MAKERERE  **UNIVERSITY**

COLLEGE OF VETERINARY MEDICINE, ANIMAL RESOURCES AND BIOSECURITY

SCHOOL OF VETERINARY MEDICINE AND ANIMAL RESOURCES

BACHELOR OF ANIMAL PRODUCTION TECHNOLOGY AND MANAGEMENT

ASSESSING THE FACTORS HINDERING BIOGAS TECHNOLOGY ADOPTION IN MASULIITA SUBCOUNTY, BUSIRO, WAKISO DISTRICT IN UGANDA

BY

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A RESEARCH PROJECT REPORT SUBMITTED TO COLLEGE OF VETERINARY MEDICINE, ANIMAL RESOURCES AND BIOSECURITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELORS DEGREE OF ANIMAL PRODUCTION TECHNOLOGY AND MANAGEMENT OF MAKERERE UNIVERSITY.

DATE OF SUBMISSION……

DECLARATION

I Musaasizi Grace Hope hereby declare to the best of my knowledge and understanding that this research project is my own work and has never been presented to any other university for the award of a degree of Bachelors of Animal Production Technology and Management.

Signature……

Name……..

Date…….

APPROVAL

I acknowledge that this research has been written under my guidance and supervision and is therefore ready for submission as a requirement for the award of a degree of Bachelors of Animal Production Technology and Management.

Signature……

Name……..

Date……

DEDICATION

This report is dedicated to my mother, Ms. Nansereko Rita for being a great pillar all through my life, stepping up time and again, it's such an awesome blessing knowing we have overcome all the bad times together and are yet to achieve another milestone.

To Mr. Mukasa Derrick Peter, I have been beyond lucky to have you in my life, shout outs for the billions of ways of always helping me out, for the countless times of coming to my rescue. You are one of the reasons I have been able to come this far, I will forever be indebted to you.

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ABBREVIATIONS AND ACRONYMS

BSP-Nepal – Biogas Support Programme

GHGs – Green House Gases

GIZ – German Agency for International Cooperation

NGOs – Non Government Organizations

SDG7 – Sustainable Development Goal 7

SDGs – Sustainable Development Goals

SNV-Netherlands - Stitching Nederlandse Vrijwilligers (Foundation of Netherlands volunteers)

SPSS–Statistical Package for Social Scientist

UBOS – Uganda Bureau of Statistics

ABSTRACT

Biogas production is through anaerobic digestion by bacteria and decomposition of livestock waste and biogas adoption process ranges from hearing about it, interest development, attribute evaluation, eventual decision making to its embracement or rejection.(Shallo et al., 2020). Theaim of this study was to assess factors hindering biogas technology adoption in Masuliita Sub County.A cross sectional survey was conducted in three parishes of Masulita sub county, Wakiso district with the use of a questionnaire to collect information about the number of people using biogas, socio-economic factors influencing biogas utilization and production, and challenges associated with biogas adoption. The study revealed low biogas adoption of 23.5% in the study area. The socio-economic factors associated with adoption of the technology included; age, gender, house hold size and average monthly income. Challenges associated with biogas adoption and productionincluded high initial costs of constructing biogas plants, lack of technical experts to repair the biogas plants, inaccessibility of the biogas, high maintenance costs among others. It is recommended that biogas dissemination companies and NGOs review implementation strategies to design and construct affordable biogas plants for the people in Masuliita Sub County.

CHAPTER ONE

INTRODUCTION

1.1 Background

Globally, energy is essential for the development of industries in developed economies and sustainable development plus poverty reduction efforts in developing countries through centrally playing a role as a production factor and domestic necessity(Shallo et al., 2020). Energy holistically contributes through serving socially, politically, economically and environmentally towards development aspects through industrial productivity, education, water, healthcare and agricultural access(Shallo et al., 2020). It caters for humanity by heat provision, electricity, food preparation, transportation, industrial processes too(Tarlue et al., 2019)

Energy has two sources: renewable or non-renewable, but most non-renewable fossil energy sources have undergone depletion thus raising interest in renewable biomass based energies(Shallo et al., 2020). Worldwide concern on energy supply security, climate change and escalated greenhouse gas emissions has hiked sustainable alternative energy searches in both developed and developing countries(Thi et al., 2017).Sustainable energy solutions paucity and wood energy overdependence is greater in developing countries still faced with challenges of lack of access to clean and efficient energy (Marambanyika et al., 2020). Developed countries have however embraced biogas technology most notably China, United States, Thailand, India, Canada etc.

