variable: Biogas technology Adoption						
b. Predictors: (Constant), Attitude of the communities’						

The above results indicate the statistical significance of the regression model that was run. Here, P=.000[b], which is less than 0.05, and indicates that, overall, attitude of the communities the statistically significantly predicts the outcome variable (biogas technology adoption).

4.19 Table showing Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.243	.375		-13.975	.000
	Attitude of the communities’	.170	.008	.837	20.715	.000
a. Dependent Variable: Biogas Technology Adoption						

The above table provides the necessary information to how Attitude of the communities 'predicts the adoption of biogas technology , as well as determine whether contributes statistically significantly to the model shown by the constant (P=.0000) and predictor variable (P=.000<.0.05).

The findings strongly agree with Abukhzam and Lee, 2010 who noted peoples' attitude towards the new technology is a crucial element in implementation of the technology and it can be a powerful activator or a barrier towards adoption of a technology. Indeed if the people are not interested in something, they not put their interest to it

The researcher agrees with Njoroge et al, (2014) that a person acquire attitude in the course of his or her experience and maintains them when they are reinforced. Thus, attitude are learned and not inherited and can be acquired in one or more ways towards technology and thus can determine if they would take it up or not.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary, conclusions and recommendations of the study. The chapter draws conclusions from the research findings in line with the stated research questions. Recommendations are twofold; firstly, recommendations in accordance to the conclusions made on the study objectives, the study recommended areas that future researchers can undertake.

5.1 Summary of Research Findings

The main objective was to carry out an in-depth assessment of the extrinsic and intrinsic factors affecting the adoption of the biogas technology. Specifically the study was undertaken to assess the effect of communities' knowledge on the adoption of biogas technology, established the effect of decision making process about the biogas technology in the household and assess the effect of attitude of the communities' on the biogas technology adoption.

The study was conducted among 186 respondents out which 61.8% of respondents were female compared to 38.2% males. This was partially because one-third of households are headed by women (GACC, 2017) and more so, the bio gas being used for cooking, women were more available to respond to the study compared to men, Walekhwa, Mugisha and Drake (2009) observed, women are not refrained from adoption of biogas in Uganda. However, the study equally generated responses from men as well. This was to ensure that opinions of both males are captured.

Out of 186, respondents (57.5%) were aged 36-49 years compared to 18.8% respondents who were aged between 18 and 35. On the other hand, 17.7% were aged between 53 to 63 years and 5.9% were above 60 years. The findings show that this study drew respondents from both the youth, adults and well as senior citizens. This was done following the observation by Simon

(2006) who noted that the case of biogas technology the decision is influenced by various factors including socio-economic factors such as education level and age.

Using linear regression the study established that;

a) Communities knowledge explain 9.0% of the variance in the bio gas adoption among the farmers in Mbarara district (Adjusted R^2= .090). This shows that community's knowledge about the bio gas is significant predictors of the adoption as explained by 9% only.

   The findings above show that the *r value* is only .309[a] with Adjusted R^2 of only .090 which show a low percentage. This is agreement with (Amigun and von Blottnitz, 2007) who noted that in many developing countries, there is over-dependence on a few conventional energy sources such as biomass (firewood, charcoal and crop residues), petroleum products and grid electricity as the driver of economic development.

b) Decision Making Process explain 69.9% of the variance in the bio gas technology adoption among the farmers in Mbarara district (Adjusted R^2= .699). The adjusted R^2 provides an idea of how well the model generalizes the study variables and every researcher would like the Adjusted R^2 values to be the same as or close to R^2. For this study, the difference for the model is (.701 -.699=0.002). The shrinkage of .002 (0.2%) means that if the model was derived from the population rather than a sample, it would account for approximately 0.5% less variance in the outcome.

