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ADOPTION OF BIOGAS AS AN ALTERNATIVE SOURCE OF ENERGY IN JINJA DISTRICT

BY

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A RESEARCH DISSERTATION SUBMITTED TO BUSITEMA UNIVERSITY, FACULTY OF AGRICULTURE AND ANIMAL SCIENCES IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR AWARD OF THE DEGREE OF BACHELOR OF ANIMAL PRODUCTION AND MANAGEMENT OF BUSITEMA UNIVERSITY

MAY, 2015

DECLARATION

I, **Alupo Gertrude** hereby declare that this is my original work and has never been submitted to any university or institution of higher learning for any academic award.

Signature: .... Date: 14th July 2015 ....

APPROVAL

This dissertation has been submitted for examination with the approval of my supervisor.

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Signature: .... Date: 14th - July - 2015 ....

DEDICATION

I dedicate this dissertation to my father, Mr. Otim Pamfilio my mother Mrs. Otim Esther and all my siblings.

ACKNOWLEDGEMENT

I acknowledge the untiring efforts of my supervisor, Ms. Akullo Jolly, who guided me throughout the research period. I also appreciate Mr. Otim Pamfilio and Mr. Mumbya Alex for their assistance in compiling and analyzing data. Not forgetting Mr. Ojakol Samson who assisted me to identify farmers in the field. I also thank Mr. Okay who gave me information concerning CARITAS JINJA and the biogas project they are running. Lastly, great thanks go to my colleague, Naika Vincent who assisted me to administer some questionnaires to farmers. Finally, great thanks go to Wagali Philip who assisted in editing this work. God bless you all.

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LIST OF ABBREVIATIONS

ABPP:	Africa Biogas Partnership Program
AEATRI:	Agricultural Engineering and Appropriate Research Institute, Namalere
CAMARTEC:	Centre for Agricultural Mechanization and Appropriate Technology
CARITAS:	Catholic Agency for Overseas Aid and Development
CBOs:	Community Based Organizations
CREEC:	Centre for Research in Energy and Energy Conservation
DGIS:	Directorate General for International Cooperation
FAO:	Food and Agriculture Organization of the United Nations
HIVOS:	Humanist Institute for Cooperation with Developing Countries
IP:	Implementing Partner
NAADS:	National Agricultural Advisory Services
NGOs:	Non Governmental Organizations
PPP:	Public Private Partnership
SACCO:	Savings and Credit Cooperative Society
SNV:	Netherlands Development Organization
SPSS:	Statistical Packages for Social Sciences
UBOS:	Uganda Bureau of Statistics
UDBP:	Uganda Domestic Biogas Program

ABSTRACT

The purpose of this study was to obtain information about adoption of biogas as an alternative source of energy in Jinja district. Data was collected from 75 households which owned livestock.

Most (60%) of the respondents were male. The most predominant age group was > 46 years (44 %), and the majority (52%) had a family size of 6 to10 people and had attained tertiary education. Majority (80 %) of respondents owned fixed domed bio digester. Major sources of information and maintenance about biogas were mainly from NGOs (64 %), Most (48%) of the respondents attributed the reason for adopting biogas to availability of feedstock and the most predominant challenge faced by most respondents who adopted biogas technology in the study area was low gas volume (20%).

Basing on the results of the study, it was concluded that all the respondents carried out mixed farming and most of the farmers owned cattle under intensive system of rearing. Most (48%) of the respondents attributed the reason for adopting biogas to availability of feedstock and the most predominant challenge faced by most respondents who adopted biogas technology in the study area was low volume of gas. The researcher recommends that operators of biogas plants should prepare feedstock appropriately that is mixing the water or urine with excrement to get a porridge mixture and use fresh excrement for feeding the digester to overcome the challenge of low gas volume.

CHAPTER ONE: INTRODUCTION

1.1 Background

Although having adequate, affordable, efficient and reliable energy services with minimum effect to the environment is a necessity to achieve social, economic and environmental aspects of development (Nyabawe & Kisaalita 2014). Marks & Wagg (2013) noted that 1.3 billion people had no access to electricity and 2.6 billion had no clean cooking solutions globally. This explains why in a report of the Ministry of water and environment, Kamuntu (2012) stated that there was need to create awareness for incentives for alternative sources of energy.

According to Dahunsi & Oranusi (2013), a biogas plant is an appropriate and sustainable method of disposal of human or animal waste to produce slurry and biogas for cooking and lighting in order to reduce on the strain on the environment by decreasing the use of biomass, and the production of green house gases as the methane produced from the manure is captured and used. Mulinda *et al.* (2013) referred biogas technology to a form of biomass energy which incorporates a wide range of biomass fuels which are often used in their unprocessed form.

In order to improve living conditions of households in Uganda, Kenya, Tanzania, Ethiopia, Senegal and Burkina Faso, the African Biogas Partnership Program (ABPP) was established in 2008. ABPP works hand in hand with The Netherlands Development Organization (SNV) which provides advisory services, with the aim of improving basic services, production, income and employment for people. In Uganda, the Uganda Domestic Biogas Program (UDBP) was initiated under the ABPP by Heifer International (Tumwesigye, 2013).

According to Sabiiti & Karugi (2006), the overall objective of the UDBP is to disseminate domestic biogas in rural and peri - urban areas with the ultimate goal of establishing a sustainable and commercially viable biogas sector in Uganda. The Catholic Agency for Overseas Aid and Development (CARITAS) JINJA was given the mandate to act as the Implementing Partner (IP) for UDBP in Busoga region of which Jinja district is inclusive.

1.2 Research Problem

According to Menya *et al.* (2013), over 93% of Ugandans rely on wood fuel in form of either charcoal or fuel wood for cooking. This implies that there is a high rate of deforestation and it is necessary to promote other energy sources like biogas, especially for use at household level. In a study carried out by Levi & Dorothy (2009), they discovered that biogas could supplement or even replace wood as an energy source for cooking and lighting besides producing heat, power and also organic fertilizers to the farmer.

Though biogas systems can operate at small and large scales in urban and rural locations Mshandete & Parawira (2009), a study Pandey *et al.* (2007) revealed that, there is limited adoption of biogas technology in Uganda. According to Walekhwa *et al.* (2014), biogas production in Uganda improves public health and pollution control. Disposal and digestion of wastes in a biogas plant reduces parasites and pathogenic bacteria count by 90%. It breaks the vicious cycle of infection via drinking water, which in many rural areas is untreated.

According to Hazra *et al.* (2014), the primary environmental cause of death was household air pollution from burning solid fuels in primitive cook stoves. Household air pollution due to inefficient combustion of solid fuels which emitted high concentrations of particulate matter and other harmful emissions had a correlation with acute lower respiratory infections in children, and chronic obstructive lung disease and lung cancer in adults. It was the third most deadly global risk factor, accounting for about 3.5 million deaths annually.

To achieve this target therefore, there is need to determine the factors for adoption and non - adoption of biogas in Jinja district.

1.3 General Objective

- To establish the reasons for adoption and challenges faced by farmers of biogas as an alternative source of energy in Jinja district.

1.4 Specific Objectives

- To identify the household characteristics of farmers who have adopted biogas technology in Jinja district.
- To identify the reasons for adoption of biogas technology among farmers in Jinja district
- To identify the challenges faced by farmers who have adopted biogas technology in Jinja district.

1.5 Research Questions

- What were the household characteristics of farmers who have adopted biogas technology in Jinja district?
- What were the reasons for adoption of biogas technology among farmers in Jinja district?
- What were the challenges faced by farmers who adopted biogas technology in Jinja district?

1.6 Significance

Much as biogas is an old technology of the 1950s, its adoption in Uganda has been limited. This research will provide data about the reasons for adoption and non - adoption of biogas technology in Jinja district. The information will be useful to the target clients of Uganda Domestic Biogas Program who include farmer groups, members of Savings and Credit Cooperative Society (SACCO), farmer groups organized by corporate organization or Non Government Organizations (NGOs); for example Send A Cow Uganda, Humanist Institute for Cooperation with Developing Countries (HIVOs), Catholic Agency for Overseas Aid and Development (CARITAS), Church of Uganda, National Agricultural Advisory Services (NAADs), Heifer Project International, and other relevant Community Based Organizations (CBOs) in localities and organizations which are active in disseminating biogas technology in Uganda like; the Ministry of Energy and Mineral Development, Agricultural Engineering and Appropriate Research Institute, Namalere (AEATRI), and other stake holders including rural households, private construction companies, masons, vocational training institutions, financial institutions, local governments, the central government, parliament, civil society organizations and development partners to act as a reference during decision making process about the adoption of biogas as an alternative source of energy.

1.7 Justification

According to Amigun *et al.* (2012) a lot has to be done to publicize biogas as an alternative source of energy for domestic use such as cooking and lighting. According to Mwirigi *et al.*, (2014), the use of biogas has created a positive impact economically, socially and environmentally. However, its adoption in Sub Saharan Africa of which Uganda is part, has been low. Therefore, there is need to explore the gaps in its adoption. According to Mark (2012), the Energy Policy for Uganda (2002), has emphasized the development, adoption and utilization of renewable energy resources like biogas in order to achieve objectives of emission reduction, protection of the environment and energy conservation. All the above facts provide the basis to research on the adoption of biogas as an alternative source of energy in Jinja district.