Increasing energy demands in Sub Saharan Africa due to increasing population densities can be met by catering for adequate, sustainable and affordable energy needs: a core of SDGs that is SDG7 to improving life quality (Marambanyika et al., 2020). Acute energy poverty in Sub Saharan Africa has led to emergence of biomass energy in the forms of firewood and charcoal as important energy sources contributing to greater than 75% wood harvests for household energy needs in Africa alone as per US Department of Energy(Marambanyika et al., 2020). This signifies human and climate security threats and hinders poverty alleviationin Sub Saharan Africa as resorting to cleaner energy sourcesis unlikely despite introduction of solar, wind and biogas technologies (Marambanyika et al., 2020)

In Uganda, there is over dependence on biomass as a major domestic energy sourcewhich has adverse impacts on the sustainability grounds(Tarlue et al., 2019). Greater population of Uganda

survives in rural settings where almost no alternatives to biomass fuel exist and the later suffer from shortage of charcoal and firewood, their energy sources (Tarlue et al., 2019).Biogas technology introduction in Uganda since 1950s asa remedy for local energy needs has overall attained very low acceptation.(Tarlue et al., 2019)Several established biogas projects have failed and functional ones aren't performing to expectationin Uganda due to: inadequate household operation and maintenance, limited construction skills and facilitating conditions,water shortage, etc.(Tarlue et al., 2019)

Biogas production is through anaerobic digestion by bacteria and decomposition of livestock wasteand biogas technology adoption as a process ranges from hearing about it, interest development, attribute evaluation, eventual decision making toits embracement or rejection.(Shallo et al., 2020)Factors influencing biogas technology: gender, water supply, income, household size and head's education level and age, technical availability (Uhunamure et al 2019). Biogas adoptionbenefits: forest protection,dropped energy costs, diminished wood fuel use, abated time for energy procurement, better lightening vs kerosene lamps, improved hygiene,de-escalated CO_2 emissions, increased farm incomes, reduced health risks associated with continuous smoke exposure.(Tarlue et al., 2019)

A number of local and international organizations, government agencies and NGOs e.g. BSP-Nepal, African Biogas Partnership Program, SNV-Netherlands are actively advancing biogas technology and biogas use ideas in countries like Uganda(Momanyi, 2018). Some studieshave been conducted to assess determinants of biogas technology adoption in rural areas in different countries and results point towards energy ladder and fuel stack /multiple fuel use approach concepts (Shallo et al., 2020). No research however, has been done to comprehensively examine factors for low biogas adoption in Busiro sub county, Wakiso district despite biogas being apotentialenergy source and ideal solution to curb energy challenges backed with heaps of wastes as sustainable feedstock.

1.2 Problem statement

Uganda has one of the lowest per capita electricity consumption rates in the world. Greater percentage of the total energy consumption isaccounted for by traditional biomass fuels (charcoal and wood) which leads to an increased forest cover loss. An energy crisis is likely if biomass fuel

reliance remains unaddressed. There is urgency for additional energy resource discoveries in Uganda due to elevating energy demand and to overcome plummeting of the forest cover.