   The *r value* was. 837[a] with Adjusted R^2 of only .699 which show a high effect means that the decision making process has a high effect on bio gas technology. This highly agrees with Rogers (2000) who concluded that even after the biogas technology adoption passes through the complex stage of implementation and confirmation. So, it is essential to understand the adoption decision of biogas is by far a great factor that affects the adoption of biogas technology

c) Attitude of the communities' explain 69.8% of the variance in the bio gas adoption among the farmers in Mbarara district (Adjusted R^2= .698). This shows that community's knowledge about the bio gas is significant predictors of the adoption as explained by 69.8% only.

d) The *r value* is only .837[a] with Adjusted R^2 of only .698 which show a high effect of the predictor variable. This is clear that Attitude and awareness towards adoption and use of the biogas technology also influence adoption and utilization of the biogas technology. This study concurs with Technology Acceptance Model by (Davis, 1989) who noted that perceived risk is taken as a direct determinant of attitude towards adoption of technology; in relation to this, the perceived usefulness and perceived ease of use are taken as direct determinants of attitude (Davis, 1989).

5.2 Conclusions

From the above findings it is concluded that;

a) The findings revealed that communities' knowledge biogas technology was essential for technology adoption. This implied that the way the community understands the bio gas technology determines whether they will adopt or not.

b) The findings on the effect decision making process revealed that it contributes highly and significantly to the overall adoption of biogas technology and thus a unit change in decision making process is a significant predictor of whether the households will adopt biogas technology

c) From the findings, it was established that the attitude of communities towards biogas technology positively significantly influence its adoption, thus if people have a negative attitude it would lead to low uptake and high uptake if its positive since in general terms attitude explains 69.8% of the choice of adoption on biogas technology

5.3 Recommendations

From the conclusions above and respect to the significance of the study, the following recommendations are drown;

a) Communities' knowledge influenced the biogas technology by only 9% which is very low perhaps because the communities are not fully sensitized on the advantages of biogas. Therefore, government through its line ministry of energy and mineral development should team up with NGO to conduct massive sensitization of farmers to adopt biogas energy which is by far has more advantages compared to other biomass energy.

b) It has also been seen that attitude contributes significantly to the adoption of technology adoption yet one of the challenges seen in the study was financing. Therefore, government should set up demonstration plants in communities as a means of developing positive attitude towards adoption of biogas technology.

5.4 Suggestions for further study

This study dealt with extrinsic and intrinsic factors on the adoption of biogas technology but did not segregate them in terms of negative and positive influence but rather looked them in general terms. Therefore a similar study can be undertaken to address this gap left. More so, there cases respondents outrightly declined to respond to the survey because they were not interested and were not ready to commit time for the interviews. Therefore a similar study could be done using other districts in Uganda with similar characteristic

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Appendices

ANNEXES

Uganda
Martyrs
University

Making a difference

Office of the Dean, Faculty of Agriculture

15th May, 2018

Your ref:
Our ref:

TO WHOM IT MAY CONCERN

This is to introduce the bearer **KUNIHIRA Barbara Evelyn** a second year student of Master of Science in Monitoring and Evaluation, Registration Number 2016-M302-20034 in the Faculty of Agriculture of Uganda Martyrs University.
He is conducting a Research Project on **"Extrinsic and intrinsic factors on the adoption of biogas technology as a source of energy in Uganda"** to enable him prepare a Dissertation as a partial requirement for the award of him degree.

I will be very grateful if you would accord the student all the necessary assistance and cooperation.

Thanks for the support

Yours Sincerely,

Ssekandi Joseph
Ag. Dean, Faculty of Agriculture

FARMER INTERVIEW QUESTIONAIRE

General information					
Date					
District					
Location (GPS)					
Age	18- 35	36-49	50-63	64above	
Gender	Male				
	Female				
Education level	1= primary	2= secondary	3=Post - secondary	4=Non-formal	
	5=farmer	6=Casual laborer	7=Business	8=Permanent employment/ pensionable	9=Wedges employment	10=Salaried employment
Means of livelihood	1= cash-crops	2=food corps	3= livestock		
If a farmer : what activities					
If livestock rearing : what rearing system do you use:	1=Zero grazing	2=free lance	c)	d)……… ………	
What amount of dung do you collect?	1=Less than 2 basins	2=More than 2 basins	3=20 basins and above		
What is your source of energy?	And how frequent? Tick all that apply				