1.8 Scope

The research was carried out in Jinja district from March to April and it was focused on the beneficiaries of UDBP who were under CARITAS JINJA. CARITAS JINJA is an NGO which promotes the use of biogas as an alternative source of energy among famers and other institutions with feedstock for the biogas digesters. CARITAS JINJA operates in Busoga region covering ten districts including Jinja. The research was conducted in four sub counties which included, Buwenge, Budondo, Wairaka, and Wanyange.

CHAPTER TWO: LITERATURE REVIEW

2.1 Perception of farmers towards biogas

Biogas is a mixture comprised of 60% methane, 40% carbon dioxide and traces of other gases like hydrogen Shokri (2011). Biogas is flammable and is produced by microbes when organic materials are fermented in a certain range of temperatures, moisture contents, and acidities, under airtight conditions. The feed stock which can be used for production of biogas include; waste water sludge, animal manure, crop residues and organic wastes. Biogas can also be collected, with special installations, from landfill sites (Seadi, 2008)

According to Tumwesigye (2013), the amount of biogas that could theoretically be produced from manure depends on the type or breed of livestock and the livestock management system. However, sufficient quantities of feedstock, especially animal manures, are needed to produce biogas. 1 to 2 cows or 5 to 8 pigs produce sufficient feedstock to provide biogas for a typical household.

Despite the very low uptake of biogas in Embu West district in Kenya, a study, (Nguu *et al.* (2014), revealed that livestock farmers had a positive perception towards biogas generation. Majority (85.9%) thought that biogas technology was useful in conserving the environment and (47.4 %) would not have difficulty in using biogas for cooking traditional foods. The farmers considered biogas as a waste disposal system and most (89.7%) of the respondents said that the regular supply of biogas reduced the task of gathering fire wood.

Another study Upham & Shackley (2007), revealed that some people in many European countries had the perception that biogas was a dirty and old fashioned way to produce energy. This attitude led to the resistance of installations of biogas and low uptake of the technology. Socio-cultural issues like the attitude and ability or willingness of the beneficiaries and operators of the respective biogas plants to handle feces also determined the acceptance of biogas plants.

In a study Nguu *et al.* (2014), most (55.5%) of the respondents perceived that bio slurry had superior nutrient qualities over usual fertilizers and cattle dung. According to Karki (2006), the biogas users' survey of 2006 showed that majority of the respondents perceived that they had increased yields due to bio slurry use. In the same study, the farmers had the perception that there was a change in pests/diseases control after bio-slurry application and (48%) of biogas users perceived that there was an increase in mosquitoes after biogas use.

According to Fred (2013) the presence of few digesters in Jinja was attributed to poor perception for the use of biogas and laziness such that the people could hardly sustain a biogas plant thus limited growth of the technology in the area.

2.2 Level of awareness about biogas as an alternative source of energy

In a study Wachera (2014), noted that increased awareness creation and community training on the benefits of biogas was an appropriate measure for potential biogas users to appreciate and embrace the technology. As such, there was need for community sensitization on the social, economic and environmental gains that would arise if they adopted biogas at the household level. She further elaborated that the draft National Energy Policy should be enforced and mechanisms put in place to sensitize people on the potential of biogas energy.

According to Nguu *et al.* (2014), majority (84%) of the farmers who had limited knowledge of a working digester could not adopt biogas. Another study, Mwakaje (2012), in Rungwe district, Tanzania showed that most of the people who had not accessed biogas technology especially from the Muslim community had the perception that biogas was a dirty thing. In Kilimanjaro region however, neighboring households including Muslims who observed the functioning of a bio-latrine in Lomwe Secondary School were motivated to adopt biogas.

In a study in Punjab, Akram *et al.* (2013) attributed the large number of biogas plants in the central town to more awareness, social contacts, an active role of media in disseminating information about adoption of biogas and the level of education. Households without sufficient gas especially in winter season were linked with the lack of awareness and training with the need to carry out operation and maintenance functions at recommended intervals and inability to supply the household with appropriate biogas specific appliances.

The findings of Heikoop (2013), showed that the biogas actors in Austria were in the view that awareness on biogas technology was very low hence the need to practically show case its potential at the local level for biogas adoption rates to improve. Emphasis was put on the need to educate the communities on the benefits and importance of biogas and participation of all stakeholders in the biogas industry to create a platform for its promotion to increase awareness and create demand among potential and interested clients.

The findings of Feder *et al.* (1985) about slow adoption of biogas due to limited access to information conquered with those of Mwakaje (2008) , who noted that biogas technology did not diffuse much to the rural poor communities where indoor fed dairy cattle were kept partly due to inadequate awareness about the technology. To add on, Walekhwa, (2009) noted that there should be educational and awareness campaigns on biogas benefits and successes to bolster wider biogas energy acceptance in developing countries.

According to Boonrod, (2015) the barriers to participation and decision making of the waste to energy policy project were attributed to lack of knowledge and understanding of the relationship between organic waste, biogas and electricity current by the general public. Therefore, prioritization and planning for enhancing understanding and awareness rising was necessary to as quickly as possible create understanding and generate knowledge in various dimensions in order to ensure the success of the waste-to-energy policy.

Karki & Expert (2006) Studies conducted in Nepal on slurry use showed that the impact of slurry extension and promotion program was very conducive to make the farmers conscious about the utilization of bio slurry as fertilizer to enhance crop production and productivity of soils. Information dissemination was through regular visits to farmers, distribution of leaflets, posters and radio discussion programs. Initially, farmers lacked interest and awareness about the value of organic fertilizers. Increasing awareness was thus achieved.

2.3 Factors responsible for adoption of biogas as an alternative source of energy

According to Sengendo *et al.* (2010), adoption of biogas is determined by availability of well-functioning, inexpensive, durable modern gas appliances including burners, lamps, refrigerators, and good-looking plants from the very start. Also, user friendliness of plants and appliances plus guaranteed supply of materials and spare parts coupled with assured repair and maintenance; determine their acceptance.

Other factors influencing the adoption of biogas as an alternative source of energy include; willingness of the farmer to use digested slurry as fertilizer, knowledge of storage and spreading techniques for slurry, and appreciation of the positive effects of fertilizing. Furthermore, availability of suitable, inexpensive slurry spreading implements; and work involved as viewed from the user's standpoint, and a positive cost-benefit ratio, let alone favorable financing in terms of loans and subsidies.

Biogas technology has both economic and social benefits which influence adoption of the technology. According to Deublein & Steinhauser (2011), the benefits of biogas include; providing organic fertilizer which is safe for the environment, biogas is clean and healthy to use as it prevents fumes due to indoor smoke when cooking. Biogas is cheaper than charcoal and firewood and it reduces work load for women and girls as there is no need to move long distances to collect firewood.

According to Gitonga (2014), biogas technology creates local job opportunities for digester production and service which translates directly into financial savings. Slurry used for agricultural purposes not only increases agricultural produce, but it also generates revenue from the sale of extra bio-slurry to other farmers. In a study, Walekhwa *et al.* (2009) discovered that bio slurry reduced weed growth by 50 percent because the weed seeds were destroyed in the digester.

According to Amigun *et al.* (2012), biogas production plays a significant role in controlling and collecting organic waste materials which, if untreated, may cause severe public-health and environmental pollution problems. According to Mwirigi *et al.* (2014), the owners of biogas plants in Kenya used bio slurry to fertilize their crops. This lessened the use of compost and inorganic fertilizers. Some households in Ethiopia valued bio slurry because use of slurry increased agricultural production and reduced input-costs.

According to Ocweija (2010), biogas plants can help meet many of the United Nation's Millennium Development Goals (MDGs). The first goal of the MDGs which is to eradicate extreme poverty and hunger may be achieved by using the slurry, which is produced from the biogas systems to fertilize crops and improve the composition of soil.

Goal Three of the MDGs is to promote gender equality and empower women. Since most families count on firewood to cook their meals; and it is the women and the girl child that assume the burden of cooking and gathering firewood, women and the girl child would have more time for other activities such as attending school related to Goal Two of achieving universal primary education, income generating activities and more social time by using biogas.

According to Pandey *et al.* (2007) the exposure to smoke produced from the cooking fire would be reduced by using biogas, thus leading to an improvement in the health of women and children; in relation to Goal Four of reducing child mortality. In addition, Goal Seven of the MDGs, ensuring environmental sustainability is assisted by biogas technology by providing sanitation for both urban and rural communities, reducing deforestation, and reducing the amount of carbon dioxide released into the atmosphere.

2.3.1 Adoption of biogas globally

According to Bhat *et al.* (2001) it was estimated that there were 16 million small-scale household digesters around the world in 2005, with most of these plants in India and China. In India, 6 million tons of firewood was replaced by the use of biogas in 1996. Furthermore, the findings of Mwakaje, (2008) showed that seven million digesters in China contributed to the energy demands of 4% of the country's population.