Most rural households' inaccessibility to electricity makes Uganda an energy poor country yet generation of own energy through scaling up biogas projects at local levels is feasiblee.g. there are significant amounts of agricultural residues, plant material, manure, waste (municipal, food, agricultural, green), sewagewhich are potential raw materials for biogas production. In addition, such wastes on accumulation create environmental and health hazardsand have socio-economic impacts on development thus waste disposal is critical of which could include acting as feedstock in biogas plants thus waste management. Biogas technology as a modern renewable energy has to increasingly take primacy but there are low adoption rates following its introduction in Uganda amidst dis-adoption and over 50% failure of productive biogas plants on installation within 2 years after commissioningperhaps dueto logistical and technical challenges. It is against this background that the research study seeks to establish factors that contribute to continued low adoption of the technology in Masuliita Sub County, Wakiso district in Uganda.

1.3 Significance

In Uganda, several organizations started the implementation and usage of biogas in rural areas as an alternative source of renewable energy as opposed to using the traditional bio fuels. However, little or no success has been achieved by these organization as the adoption and usage of biogas energy remains low in the rural areas of the county. It is on this background that this study seeks to assess the factors hindering the adoption of biogas energy in Masuliita Sub County

The study will generate information on biogas adoption that can be relied on by development agencies, organizations and the government in a bid to promote and disseminate biogas technology as an alternative energy source to wood based energy as clean, affordable as sustainable energy (SDG7). This checks on wood energy consumption and counteractsindoor air pollution and human health issues like respiratory ailments due to prolonged exposure to smoke, encroachment on the forest cover and climate change.

Examination of challenges of biogas adoption in the households from user's perspective during the study will guide on sustainable adoption and implementation of biogas initiatives with its

related benefits e.g. meeting the increasing energy demands consequently easing life andimproving standards of living in rural areas.

Findings and conclusions of the study will equally mentor policies on renewable energy use highlighted in the national development plan for environmental conservation, forest protection and broadening Carbon credits

1.4 Objectives

1.4.1 General objective

To assess determinants of biogas technology adoption in Masuliita sub county, BusiroCounty, Wakiso district in Uganda.

1.4.2 Specific objectives

To document the number of people using biogas energy in Masuliita sub county, Busiro in Wakiso district, Uganda.

To determine socio-economic factors influencing biogas energy utilization and production in Masuliita sub county, Busiro in Wakiso district, Uganda.

To establish challenges associated with biogas adoption in households and those that backslid in Busiro, Wakiso district in Uganda.

1.5 Research question

How many people use biogas energy in Masuliita sub county, Busiro, Wakiso district in Uganda?

Which socio-economic factors influence biogas energy utilization and production in Masuliita Sub County?

What challenges are associated with biogas adoption in households in Masuliita Sub County?

1.6 Scope of the research

1.6.1 Contextual scope

The research was to assess factors limiting biogas technology adoption in Masuliita Sub County, Busiro Wakiso district in Uganda explicitly accentuating determinants for biogas adoption and utilization, challenges due to biogas use along with number of people using biogas.

1.6.2 Geographical scope

The research was conducted in Masuliita sub county, Busiro, Wakiso district in Uganda. A simple random approach was utilized to select either households with or without biogas projects i.e. both adopters and non-adopters to constitute the sample.

1.6.3 Time scope

The research surveyed data from about 8 years back and it was concluded in a four months span viz October to January.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Biogas technology

Biogas technology in Uganda is believed to have started in 1985 when Uganda's vice president by then visited China on a business trip and was shown how people in rural areas were reaping from usage of biogas energy. On his return to Uganda, he came with three experts to train Ugandans in production and usage of biogas energy. But being a period of political turmoil and liberation wars, plan did not work, so project did not take off. It is on such a background that current utilization and production of biogas in Uganda is still low. In developing countries like Uganda where food is scarce and reliable energy supplies scarcer, necessity often becomes the mother of invention. It is possible for farmers to use human urine and excreta, banana peelings, algae, water hyacinth, cow dung and poultry droppings as an inexpensive source of biogas. In Uganda particularly Kampala district, the technology is being employed in cooking, lighting pressure lamps and in various suburbs residents already reap through use of slurry a byproduct of biogas for soil enrichment contributing to larger crop outputs(Wamuyu, 2014).