Charcoal	1=Frequently Used	2=Moderately Used	Less Used	Never Used
Wood fuel				
Liquid petroleum Gas(Shell, Total, etc)				
Biogas				
Electricity				
Kerosene				
Any other specify				
Briefly explain why it is your main source of energy?				
[redacted]				
2.1 Do you know that biogas is an alternative source of energy for cooking?			1=No	2=Yes
2.2 What is biogas according to you? 1= Gas that is generated from decomposing organic materials 2= Gas used for cooking and lighting				
2.3 Have you ever seen a biogas plant?			1=No	2=Yes
2.4 What are the raw materials of biogas	1= Animal waste	2=Plant residue	3= Urine	4= others
2.5 What are the bi-products of biogas?	1= Bioslurry	2= Biogas	3=Others	
2.6 What are the benefits of biogas?	1= cooking	2= lighting	3= fertilizer	
2.7 Do you have a biogas plant?			1=No	2=Yes
2.8 Are you satisfied with biogas plant			1=No	2=Yes

If No, why don't you have a biogas plant? *Tick all that apply*	1=No access to technology 2=Availability of funds 3=No enough land 4=Poor mentality about biogas 5= Process is tiresome 6= Something I haven't yet thought about			
2.8 How has your community embraced the biogas technology?	1=Very many people have biogas plants	2=Many people have	3=Very few have	4=None
2.9 Who is responsible for looking for the source of energy at your home (be it charcoal, fire wood, etc)				
1=Father	2=Mother	3=others (specify)		
2.10 Do you think having biogas would save you some time? If Yes how?	1=No	2=Yes		
2.11 What do u think should be done so that so that many people can embrace the biogas technology	1=Creating awareness 2=Government intervention 3= Subsidizing biogas			
[redacted]				
3.1 As a household how are decisions made?	1=Made by husband	2= Made by wife	3=None	
3.2 Who makes the decision about space utilization	1=Husband,	2=Wife	3=Children	
3.3 Who makes the decision to buy materials	1=Husband,	2=Wife	3=Children	
3.4 Who makes the decision to manage and maintain the digester?	1=Husband,	2=Wife	3=Children	
3.5 How often is a discussion on biogas done in the household as a family?	Never,	Weekly,	Monthly	

3.6 Are the decisions made discussed among the family as in husband and wife?	1=no	2=yes

3.7 Gender relations check list (Probe for)	**S/Agree =1**	**Agree=2**	**Disagree= 3**	**S/Disagree =4**	**D/Know=5**
a) Both man and woman contributed to the purchase the Biogas technology appliances					
b) Both man and woman decided jointly on the purchase of biogas plant					
c) Both man and woman use biogas for cooking and lighting					
d) Biogas has escalated conflicts between man and woman					
e) Only man is responsible for the operation of the biogas plants					
f) Both man and woman were trained and have the skills in operating the biogas system					
g) Both man and woman share the responsibilities in areas of gardening.					
h) Both man and woman share the responsibility of handling the slurry /fertilizer					
i) Both man and woman engage in taking care of the livestock					
j) Boys and girls have more time for study					
k) Women have more time to participate in community activities					
l) Women have more time for leisure					

m) man and woman share ownership of livestock, land, households assets					

4.1 User’s Perception/attitude on Biogas Plant

Biogas is good because	**S/Agree=1**	**Agree=2**	**Disagree=3**	**S/Disagree=4**	**D/Know=5**
a) It’s Easy, fast and comfortable cooking (can be used any time, easy to ignite and burn, no need of constant caring while cooking, no smoke)					
b) It Saves money (no need to purchase charcoal)					
c) It Liberates from collecting firewood from jungle (saves time and efforts)					
d) Its Time saving – children get time to study					
e) Provides light for children to revise					
f) Clean surrounding/good environmental condition					
g) Good organic fertilizer					
h) Easy to clean cooking utensils					
i) A very reliable energy source					
j) Improvements in health and hygiene					
k) Reduces bad smell in and around the houses					
L) Proper use of waste materials (dung)					
M) Cattle stable remains clean					
n) Kitchen remains clean					
1) Saves chemical fertilizer					
o) Create employment					
p) Improves gender relation in the home					

q) Reduced tree cutting					
4.2 Have you share the knowledge of biogas with your peers				1=Yes	2=No