In a review on the use of biogas in the Sirsi region of India, Bhat *et al.* (2001) determined that the area experienced a high rate of success compared to other regions due to a large population of livestock, which prevented plant abandonment because of insufficient dung. They also found that there was greater access to free or low cost digester maintenance through intermediate financing institutions, like agricultural cooperatives. This infrastructure provided greater support to clients, impacting the overall success of biogas in the region.

According to Deublein & Steinhauser (2008), the first biogas program was implemented in Nepal in 1989. Austria constructed biogas plants which were fed with the excrement of 9,000 laying hens, 1,500 poultry and 50 pigs in 2005. In addition, Sweden invented communal vehicle fleets and a train running on biogas.

According to Deublein & Steinhauser (2011), the government of Germany planned to construct 43,000 biogas plants until the year 2020. In December 2005, Hungarians inaugurated a biogas plant with a capacity of 2.5 MW. The plant was fed with liquid manure from several cattle farms and wastes from poultry farming. Russia installed more than 70 plants. Countries in Latin America, like Argentina, Peru, Brazil, Chile, and Mexico started the implementation of biogas plants around 2008.

According to Smith *et al.* (2012) a highly successful national program which involved integration of cheap biogas digester technology into holistic farming systems and used the nutrient rich digester slurry in fish ponds to grow algae to feed the fish and provide an additional source of food and income was invented in Vietnam. SNV implemented the program in Vietnam in 2003, Bangladesh and Cambodia in 2006, Lao PDR in 2007, followed by Pakistan and Indonesia in 2009 and Bhutan in 2011.

By 2010, 360,000 households had been equipped with SNV biogas plant globally. SNV together with Asian Development Bank aims to build additional one million plants by 2015 in their "Energy for All Partnership" program.

2.3.2 Adoption of Biogas Regionally

In a study by Mulinda *et al.* (2013), they found out that the scarcity of wood fuel was exacerbated by overpopulation, the rising need for cropland, a high rate of deforestation and soaring demand for wood fuel inform of charcoal in order to meet household energy requirements. According to Mwirigi *et al.* (2014), the African Biogas Initiative set a target to construct at least two million biogas units in Africa by the end of 2020 with an operation rate of 90% to meet the high demand for fuel.

In a study, Mwirigi *et al.* (2014) pointed out that biogas was an appropriate solution to Sub Saharan Africa (SSA) energy needs due to the decentralized nature of human settlements in the region, resulting in very high distribution costs for conventional centralized power systems. According to Pandey *et al.* (2007), the first biogas digesters in Africa were set up in South Africa and Kenya in the 1950s, Tanzania introduced biogas in 1975 and South Sudan initiated biogas in 2001.

Other Sub- Saharan countries with biogas technology included; Botswana, Burkina Faso, Cote d'Ivore, Ethiopia, Ghana, Guinea, Lesotho, Namibia, Nigeria, Zimbabwe, South Africa, Uganda, in commercial farms such as in chicken and dairy farms in Burundi, health clinics in Tanzania, a public latrine block in Kibera in Kenya and prisons in Rwanda. According to Amigun *et al.* (2012), the commonest type of biogas design in Africa was modified by the Centre for Agricultural Mechanization and Rural Technology (CAMERATEC), Tanzania.

According to Tumwesigye (2013), biogas technology in SSA was promoted by ABPP; a Private Public Partnership (PPP) between the international and foreign aid agencies like the Directorate General for International Cooperation (DGIS), Humanist Institute for Cooperation with Developing Countries (HIVOs), SNV, and Heifer International. According to Smith *et al.* (2012) East Africa, Ethiopia, Cameroon, Benin, Burkina Faso had national domestic biogas programs with national targets of installing over 10,000 domestic systems by 2015.

According to Kahubire *et al.* (2010), the expected benefits of biogas were; improvement in health and living conditions in rural households especially in regard to women and children, improved soil fertility and agricultural production, reduction of firewood use and time to collect it, reduction of green house gas emission, and creation of new jobs and a new biogas business sector.

2.3.3 Adoption of Biogas in Uganda

According to Sengendo *et al.* (2010) in general, the willingness to accept construction and operation of biogas plants is influenced by; project organization by involving the users, especially the women, in all decisions concerning biogas plant and coordinating all essential program measures with target group representatives.

In a study Pandey *et al.* (2007), the Church Missionary Society in Uganda built the first biogas plant in the early 1950s in Mbarara district with emphasis on the treatment of sewage. Later on in the 1960s, some missionaries built a demonstration plant in Kotido district. In 1985, the Chinese biogas technical team carried out a feasibility study covering many private, government and cooperative farms in Uganda and they concluded that biogas technology was most viable in small scale private dairy farms with easy access to feedstock.

In 1989, demonstration plants were constructed in Karamoja district. FAO carried out another study through the ministry of energy which led to creation of a national biogas program in Uganda. They recommended a Chinese type design to be built at secondary schools as a bio latrine system using cow dung but with possibilities of incorporating human manure. However, acquisition of feedstock became the main constraint with inadequate knowledge about the technology.

During 1980 to 1990s, a number of government and private initiatives went into development and popularization of biogas technology in Uganda. According to Okaka (1988), a biogas plant was established in east Ankole diocese in 1982 with five more installations for domestic application in Mbarara district. The Ministry of Animal Industry and fisheries through assistance of Chinese established three units of Chinese type biogas plants in Mbale and Tororo for water heating, cooking and lighting.

Also, the Lugazi sugar corporation (SCOUL) was operating a 2 cubic meter biogas plant using the Indian type of floating gas-holder. The Ministry of Energy plans to install five more demonstration biogas plants in some parts of the country including Mukono District Farm Institute, Ruti, Rubona, Ngetta district Farm Institute and Arapai in order to share the experiences of other countries like Ethiopia, Burundi, Botswana, Tanzania and Zambia where studies have been made in the field of biogas technology with increasing usage.

According to Tumwesigye (2013), both government and non government institutions were promoting biogas technology in Uganda. According to Walekhwa *et al.* (2009), most biogas systems that were built in Uganda used cow manure as the main source of substrate for the system. This could be expanded to include manure from pigs, chickens, and goats, crop residue and human waste.

2.4 Factors for non- adoption of biogas

According to Dahunsi & Oranusi (2013), the slow pace of development of biogas technology in Africa was attributed partly to shortage of raw materials to feed the digester due to poor infrastructural development in animal rearing and plant cultivation. In a study Pandey *et al.* (2007), reported that adoption of biogas in Uganda had been limited, partly because of the upfront cost of a biogas digester and the social stigma against its use among some individuals.

Furthermore, Nguu *et al.* (2014) showed that the factors contributing to low adoption of biogas technology in Embu West district in Kenya included; low gas pressure, lack of installation capital, inadequate supply of dung to feed digesters, lack of interest, labor involved in feeding the digester, lack of knowledge of digesters' operations, shortage of trained technicians to install and service digesters, lack of exposure to a working digester, preference for electricity, wood, charcoal and LPG gas, broken down digesters.

According to Sabiiti & Karungi (2006), the constraints to adoption of biogas included; awareness creation, land tenure security, financial capital, livestock improvement and research and policy review. The findings of a study Mwirigi *et al.* (2014) showed that limitations to adoption of biogas as an alternative source of energy in Sub- Saharan Africa included; low levels of awareness of the potential uses of biogas, and the small size of land-holdings, which limited the number of different types of land use.

According to Njoroge (2002), the non-progressiveness of most biogas programs in Africa were due to; failure of African governments to support biogas technology through a focused energy policy, poor design and construction of digesters, wrong operation and lack of maintenance by users, poor dissemination strategies, lack of project monitoring and follow-ups by promoters, and poor ownership responsibility by users.

In Kenya, a study commissioned by Shell Foundation in 2007 identified, the high costs of installing the biogas systems as the major bottleneck in adopting the technology. Reviews by Gitonga (1997), indicated that lack of credit schemes to help farmers to acquire biogas plants, was another barrier that hindered the adoption of this technology especially among the potential users. Many of the banking institutions had unfavorable requirements for renewable energy technologies financing such as biogas technology.

In cases where financing mechanisms were provided for end users, these were often not within the reach of the majority of the population. For example, a biogas project in Zimbabwe benefited mainly affluent rural households, since over 80 percent of rural population could not afford the smallest biogas system even at the cheapest rates. Moreover, stringent requirements for loan applications excluded majority of the rural population from qualifying, deterring the potential users (Mapako, 2000).

Another factor that hindered biogas adoption was the minimal disposable income among farmers and competing needs for the limited available financial resources Görgen *et al.* (2009) Due to poor economic performance, there was an increasing level of household poverty, which affected the purchasing power of the rural households. As result, many households had very little savings to invest in non-polluting energy technologies such as biogas.