2.2 Biogas production- the process

Biogas is produced in a biological anaerobic process in absence of oxygen. Organic matter is broken down to form a gas mixture known as biogas. The process is widely found in nature, taking place in moors, e.g. at bottom of lakes, in slurry pits and in rumen of ruminants. The organic matter is converted almost entirely to biogas by a range of microorganisms. Energy in form of heat and new biomass are also generated. Resulting gas mixture consists primarily of methane (50-75 vol. %), carbon dioxide (25-50 vol. %), small quantities of hydrogen, hydrogen sulphide, ammonia and other trace gases. Composition of the gas is essentially determined by the substrates, the fermentation/ digestion process and the various technical designs of the plants.

The process by which biogas is formed can be divided into majorly three steps. The individual stages of decomposition (degradation) must be coordinated and harmonized with each other in the best way possible to ensure that the process runs smoothly. During the first stage, hydrolysis, the complex compounds of starting material e.g. carbohydrates, proteins and fats are broken down into simpler organic compounds e.g. amino acids, sugars and fatty acids.

The hydrolytic bacteria involved in this stage release enzymes that decompose the material biochemically.(*Guide to Biogas From Production to Use*, n.d.)

Intermediate products formed by this process are then further broken down during acidogenesis (the acidification phase) by fermentative acid forming bacteria to form lower fatty acids (acetic, propionic, and butyric) along with carbon dioxide and hydrogen. In addition, small quantities of lactic acid and alcohols are also formed. In acetogenesis (formation of acetic acid), products from acidogenesis are converted by acetogenic bacteria into precursors of biogas (acetic acid, hydrogen and carbon dioxide)with hydrogen partial pressure being particularly important in the connection. Excessively high hydrogen content prevents conversion of intermediate products of acidogenesis due to energy related reasons. As a consequence, organic acids such as propionic acid, isobutyric acid, isovaleric acid and hexanoic acid accumulate and inhibit methane formation. For this reason, acetogenic bacteria (hydrogen forming bacteria) must co-exist in close biotic community with hydrogen consuming methanogenic bacteria, which consume hydrogen together with carbondioxide during formation of methane (interspecies hydrogen transfer) thus ensuring an acceptable environment for the acetogenic bacteria. During the subsequent methanogenesis phase, the final stage of biogas generation, acetic acid, hydrogen and carbon dioxide are converted into methane by strictly anaerobic methanogenic bacteria.(*Guide to Biogas From Production to Use*, n.d.)

2.3 Overview of the biogas industry

As of today, Germany is the world's biggest biogas producer and the market leader in biogas technology. Biogas plants operating throughout the country were estimated at 5,905 in 2010: lower Saxony, Bavaria, and the Eastern federal states as the main regions. Most of the plants are employed as power plants. Biogas in Germany is primarily extracted by the co-fermentation of energy crops mixed with manure with corn as the main crop. Organic waste, industrial and agricultural residues such as waste from the food industry are also used for biogas generation. The level of development varies greatly in developed countries in that while countries like Germany, Austria and Sweden are fairly advanced in their use of biogas, there is vast potential for this renewable energy source in the rest of the continent especially in Eastern Europe. Different legal frameworks, education schemes and the availability of technology are among the prime reasons behind the untapped potential.(Fuels, 2020)

Biogas production in most developing countries particularly Uganda has not been exploited. The main biogas depot in Uganda as at 2015 was in Mubende district and the Mobuku irrigation scheme. Efforts however, by international organizations like GIZ have increased biogas depots numbers in Uganda.(Mshandete& Parawira, 2009) These facilities have since been run down by poor government policies of reconditioning and maintenance for mass production. Biogas fuel is an important contribution and improvement of natural resources and environment through provision of energy for cooking and lighting at cheaper costs. It can be used as a tool for clearing and digesting animal manure making it better and ready as a fertilizer for use in gardens and fish ponds as it helps improve the sanitary conditions in homesteads.(Nina, 2020)