If yes how many have constructed biogas plants

1=Less than 10 and below

2= Above 10

4.5 Impact of biogas on health and sanitation

Reduced smoke in the kitchen	1=Yes	2=No
Household have three meals a day	1=Yes	2=No
Proper waste disposal	1=Yes	2=No
Household feed on a balance diet	1=Yes	2=No
Household have bio latrines with hand washing facilities	1=Yes	2=No
Bio-slurry is a good pesticide	1=Yes	2=No

4.6 What changes have you experienced at an individual and household level, as a result of the biogas plant	**1=Improved**	**2= No changes**	**3=Reduced**
a) Availability of food in the household			
b) Crop production (yields from garden- per acreage)			
c) Diversification of income sources			
d) Farm productivity and income			
e) Sales from animal products			
f) Children attendance at school- girls			
g) Children attendance at school –boys			
h) Access to health services			
i) Access to information			
j) Exposure to Local, National and International visitors			
k) Hygiene and sanitation			

Summary of monitored parameters and findings

Parameter	Data unit	Description	Applied value	
$O_{p1,y}$	number	The average technology-days during which the bio digesters are operational for project scenario	The mean estimated time taken for which the bio digesters have been out of operation was determined to be 433.3 days.	
$BB_{b1,bio}$	tonnes/ year	Amount of woody biomass used in the baseline scenario b1	This parameter was measured through KPT and results submitted in raw form	
$MS_{P,S,K}$	%	Fraction of livestock category T's manure not treated in bio-digester, in climate region k	Dairy Cattle	**9%**
			Local Cattle	**20%**
			Pigs for market	**63%**
			Pigs for breeding	**90%**
			Sheep	**100%**
			Goats	**97%**
			Poultry	**100%**
			Dogs	**100%**
			Donkeys	**100%**
			Rabbits	**100%**
Number of	Average Number		Dairy Cattle	**5.9**
			Local Cattle	**8.4**
			Pigs for market	**6.6**

animals			Pigs for breeding	**6.8**
$\boldsymbol{N_T}$			Sheep	**4.4**
			Goats	**7.07**
			Poultry	**35.5**
			Dogs	**1.86**
			Donkeys	**4**
			Rabbits	**4**
$\mathbf{MS_{T,S,k}}$	%	Fraction of livestock category manure fed into the bio-digester	Dairy Cattle	**91%**
			Local Cattle	**80%**
			Pigs for market	**37%**
			Pigs for breeding	**10%**
			Sheep	**0%**
			Goats	**0%**
			Poultry	**0%**
Bio		Use of bio-slurry	Daily Spread; **41%** Liquid Slurry and Daily spread; **47%** Daily Spread and Added to pig feed; **2%** Discarded; **2%** Daily Spread and Sold to other farmers; **2%.** Daily Spread and Uncovered lagoon; **5%** Liquid slurry; **2%**	

GS-07 Livelihood of the poor	%	The livelihood of the poor refers to changes compared to the baseline in living conditions, access to healthcare services including affordability and poverty alleviation.	**Change in expenditure on artificial fertilizer** 'Decreased' or Zero: **17.3%** (24/139) 'Stayed the same': **1.4%** (2/139) 'Zero purchase of artificial fertilizer before and after bio-slurry': **81.3%** (113/139) **Change in the incidence of eye problems and respiratory illnesses** 'Reduced': **91.4%** 'Not changed': **8.6%** **Change in expenditure on fuel** 'Decreased': **93.53%** 'Stayed the same': **6.47%**