In Tanzania Mwakaje (2008), concluded that, despite a high biogas demand of 90% and favorable conditions, such as large numbers of indoor-fed cattle coupled with inadequate firewood, water availability strongly constrained adoption of biogas technology. Limited water availability posed a constraint to biogas operation because biogas units typically required water and manure to be mixed in an equal ratio.

According to Walekhwa *et al*. (2009), In Uganda, age of the household head, household size, traditional fuels and level of education of the household head were contributing factors to adoption of the technology: increase in age and level of education were inversely related to adoption while availability of traditional fuels and increase in household size had positive impacts on acceptance of the technology.

Socio-economic surveys carried out in Uganda and Kenya, highlighted low levels of education and income as the main causes of limited, little or no involvement of women in the decision for procurement of energy sources; the decision to install biogas was mainly taken by the male heads of households who controlled resources and their allocation.

In Uganda, the impact of education was contrary to the findings in Kenya Mwirigi *et al*. (2009) and elsewhere Mwirigi *et al*. (2014), more educated people in Uganda generally had more income and thus could afford other sources of energy, such as electricity, which they considered to be more convenient. In Kenya, size of the farm, land tenure security, number of dairy cattle, farming system and the cost of a cow were positively correlated with adoption of the technology Mwirigi *et al*. (2009)

In addition, biogas units were expensive to construct and some biogas digester designs, such as the fixed dome, remained operational for many years, thus necessitating the need for land tenure security. This implied that areas with higher numbers of zero grazing farming systems were more likely to adopt the technology because of increased availability of feedstock due to ease with which cow dung could be collected to feed the digester and the high selling cost of a cow which implied that a farmer could raise sufficient funds to construct a biogas unit.

In Sudan, lack of proof of economic benefit analysis led to low adoption (Omer *et al*., 2003). According to Renwick *et al*. (2007), Winrock International carried out a financial and a holistic cost-benefit analysis of biogas technology and found a high financial and economic return. It was concluded that biogas technology had a potential to make progress simultaneously on a number of the Millennium Development Goals, thereby significantly improving the lives of poor African households. Contrary, biogas uptake in the SSA is still low. There is need to explore gaps in its adoption.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

The study was carried out in Jinja district which is bordered by **Kamuli District** to the north, **Luuka District** to the east, **Mayuge District** to the southeast, **Buvuma District** to the south, **Buikwe District** to the west and **Kayunga District** to the northwest. The annual average high temperature is 28.1°c; the annual average low temperature is 16.3°c. The average temperature is 22.2°c. The average annual precipitation is 1324mm. Jinja district has the following subcounties, Budondo, Busedde, Butagaya, Buwenge, Buwenge T C, Buyengo, Central Division, Kakira, Mafubira, Masese/ Walukuba, Mpumudde/ Kimaka.

3.2 Study Design

The study was a survey to establish the factors influencing adoption of biogas as an alternative source of energy in Jinja district.

3.3 Study Population

According to Burns & Grove (1993), a population has been described as an element that meets the sample criteria for inclusion in a study. The study population included 75 households which owned livestock.

3.4 Sampling Design

A sampling design is a definite plan for obtaining a sample from a given population (Kothari, 2004). A non probability snowballing technique was used to obtain farmers with biogas (Noy, 2008). The method or technique started with identification of a biogas promoter from the office of CARITAS Jinja who later linked the researcher to a farmer who had adopted biogas technology. There were (9) farmers from Budondo sub county, (6) from Busedde, (17) from Buwenge, (4) in Buwenge Town Council, (13) from Buyengo, (11) from Kakira and (15) from Masese/ Walukuba

3.5 Sample size determination

The sample size was statistically manipulated using (Wenpeng, 2002).

$$N = \frac{Z^2PQ}{e^2}$$

Where;

N = Sample size

Z^2 = Standard deviate set at 1.96 corresponding to 95% confidence interval

P = Percentage or probability proportion of the case under investigation

In this case, 52.6% of all the total households in Jinja district were rearing livestock. (MAAIF, 2009).

Q = 1-P

e^2 = Permissible error term set at 0.05 significance level

$$N = \frac{1.96^2 \text{ X } 0.526 \text{ X } 0.474}{0.0128}$$

N = 74.828

Therefore, 75 respondents were interviewed

3.6 Operational Design

An introduction letter was obtained from Busitema University. It was taken to the director CARITAS JINJA who authorized the researcher to go on with the research. Data was collected with the assistance of two research assistants who were trained to interpret, collect and properly record data using questionnaires. This information was then validated by the researcher. Interviews were conducted at the farmers' residence.

3.7 Observational Design

The primary data was collected using closed and open ended questionnaires which were administered in form of an oral interview in their respective farms. The questionnaires contained information on the general characteristics of respondents, energy availability and biogas adoption, perception of respondents towards biogas and limitations to adoption of biogas, were some of the major variables that were captured. Personal observation was used to generate information on observable features of households.

3.8 Statistical Design

Descriptive research design was applied to help in collection, compilation, presentation and analysis of quantitative data to determine the factors affecting adoption of biogas by the farmers. This design was selected because it had the advantage of flexibility in changing of variables to suit the data collection procedures that were employed.

3.9 Data presentation and analysis

Data collected was analysed by use of Excel for windows application software and Statistical Package for Social Sciences (SPSS) Version 16. Information was presented in form of descriptive statistics that were generated in form of frequency distribution tables. Further presentations were made in figure form using comparative bar graphs.

3.10 Ethical considerations

All recruited households were told that data collection was an academic project. So, this eliminated the need of commercial payments for the selected target population. The principles of confidentiality, no harm to any party, freedom of opting in and out of the study were granted. Consent was obtained from various owners of livestock and biogas plants before any data collection session kicked off.

3.11 Environmental Considerations

The study did not have any major effect on the environment. The materials used during data collection were properly disposed off.

3.12 Limitations

The following are the challenges which were encountered during the process of this research;

Travelling long distances in search for farmers who had adopted biogas technology was too expensive since it resulted in incurring high costs of transportation.

In some places, some farmers refused to be interviewed. This was overcome by collaborating with the extension officers of CARITAS JINJA, to link me up with the people who had adopted the technology.

Statistical tables generated by the use of Excel and SPSS were not an easy task. A statistician was approached to guide in the use of the computer based software.

CHAPTER FOUR: RESULTS

4.1 Household characteristics of the respondents who adopted biogas technology.

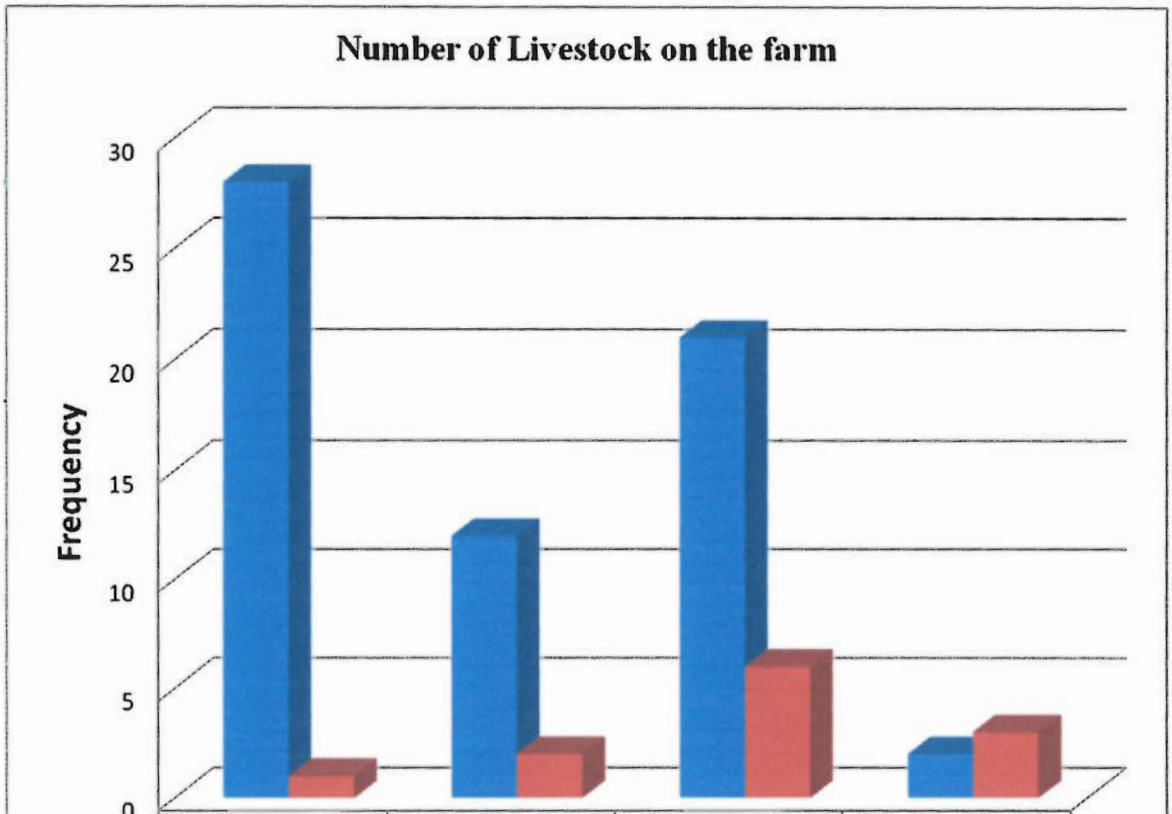
Most (60%) of the respondents were male. The most predominant age group was > 46 years (44 %), 18-35 years (40 %). The majority (52%) had families of 6 to10 people and had attained tertiary education (**Table 1**).