2.4 Benefits and usage of biogas

Biogas provides multiple benefits that can contribute to addressing vital local and global development challenge.(Yu et al., 2008)Biogas production has great potential to contribute to sustainable development by providing a wide variety of socio-economic benefits(Mshandete& Parawira, 2009), including diversification of energy supply, creation of domestic industries (lpgs) and employment opportunities(Burguillo, 2008), increased crop productivity (through use of slurry as a fertilizer) and provision of clean fuel, income generation(Ã, 2008). Biogas can have significant health benefits by alleviating poor indoor air quality. Use of biogas system in livestock rearing community can reduce methane emissions and enhance soil fertility. The slurry obtained after methanogenesis is enriched with important nutrients.(Yu et al., 2008) estimated the environment benefits of bio digesters in China by determining GHGs reduction. Their study revealed reduction of 45.59×10^{6} tonnes of carbon dioxide equivalent per annum between 1991 and 2005 in rural China.

Globally, 16 million households still depend on small scale biogas digesters to meet their cooking and lighting needs in rural communities. However, developed countries like China, are successfully implementing biogas production on large scale with an estimated 8 million biogas digesters (Cushion et al., n.d.). In Africa, production of biogas on large scale is growing gradually with Ghana, Nigeria, Uganda, Kenya and Rwanda being pioneering countries.(Ã, 2008)

2.5 Factors affecting the adoption of biogas technology in Uganda

Locally, biogas has been realized as a potential sustainable source of energy with respect to the increase in environmental degradation (deforestation as source of traditional biomass, firewood). However, the total production volume is still very low which raises concerns and questions about the factors hindering biogas technology adoption. These factors range from economic, technical, competition from other locally available biomass, socio-cultural to institutional in nature.(Maiyah, 2019)

The availability of money is considered to be vital in choosing an energy source. Biogas installations require high amounts of money and inability of government to put incentives on materials used when constructing biogas digesters has also contributed to the low adoption rate of biogas technologies. In some areas, biogas installations have been left to mercy of non-government organizations that source from abroad as the local populations cannot afford to pay the large sums of money. Initial cost of a biogas digester is estimated to cost 6 to 20 million Uganda shillings depending on its capacity. (Arthur et al., 2011)

Lack of training biogas users in the use of biogas digesters affects their maintenance which is essential in ensuring efficient delivery of energy to the households. Households need to be informed about benefits, correct use, maintenance, limitations and safety of biogas plants. The frequent need for repairs as stated by some authors, inadequate expertise among the construction and maintenance teams are additional constraints to use of and adoption of biogas.(Momanyi, 2018)

Locally available biomass like firewood and charcoal can be acquired at lower prices as compared to prices of biogas. In the long run, however, biogas prices are lower than that of firewood and charcoal. On the other hand, in rural parts of Uganda, traditional biomass is readily available and thus communities are forced to rely on them.

From a socio-cultural view, there is a lack of public participation and interest from consumers. This is brought about by insufficient knowledge about the technology of which the communities think the technology word is synonymous with activities that require high education levels and large sums of money to implement yet most communities prefer to use cheaper options. Stigma

among some communities is another barrier to adoption of biogas technology especially in religious and traditional societies where biogas technology projects might fail due to beliefs that they cannot get energy from fecal matter due to strict rules about cleanliness and the whole process being considered dirty.(Sigamoney, 2008)

Government institutions are very key in the adoption and implementation of new technologies. For Uganda, however, there is little or no political support and specific programs to promote biogas technologies. The energy sector has not received significant attention from policy makers. The bureaucracy of government bodies has also hindered the financing of biogas projects due to the many requirements, legal procedures which slow down the process of biogas plants installation.(Maiyah, 2019)

2.6 Research gap

Different studies have been conducted on factors hindering adoption and challenges related to adoption of biogas for example(Patricia Tarlue J.V et al., 2019),(Shallo et al., 2020),(Erick et al., 2018)However, none of these studies have focused on Masuliita Sub County despite the energy source challenges the residents suffer.

CHAPTER THREE

METHODOLOGY

3.1 Research design

Across sectional survey was adopted in the research to obtain information concerning current status of adoption, number of biogas users, socio-economic factors, and challenges associated with biogas production and adoption in Masuliita Sub County

3.2 Study area

Thestudy was conductedin Masuliita sub county, Busiro county, Wakiso district in the central region of Uganda. Wakiso is 3,870ft above sea level with coordinates 01 00N, 31 46E and is bordered by districts: Mukono, Nakaseke (in the North East), Luwero, Kalangala, Mpigi, Mityana (in the South), and Kampala. Masuliita is one of the 17 sub counties in Wakiso and has 11 parishes: Masuliita, Kabale, Katikamu, Bbale-mukwenda, Manze, Nakikungube, Kanzize, Kyengeza, Lugungudde, Lwemwedde, and Ttumbaali with 49 villages. Masuliita is about 12.5kilometres north of Kakiri, nearest large town and about 22kilometres northwest of Wakiso, where district headquarters are located and is located approximately 38kilometres by road northwest of Kampala, Uganda's capital city.Masuliita is seated on an area space of 113.8square kilometers andhas a population of about 21,300 people with 50% males and 49.2% females (UBOS, 2020). Majority of the populationsurvives on agriculture (both farming and animal keeping) either directly or indirectly. Other economic activities include mining, quarrying, timber resources and services sector.

Preference of Masuliita sub county, Busiro in Wakiso was due to convenience of the site, and it being my home town a place of acquaintance. The parishes of Masuliita, Nakikungube and Kanzize were of concern because greater percentages of inhabitants of the villages in these parishes are unable to access UMEME electricity and can neither afford it nor can they afford solar, thus continuous reliance on wood and charcoal. However, there were handfuls of wastes for feedstock in biogas plants given the fact that they are livestock farmers even though very poor.

3.3 Sample size determination

According to (Ziegel et al., 1999), it was necessary to sample more than 10% of the population living in the area under study as long as the resultant sample was not less 30 units and not more than 1000 units. They further noted that for population sizes of 10,000 and above, 200 to 1000 were the appropriate minimum and maximum units to be sampled from. The minimum limit for populations above 10,000 were taken as the sample size thus 149 respondents as the sample size for the study. Respondents were sampled randomly and number of respondents was evenly distributed in parishes in the area of study.

3.4 Data collection methods and Sampling technique

Primary and secondary data was collected. Primary data was collected using questionnaires and interviews with households whereas secondary data was obtained from existing literature relevant to the study. The household heads were questioned about usage, socio-economic factors, challenges associated with adoption and dis-adoption of the technology.

In event of absence of a household head, an individual above 18 years of age was interviewed on behalf of the household head. The questions were in English language but translations were done by the interviewer.

3.5 Data entry and analysis

Data was collected using semi structured approaches and it was checked for any errors or un-answered questions in questionnaires then entered into excel for analysis. The analysis in excel was for descriptive statistics focusing on mainly frequencies and percentages but for inferential statistics like relationships between dependent and independent variables, statistical package for social scientist (SPSS) was used.

3.6 Ethical consideration

The key principles of research were taken into consideration for example voluntary participation, informed consent and confidentiality. This was achieved by first explaining to the respondent the objectives of the research and asking for their consent. The names of respondents were withheld during data collection and presentation

CHAPTER FOUR

RESULTS

4.1 Socio-demographic characteristics of the respondents.

Most of the respondents were females at 53.1% andmaleswere 46.9%. Majority were aged between 36-55years of age (43.6%), 36.9% were aged between19-35years of age, respondents above 55years of age made up 12.1% of the sample size and 7.4% were below 18years of age.

Table 1 Gender And Age Distribution Of The Respondents.

	Variables	frequency	Percentage
Gender	Male	70	46.9
	Female	79	53.1
Age	0-18years	11	7.4
	19-35years	55	36.9
	36-55years	65	43.6
> 55years		18	12.1

As per the level of education, 39.6% attained a secondary education, 30.9% attained tertiary education, 18.1% attained primary education and 11.4% had no education at all. Respondents with a household size of between 4 -5 members were 47%, those above 5 members were 37.6% and those with 1-3 members were 15.4%.