Table 1: Showing the socio economic characteristics of the respondents

Variable	**Category**	**Frequency (N=75)**	**Percentage (100%)**
Sex	Males	45	60
	Females	30	40
Age	<18	00	00
	18-35	30	40
	36-45	12	16
	46+	33	44
Family size	2-5	21	28
	6-10	39	52
	11-15	06	08
	>15	09	12
Level of education	No formal education	09	12
	Primary	12	16
	Secondary	18	24
	Tertiary	36	48
Religion	Christians	24	32
	Muslims	00	00
Total		**N= 75**	**100%**

4.1.1 Type of farming and system of rearing livestock

Majority of the farmers (76%) were carrying out both crop cultivation and livestock rearing. Most (84%) of the farmers owned cattle while 16% reared pigs. Most of the farmers (84%) carried out intensive system of rearing followed by (12%) that carried out semi-intensive system and the least (4%) carried out free range system of rearing. Most (37.3%) of the respondents owned between 1 to 5 cattle (**Figure 1**).



	1 to 5	6 to 10	11 to 15	Above 15
Cattle	28	12	21	2
Pigs	1	2	6	3

Figure 1: Number of livestock owned by respondents

4.1.2 General information about the respondents and biogas technology

Majority (80 %) of respondents owned fixed domed bio digester. Only 20 % owned floating drum bio-digester. The most predominant size of digester was the 6 m^3, owned by 57 % of the respondents. Thirty two percent of the respondents had used biogas for 6- 12 months at the time of the study while 20% had used their biogas plant for over 5 years. Most of the biogas plants were funded by NGOs (64 %). Biogas was mainly used for cooking (75%). All the respondents interviewed were familiar with routine procedures in biogas operations and maintenance (**Table 2**).

Table 2: Shows general information about biogas and respondents

Parameter		Number of respondents (n=75)	Percentage
Type of biogas plant	Fixed dome shape bio digester	60	80
	Floating drum	15	20
Size of bio digester	6 m^3	43	57
	9 m^3	26	35
	12 m^3	06	08
Length of usage of biogas plant	0-6 months	20	27
	6-12 months	24	32
	1-5 years	16	21
	Over 5 years	15	20
Funder of the biogas plant	Government	15	20
	NGOs	48	64
	Family project	04	05
	Own resources	08	11
Usage of biogas	Cooking	56	75
	Cooking and lighting	19	25
Familiarity with biogas plant operation and maintenance	Yes	75	100
	No	00	00

Major sources of information and maintenance about biogas were mainly from NGOs (64 %), this was followed by demonstration effect (20 %). Very few people received information from print media (08 %), friends (04 %), biogas Construction Company (03 %), and relatives (01 %) as shown in **Table 3**

Table 3: Showing sources of Knowledge on operation and maintenance of a biogas plant and feed stock used by respondents

Parameter		**Number of respondents (n=75)**	**Percentage**
Source of knowledge on operation and maintenance of a biogas plant	Biogas construction company	02	03
	Print media	06	08
	Demonstration effect	15	20
	Friends	03	04
	Relatives	01	01
	NGOs	48	64
Feed stock for feeding the digester	Animal excreta	56	75
	Both animal and human excreta	19	25

4.2 Reasons for adoption of biogas among respondents in Jinja District

Most (48%) of the respondents attributed the reason for adopting biogas to availability of feedstock, 32 % attribute adoption to the reduction of the need for fuel wood in traditional cooking stoves, while 4 % thought that biogas is cheaper than other source of fuel in a long run. The least percentage 3% indicated that adoption of biogas is because it is user friendly **(Figure 2)**

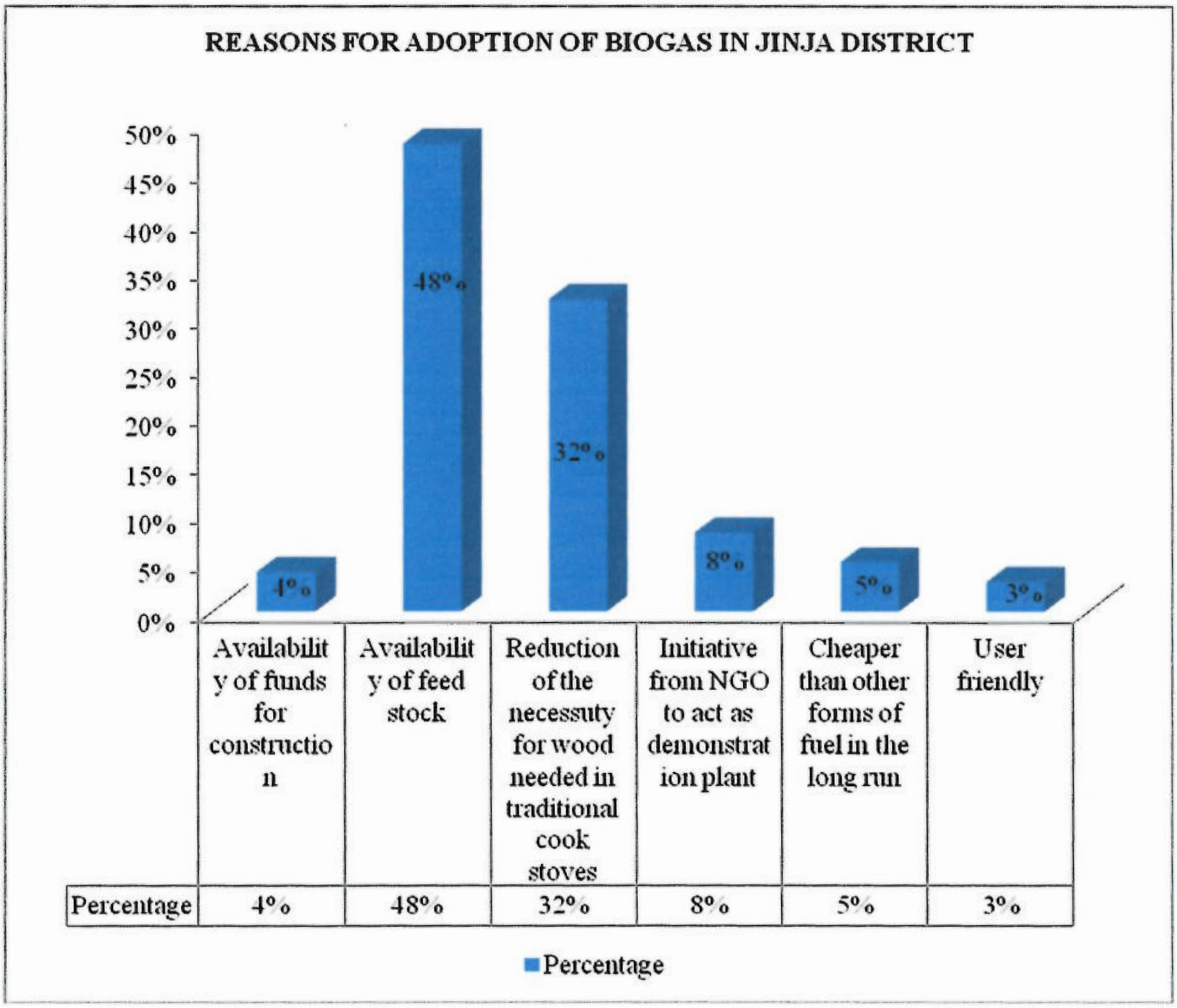


Figure 2: Showing reasons for adoption of biogas

4.3 Challenges faced by farmers who adopted biogas technology

The most predominant challenge faced by most respondents who adopted biogas technology in the study area was low volume of gas. This was followed by inadequate feed stock (16%), the respondents also indicated that the gas is smelly and it irritates (15%). Few respondents highlighted the challenges of water scarcity and high cost of installation (4%). **(Figure 3)**

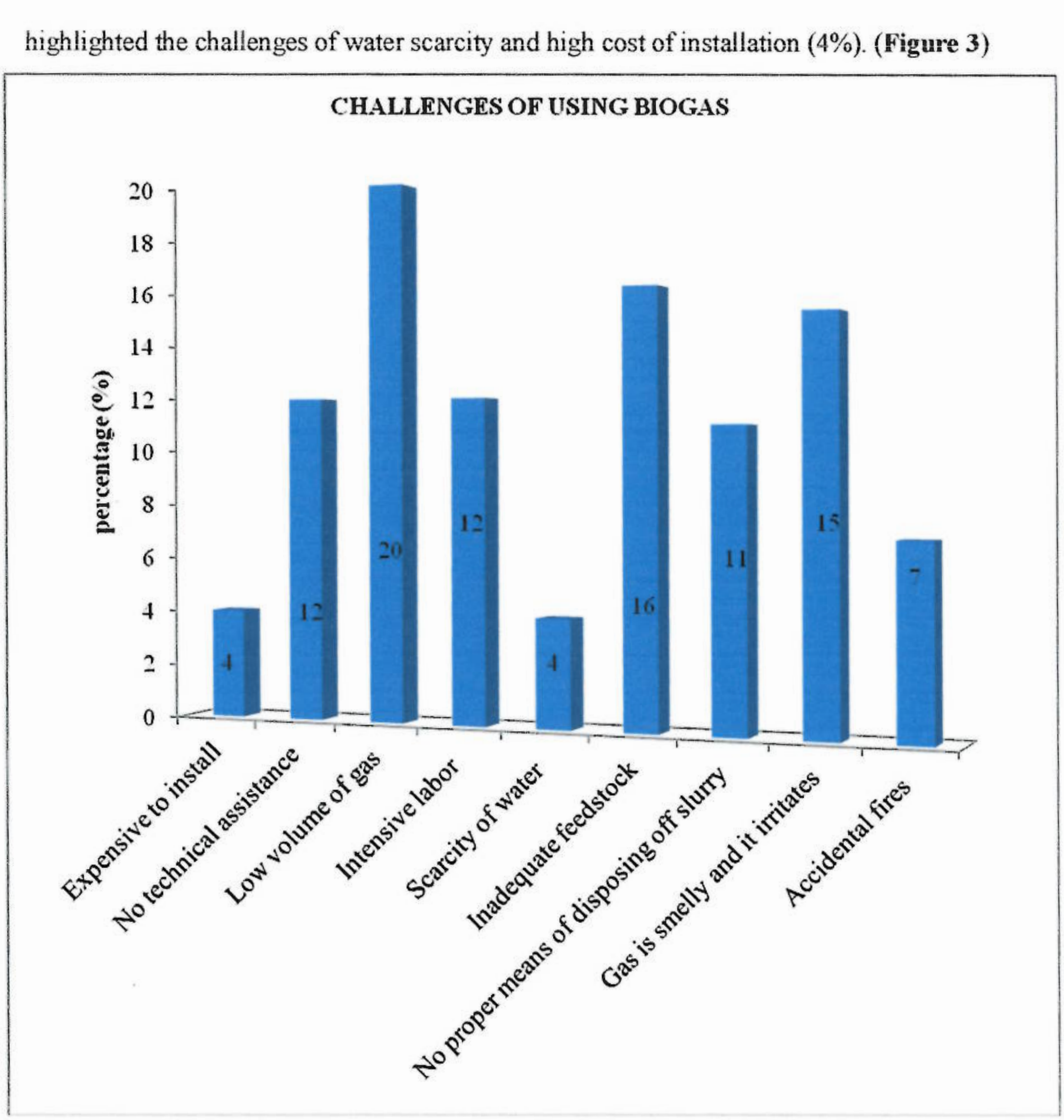


Figure 3: Showing challenges faced by farmers who had adopted biogas

CHAPTER FIVE: DISCUSSION

From the study, the higher percentage of males (60%) indicates that more males had adopted biogas than the female counterparts. This is because most of the farms were owned by men and decisions pertaining adoption of biogas required their consent. These results are backed up by Ndereba (2013) whose findings showed that majority of the households (87%) were headed by males.

The most predominant age group was above 45 years. These findings are in agreement with (Wanjiru, 2009). This could be because most land holdings were owned by people above 45 years and the young people especially under 18 did not own any land where to place the digesters.

The majority of respondents had an average household size of 8 people. This contrasts with (UBOS, 2014) which reported that the average household size was 4.4. This could be due to variability in the methods of collecting data (UBOS used enumeration while the researcher used sampling).

The study revealed that, the levels of education of the respondents were high, 48 % had attained secondary / tertiary level education. These findings are similar to those of other scholars Mary *et al.* (2007) who postulated that education enabled people to have the ability to understand and embrace new innovations and have the exposure to development dynamics. In another study by Karuiki (2009), a higher level of education was associated with adoption of biogas technology.

Majority of the respondents were carrying out both crop cultivation and livestock rearing. This agrees with the findings published by (Ruthenberg, 1980; Pingali *et al.*, 1987). This could be because rearing of livestock and crop cultivation are sustainable as the livestock provide the crops with manure; the crops provide the livestock with feeds as well.

Most (84%) of the farmers owned cattle while 16% reared pigs. These findings are in agreement with a study (Wanjiru, 2009). The larger number of cattle could be attributed to the fact that most of the farmers in the study had been given cattle by NGOs while the rest who used their own resources had the assumption that cattle produced larger amount of dung to be used as feedstock than the pigs and thus the preference for cattle.

Most of the farmers (84%) carried out intensive system of rearing. These findings agree with Nguu *et al.* (2014) in Embu West district Kenya. This could be because most of the farmers said it was easier to collect feedstock in a zero grazing unit than from free range animals.

The study revealed that most (37.3%) of the respondents owned between 1 to 5 cattle. These findings agree with Nguu (2014). This could be because a minimum of two cows is sufficient to produce enough feedstock for feeding the digester (Schwengels, 2009).

Majority (80 %) of respondents owned fixed domed bio digester and only 20 % owned floating drum bio-digester. These findings are in agreement with (Walekwa *et al.*, 2009).This could be due to the fact that the fixed dome and floating drum digesters have a long lifespan compared to other types like the tubular digester.

The most predominant size of digester were the 6 m^3 owned by 57 % of the respondents. This is in agreement with (Walekwa, 2009). This could be because the gas is sufficient for a small household. Thirty two percent of the respondents had used biogas for 6 - 12 months at the time of the study while 20% had used their biogas plant for over 5 years and above. These results disagreed with (Nguu *et al.*, 2014). The variation may be due to the difference in the time of adoption of biogas.

Most of the biogas plants were funded by NGOs (64 %). These results are in agreement with (Fred, 2014). This could be because most of the respondents had little savings to invest in installing biogas plants thus relying on the NGOs for funding.

Biogas was mainly used for cooking (75%). These findings are in relation to (Fred, 2014). This could be because the volume of gas was insufficient to facilitate other purposes like lighting and power generation.

All the respondents interviewed were familiar with routine procedures in biogas operations and maintenance. These findings are in agreement with (Nguu *et al.*, 2014). This could be probably due to the training which farmers were given during promotional activities by the extension officers of the local NGOs which were promoting biogas in Jinja

Major sources of information and maintenance about biogas were mainly from NGOs (64 %); this was followed by demonstration effect. Very few people received information from print media, friends, biogas Construction Company, and relatives. These results are in disagreement with Nguu *et al.* (2014) whose study revealed that most of the respondents received information from fellow farmers, then print media, agric officers, then NGOs

The study revealed that most farmers used animal excreta for feeding their digesters and only a few used both animal and human excreta. These findings agree with (Fred, 2014). This could be attributed to the poor perception that most farmers had for the human excrement as they looked at it as a dirty thing

Most (48%) of the respondents attributed the reason for adopting biogas to availability of feedstock. These findings agree with (Mwakaje, 2008). This could be because sufficient feedstock is required to produce biogas (Tumwesigye, 2013)

Some farmers attributed adoption of biogas to the reduction of the need for fuel wood in traditional cooking stoves; this is in agreement with Nguu *et al.* (2014). This is because some farmers stated that there was a scarcity of wood fuel and they wanted to reduce the hustle for looking for it.

Some respondents thought that biogas was cheaper than other source of fuel in a long run. This is in agreement with the findings of (Gitonga, 2014). This could be because once a farmer had the feedstock and the biogas in place with family labor used for collecting and mixing excrement, then there would be no need to incur more costs especially in buying fuel for cooking.

The least percentage 3% indicated that adoption of biogas is because it is user friendly. These findings agree with (Tumwesigye, 2013). This could be because cooking with biogas does not produce smoke and it cooks faster making the cooking less tedious.

The most predominant challenge faced by most respondents who adopted biogas technology in the study area was low volume of gas. This could be because most user and operators fed the digesters with insufficiently prepared and dried feedstock thus the low values for methane and the high values for hydrogen sulphide gas. These findings are in agreement with the findings of (Fred, 2013) and Nguu *et al*. (2014) in Embu West district in Kenya.

The other challenge was inadequate feed stock. This is in agreement with (Nguu *et al*., 2014). The scarcity of feeds was attributed to prolonged draught which led to less quantities of feed being fed to cattle to the extent that some farmers who were I initially practicising zero grazing resorted to tethering and free-range leading to collection of lesser quantities of feedstock as less fed animals produced less dung and it was difficult to collect dung from animals which were being moved from place to place for feeding

Few respondents highlighted the challenges of water scarcity for mixing the excrement to feed the digester leading to abandonment of some digesters. These findings are in relation to another study (Mwakaje, 2008) this could be because biogas units typically required water and manure to be mixed in an equal ratio.