Table 2 Education Level and House Hold Size

	Variables	Frequency	Percentage
Education level	Primary level	27	18.1
	Secondary level	59	39.6
	Tertiary level	46	30.9
	None	17	11.4
Household size	1-3	23	15.4
	4-5	70	47
> 5		56	37.6

Furthermore, the study revealed that most of respondents were using charcoal (38.3 %), firewood (24.2%), followed by biogas (19.5%), electricity (10.7%) and kerosene(7.3%) as their sources of energy for cooking.

Table 3 source of energy for households in Masuliita Sub County

Source of energy	Frequency	Percentage
Charcoal	57	38.3
Firewood	36	24.2
Biogas	29	19.5
Electricity	16	10.7
Kerosene	11	7.3

4.2 Number of people using biogas energy in Masuliita Sub County.

The respondents that took part in the study were given questionnaires to determine biogas users. 23.5% said that they were using biogas energy and the highest percentage of respondents (76.5%) said that they were not using biogas energy.

4.3 Socio-economic factors influencing biogas energy utilization and production in Masuliita sub county.

Table 4 socio-economic factors that influence the adoption and production of biogas

	Variables	**Biogas users**	**Biogas non users**
Gender	Male	14	56
	Female	21	58
Age	0-18years	3	8
19-35years		13	42
36-55years		16	49
> 55years		3	15
Education level	Primary level	3	24
	Secondary level	15	44
	Tertiary level	12	34
	None	5	12
Household size	1-3	8	15
	4-5	15	55
> 5		12	44
Household Income	<100,000	7	21
110,000-300,000		9	32
310,000-600,000		14	48
610,000-900,000		3	7
> 1Million		2	6
monthly energy cost	< 50,000	8	51

50,000-100,000	15	36
110,000-200,000	8	21
> 200,000	4	6

4.4 Challenges associated with biogas energy adoption in households and how can be addressed in Masuliita Sub County.

The study showed that 76.5% of the respondents were not using biogas energy and 23.5% were using biogas energy.

Biogas users

A high percentage of the biogas users (31.43%) cited the inadequacy of raw material needed for the production of biogas as their main challenge, 28.57% claimed that biogas production required high maintenance costs and lack of technical expertise on how to maintain or repair biogas digesters whereas 11.43% said that biogas is not easily accessible in the area.

The respondents suggested the solutions including: educating masses on the benefits of biogas to the household and environment (40%), involving masses in the production and marketing of the gas (31.43%) andinvolvement of the government through improving the renewable energy policies (28.57%.)

Biogas non-users

Among the non-users, 43.86% said that biogas production requires high cost of construction, 23.68% were not aware of the technology and as well had inadequate funds for both construction and maintenance while 8.77% said they didn't see the benefits of using biogas.

Biogas non-users suggested solutions that included: the government supporting the technology through incentives and constructing regional biogas plants(33.3%), educating the masses on how biogas is actually produced(28.07%), educating masses on the advantages of biogas compared to other energy sources(21.93%) and proper marketing of the biogas(16.7%).

CHAPTER FIVE

5.1Discussion

The current study revealed that most of the respondents were females 53%, because women dominate rural household energy consumption than their counterparts (Shallo et al., 2020). The results further show that majority of the respondents (43.6%) are between the age group of 36-55 years. Older household heads could have a greater economic capacity to afford investments in adopting biogas technology. On the contrary, older household heads are less flexible and less likely to accept new technologies. Because older household heads might be more risk-averse than younger ones and have a lower likelihood of adopting new technology (Costa et al., 2015). In this study, the age of the household head was expected to have a positive or a negative influence on the decision to adopt biogas technology.