Some respondents noted the challenge of high cost of installation. The findings are in agreement with Pandey *et al*. (2007) who reported that adoption of biogas in Uganda had been limited, partly because of the upfront cost of a biogas digester.

The study also showed that (12%) of the respondents faced the challenge of no technical assistance. This finding agrees with Nguu *et al*. (2014) who observed that there was a shortage of trained technicians to install and service digesters in Kenya thereby limiting adoption of biogas by some farmers.

The findings of the study revealed that there was no proper means of disposing off slurry. These findings were in agreement with (Fred, 2013). This may be because the farmers own small land holdings such that they have nowhere to dispose of slurry on their land.

Some of the respondents reported that they had accidental fires. These findings are in relation to (Upham & Shackley 2007). These findings may be due to gas leakage incase of lose connection of gas pipes.

Gas is smelly and it irritates. These findings agree with (Mulinda *et al.*, 2013). The bad smell of the gas may be due to the escape of hydrogen sulphide and methane gas as a result of leaving the gas taps open.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Most (48%) of the respondents attributed the reason for adopting biogas to availability of feedstock and the most predominant challenge faced by most respondents who adopted biogas technology in the study area was low volume of gas.

6.2 Recommendations

I recommend that operators of biogas plants should prepare feedstock appropriately that is mixing the water or urine with excrement to get a porridge mixture and use fresh excrement for feeding the digester to overcome the challenge of low gas volume.

REFERENCES

Akram, W., M. Irfan, et al. (2013). "The Perception about the Biogas Technology Adoption: A Case Study of District Faisalabad (Punjab, Pakistan)." Middle-East Journal of Scientific Research 17(2): 256-259.

Al Seadi, T., D. Rutz, *et al.*, (2008). Biogas Handbook.–University of Southern Denmark Esbjerg, ISBN 978-87-992962-0-0.

Amigun, B., A. Aboyade, et al. (2012). Anaerobic biogas generation for rural area energy provision in Africa, INTECH Open Access Publisher.

Bhat, P., H. Chanakya, et al. (2001). "Biogas plant dissemination: success story of Sirsi, India." Energy for sustainable development 5(1): 39-46.

Boonrod, K., S. Towprayoon, et al. "Public Perspective toward Waste-to-energy Applications in Thailand: An Opportunity on Biogas Production from Organic Waste."

Burns & Grove (1993), The practice of nursing research; ISBN : 9781455707362.

Crook. M & Buren. A (1979) A Chinese Biogas Manual. Popularizing technology in the country side Pg 20 ISBN 0 903031 65 5 .

Dahunsi, S. and S. Oranusi (2013). "Co-digestion of food waste and human excreta for biogas production."

Dieter, D. and A. Steinhauser (2008). Biogas from waste and renewable resources: an introduction, Weiheim, Germany: Wiley-VCH.

Feder, G., R. E. Just, et al. (1985). "Adoption of agricultural innovations in developing countries: A survey." Economic development and cultural change: 255-298.

Frankel, J. R & Wallen, E (2004).How to design and evaluate research in education.

Fred. L (2013) Quality and usage of biogas digesters in Uganda. Un published report.

Görgen, M., B. Rudloff, et al. (2009). Foreign direct investment (FDI) in land in developing countries, GTZ.

Hazra, S., J. Lewis, et al. (2014). Adoption and use of improved stoves and biogas plants in rural India.

Heikoop, B. (2013). How Could the Uptake of Biogas Technology be Increased in Uganda?, United Nations University.

Kahubire, E. B., Andrew, B., Kahubire, B., Byaruhanga, A. B. & Mohammed, S. A (2010) Socio-economic and gender baseline survey for the Uganda domestic biogas project.

Kamuntu .E (2012) Ministry of Water and Environment Sector Performance Report.

Karki, A. B. and B. Expert (2006). "Country Report on the Use of Bio-slurry in Nepal." Kathmandu: BSP-Nepal.

Kasisira L.L, & Muyiiya. N.D. (2009) Assessment of the Effect of Mixing Pig and Cow Dung on Biogas Yield. Agricultural Engineering International: the CIGR E journal. Manuscript PM 1329, Vol. XI.

Kothari, C. (2004). Research methodology: Methods and techniques, New Age International.

MAAIF, U. (2009). "THE NATIONAL LIVESTOCK CENSUS REPORT 2008." Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Entebbe/Uganda Bureau of Statistics, Kampala, Uganda.

Mark, E. (2012). Assessing the use of power generation technologies in Uganda: A case study of Jinja Municipality, PhD Thesis. Stockholm University.

Marks. J & Wagg. O (2013) Clean Start Connections Expanding Market based - energy finance solutions. A business led approach to providing clean energy financing for the rural poor. Issue 1 Publisher UNCDF CleanStartwww.uncdf.org/en/clean start

Menya. E *et al.*, (2013) Biogas initiative as an alternative to fuel wood for a household in Uleppi sub-county in Uganda. Agricultural engineering International: CIGR Journal 15(1):50-58.

Miah, M. D., H. Al Rashid, et al. (2009). "Wood fuel use in the traditional cooking stoves in the rural floodplain areas of Bangladesh: a socio-environmental perspective." Biomass and Bioenergy **33**(1): 70-78.

Mulinda, C., Q. Hu, *et al.*, (2013). "Dissemination and Problems of African Biogas Technology." Energy and Power Engineering 5(08): 506.

Mwakaje, A. G. (2008). "Dairy farming and biogas use in Rungwe district, South-west Tanzania: A study of opportunities and constraints." Renewable and Sustainable Energy Reviews **12**(8): 2240-2252.

Mwakaje, A. G. (2012). Dairy Farming and the Stagnated Biogas Use in Rungwe District, Tanzania: An Investigation of the Constraining Factors, INTECH Open Access Publisher.

Mwirigi, J., Balana. B. B., *et al.*, (2014). "Socio-economic hurdles to widespread adoption of small-scale biogas digesters in Sub-Saharan Africa: A review." biomass and bioenergy 70: 17-25.

Mwirigi. J. W, Makenzi. P. M, Ochola. W. O. Socio-economic constraints to adoption and sustainability of biogas technology by farmers in Nakuru districts, Kenya. Energy Sustain Devel 2009;13(2):106e15.

Ndereba, P. (2013). Factors influencing the usage of Biogas in Kenya: A case of Ndaragwa constituency, Nyandarua county.

Ndyabawe, K. & Kisaalita W. S. (2014). "Validity of the Africa-wide Lang factor of 2.63 for estimating small biogas plant installation costs in Uganda." International Journal of Agricultural and Biological Engineering 7(1): 70-76.

Nguu. J, Ndivo. S, Aduda. B, Nyongesa. F, Musembi. R, (2014) Livestock farmers' perception on generation of cattle waste- based Biogas methane: the case of Embu West district, Kenya. Journal of Energy technologies and policy ISSN 2224-3232 Vol. 4, No. 8.

Noy, C. (2008). "Sampling knowledge: The hermeneutics of snowball sampling in qualitative research." International Journal of social research methodology 11(4): 327-344.

Ocwieja, S. M. (2010). Life cycle thinking assessment applied to three biogas projects in central Uganda, Michigan Technological University.

Okaka, W. T. (1988)"The energy scene in Uganda: an image of the national energy sector."

Omer .A. M, Fadalla. Y. (2003) Technical note: biogas energy technology in Sudan. Renew Energy perspective." Biomass and Bioenergy. Vol. 33. pp. 70 -78.

Pandey, B., Subedi, P. S., Sengendo, M. & Monroe, I. 2007. Biogas for a better life: An African initiative. *Report prepared for the Dutch Ministry of Foreign Affairs by Winrock International.*

Pingali, P. L., Bigot, Y. & Binswanger, H. P. 1987. *Agricultural mechanization and the evolution of farming systems in Sub-Saharan Africa*, Johns Hopkins University Press.

Polit, D. and B. Hungler (1995). "Evaluating research reports." Nursing research. Principles and Method: 574-588.

Renwick M, Subedi PS, Hutton G. Biogas for better life: an African initiative. A cost-benefit analysis of national and regional integrated biogas and sanitation programs in Sub- Saharan Africa. Little Rock, Arkansas: Winrock International; Apr. 2007. p. 68.

Ruthenberg, H. 1980. *Farming systems in the tropics*, Oxford University Press.

Schwengels, P. (2009). "Dairy Manure Biogas Opportunitiesin Manica Province, Mozambique." A Preliminary Assessment. Prepared for Land O'Lakes International Development Smallholder Dairy Development Programin Manica Province, Mozambique.

Seadi, T, (2008). "Biogas handbook", Published by University of Southern Denmark Esbjerg, Niels Bohrs Vej 9-10, DK-6700 Esbjerg, Denmark.

Sengendo, M., Turyahabwe, E., Christopher, K., Muganzi, M., Kamara, E., Rugumayo, A., ... & Mussazi, M. (2010). Programme Implementation Document (PID) for Uganda Domestic Biogas Programme. *Uganda Domestic Biogas Programme: Kampala, Uganda.*

Shokri. Sh (2011) *Biogas Technology, Applications, Perspectives and Implications* International Journal of Agricultural Science and Research Volume 2, Number 3, Pg 54 paragraph 10 Summer 2011(Serial #4) www. SID.ir.

Smith, J., G. Austin, et al. (2012). The potential of small-scale biogas digesters to alleviate poverty and improve long term sustainability of ecosystem services in Sub-Saharan Africa. Interdisciplinary Expert Workshop.

Statistics, U. B. O. (2014). Statistical Abstract.

Tumwesige, V. (2013). The potential of flexible balloon digesters to improve livelihoods in Uganda. A case study of Tiribogo, James Hutton Institute.

Uli.W, Nicolai.H, Ulrich Stohr-Grabowski (1989) Biogas plants in animal husbandry a practical guide. A Publication of Deutsches Zentrum fiir Entr. ddungstechnologien – GATE in: Deutsche Gesellschaft fiir Technixhe Zuszmmenarbeit (GTZ) GmbH ISBN J-528-02048-2.

Upham. P. & Shackley. S. (2007) Local public opinion of a proposed 21.5 MW (e) biomass gasifier in Devon: Questionnaire survey results, Biomass and Bioenergy. 31(6), p 433-441.

Volk. S & Janssen. R (2008) Biogas handbook Pg 13 http:// lemvigbiogas.com/.

Wachera. W. R. (2014) Assessing the challenges of adopting biogas technology in energy provision among dairy farmers in Nyeri county, Kenya. Un published report.

Walekhwa PN, Mugisha J, Drake L. (2009) Biogas energy from family-sized digesters in Uganda: critical factors and policy implications. Energy Policy; 37(7):2754e62. WP 86–14 ISBN: 978-9937-596-16 ISBN: 978-3-527-31841-4.

Wenpeng, Z. (2002). "On a Cochrane sum and its hybrid mean value formula." Journal of Mathematical Analysis and Applications 267(1): 89-96.

BUSITEMA UNIVERSITY
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QUESTIONNAIRE FOR FARMERS

Dear respondent, Iam **Alupo Gertrude** a student of Busitema University pursuing a Bachelor of Animal Production and Management who is conducting a research on reasons for adoption and non - adoption of biogas as an alternative source of energy in Jinja district.

My purpose of visiting you is to obtain information from you. The information obtained from you will be kept confidential and will only be used for academic purposes. Therefore, I request for your cooperation, openness, and sincerity.

Enumerator's name: ………………………………………. Questionnaire No: ……………………

Parish: ………………………………………………….. Village: ……………………………..

Date: ………………………………………………………

SECTION A: GENERAL CHARACTERISTICS OF RESPONDENTS

GENDER	A. Female	☐	B. Male	☐
AGE	A. Under 18 years	☐	B. 18 to 35 years	☐
	C. 35 to 45 years	☐	D. Over 45years	☐
MARITAL STATUS	A. Single	☐	C. Married	☐
	B. Divorced	☐	D. Others	☐

	If others, specify ....
FAMILY SIZE	A. 2 to 5 ☐ C. 5 to 10 ☐ B. 10 to 15 ☐ D. Others ☐
LEVEL OF EDUCATION	A. No formal education ☐ B. Primary ☐ C. Secondary ☐ D. Tertiary ☐
OCCUPATION	....
RELIGION	A. Catholic ☐ Anglican ☐ B. Moslem ☐ SDA ☐ C. Bornagain Christian ☐ D. If others, specify ....

1. Which type of farming are you engaged in?

A. Livestock rearing ☐ D. None ☐

B. Crop cultivation ☐ E. Others ☐

C. Livestock and crop cultivation ☐

2. What livestock species do you rear?

A. Cattle ☐ D. Fish ☐

B. Pigs ☐ E. Others ☐

C. Poultry ☐

3. How many animals are you keeping on your farm?

A. Cattle

i. 1 to 5 ☐ iii. 11 to 15 ☐

ii. 6 to 10 ☐ iv. Above 15 ☐

B. Poultry

i. 1 to 10 ☐ iv. 31 to 40 ☐

ii. 11 to 20 ☐ v. Above 50 ☐

iii. 21 to 30 ☐

C. Pigs

i. 1 to 5 ☐ iii. 11 to 15 ☐

ii. 6 to 10 ☐ iv. Above 15 ☐

4. If owning livestock, which system of rearing do you use?

A. Free range system ☐ B. Intensive system ☐

C. Semi - intensive system ☐

SECTION B: ENERGY AVAILABILITY AND BIOGAS ADOPTION

5. Which form of energy do you use in your household or farm?

A. Hydro power electricity ☐ F. Kerosene ☐

B. Biogas energy ☐ G. Charcoal ☐

C. Solar energy ☐ H. Firewood ☐

D. Liquefied Petroleum Gas (LPG) ☐ I. Briquettes ☐

E. Improved cook stoves ☐ J. Dry cells ☐

If others, specify

....

....

6. Do you own a biogas plant?

A. Yes ☐ B. No ☐

7. If yes, which type of a biogas plant is it?

A. Fixed dome shape bio digester ☐ B. Tubular digester ☐

C. Floating drum digester ☐ D. Modified CARMATEC model ☐

A. Others ☐

8. What is the size of your biogas digester?

A. 4 m^3 ☐ B. 6 m^3 ☐ C. 9 m^3 ☐ D. 12 m^3 ☐

9. How long have you used the biogas plant

A. 0 to 6 months ☐ D. 1 to 5 years ☐

B. 6 to 12 months ☐ E. Over 5 years ☐

C. Others (Specify)

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10. Who funded of the biogas project you are using currently?

A. Government ☐ B. Non Government Organization ☐

C. Family project ☐ D. Own resources ☐

11. What do you use the biogas for?

A. Entire cooking ☐ D. Cooking and lighting ☐

B. Light cooking ☐ E. Emergencies only ☐

C. Commercial purposes ☐ F. Others ☐

If others, specify

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12. Are you familiar with biogas operation and maintenance?

A. Yes ☐ B. No ☐

13. If yes, where did you obtain from the knowledge of operation and maintenance of a biogas plant?

A. Biogas construction company ☐ D. Friends ☐

☐ ☐

B. Print media E. Relatives

C. Demonstration effects ☐ F. NGOs ☐

14. Which feedstock do you use for feeding the bio- digester?

A. Crop residues ☐ B. Kitchen wastes ☐

C. Animal excrement ☐ D. Human excrement ☐

SECTION C: PERCEPTION OF RESPONDENTS TOWARDS BIOGAS

15. Which factors favored your decision to own a biogas plant?

A. Availability of funds for construction ☐

B. Availability of feedstock like dung ☐

C. Reduction of necessity for wood needed in traditional stoves ☐

D. It was an initiative from an NGO to act as a demonstration plant ☐

E. If others, please specify ☐

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16. Have you benefited from the biogas plant? If yes, what benefits have you accrued from using biogas as an alternative source of energy?

A. Financial benefits, I no longer buy wood fuel ☐

B. Agricultural, I use slurry as manure and it has improved crop yield ☐

C. Health benefits, no more chocking by indoor smoke when I use biogas for cooking ☐

D. Psychological, I have a peace of mind due to less drudgery as it is easy use biogas rather than firewood ☐

E. Time saving, it cooks faster than other forms of energy ☐

F. Others, (please specify) ☐

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17. Do you think biogas has an impact on your health? If so, specify

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18. What is your opinion about using bio - slurry as manure for your garden?

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SECTION D. LIMITATIONS TO ADOPTION OF BIOGAS

19. Do you encounter any challenges with this technology?

A. Yes ☐ B. No ☐

20. Which challenges?

A. It is expensive to install a biogas plant ☐
B. There is no technical assistance as regards to usage, repair and maintenance ☐
C. The volume of the gas is too low to be used for cooking / lighting ☐
D. We experience accidental fires due to gas leakage ☐
E. It requires intensive labor to mix dung and collect water for mixing ☐
F. Inadequate feedstock ☐
G. The digester consumed a lot of space for other purposes ☐
H. Gas is smelly and it irritates ☐
I. We have no proper means of disposing off the bio slurry ☐
J. The digester is no longer functional, it broke down due to mechanical breakage ☐
K. If others, specify ☐

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21. How do you overcome the above mentioned challenges?

A. Through seeking for technical assistance ☐
B. There is no way of overcoming these challenges ☐
C. If others, please specify ☐

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22. According to your own view, which factors are attributed to not owning a biogas plant? ☐

A. Inadequate funds for construction
B. Shortage of raw materials to feed the digester ☐
☐

C. Social stigma against use of biogas

D. Low level of awareness about the benefits of biogas ☐

E. Small size of land, therefore no space for a biogas digester ☐

F. Others (specify) ☐

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Thank you for your anticipated cooperation

Map 1: A map of Uganda showing the location of Jinja district