Majority of the respondents in the study had attained a higher level of education (secondary and tertiary). With such high levels of education, respondents are believed to be in position to internalize and understand the technicalities that may be used in biogas technology production and adoption. This may positively affect their ability in adopting the new technology and even embrace it completely. However this was not the case in this study. The results contradict with the results of (Momanyi, 2018) whose study found out that majority of the adopters had actually attained a higher level of education.

Majority of households had between four to five members. This is often a sign of adequate labor to run biogas plant operations and it might be a motivation for family to embrace biogas. Similar findings reported by(Jan & Akram, 2018), found out that excess labor positively influenced households' willingness to adopt biogas. These findings contradict with the results of this study, where the households with a large size did not adopt biogas technology.

Average monthly income of both adopters and non-adopters was in the range of 310,000 - 600,000Ugshs. This implied that the adopters were either producing the biogas themselves so the costs incurred were mainly for maintenance. However, for the non-adopters, this income could not cater for construction of a bio digester where the cheapest bio digester would cost on average one million four hundred thousand Uganda shillings (1,400,000) without maintenance costs, so this is not affordable for majority of the residents of Masuliita sub county hence the high number of non-users/adopters.

The average monthly expenditure on energy for adopters/users was in the range of 50,000 – 100,000. This makes them able to afford maintenance of bio digester for those that produce the gas themselves and also be able to refill their cylinders for those purchasing the gas in cylinders. For the non-users, their expenditure fell in the range of below 50,000 and this amount is not enough to maintain or even refill a gas cylinder so they resorted to cheaper energy sources like firewood and charcoal.

The main challenge faced by non-users which in turn was the main reason for non-adoption was the high initial cost of construction of the biogas digesters. Findings of this study agree with those of (Juma et.al, 2020) that technology cost was a major impediment to rapid uptake in Ghana and a study conducted by (Godfrey, 2012) in Tanzania also had similar observations that rural farmers were willing to install the systems but they were barred from doing so by high initial costs.

Biogas users faced a major challenge of inadequate supply of raw materials needed for the production of biogas. This could be because the average livestock size of most households was insufficient to produce the required manure for the digester. The problem of low number of livestock was further compounded by insecurity (theft) of livestock in the area. This hinders increase in the livestock size and increase in biogas production as well. Thus, inability to get needed materials like animals' dung to generate gas (Tarlue et al., 2019).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1Conclusion

Biogas adoption and usage in Masuliita was low given the number of people using biogas made up on 23.5% of the sample size population

Age, gender, household size, education level, monthly income and the average amount of money spent on energy needs were all factors that greatly influenced the adoption of biogas in Masuliita Sub County

Adoption of the technology was marred with challenges ranging from high initial costs of installation, high maintenance costs, inaccessibility, inadequacy of raw materials to inadequacy of technical personnel and expertise to maintain and repair the biogas plants.

6.2 Recommendations

Basing on the findings of the study, I would like to recommend the following:

1. Biogas disseminating companies and NGOs should review implementation strategies to design and construct low cost biogas plants that are affordable to all people in Masuliita Sub County.
2. Stakeholder institutions should arrange smooth and reasonable credit sizes for all potential adopters to enhance households' decisions to adopt biogas technology.
3. Sensitization of locals on economic, social and environmental benefits of biogas is required from Ministry of energy and private sector through awareness creation campaigns and seminars to enable them understand why biogas should be a choice for everyone.
4. Further studies should be done regarding the role of women in the adoption of biogas since they are a marginalized gender and re responsible for running rural homes so they have carnal knowledge about energy utilization as compared to men.

REFERENCES.

Ã, A. G. M. (2008). *Dairy farming and biogas use in Rungwe district , South-west Tanzania : A study of opportunities and constraints*. *12*, 2240–2252. https://doi.org/10.1016/j.rser.2007.04.013

Arthur, R., Francisca, M., & Antwi, E. (2011). Biogas as a potential renewable energy source : A Ghanaian case study. *Renewable Energy*, *36*(5), 1510–1516. https://doi.org/10.1016/j.renene.2010.11.012

Burguillo, M. (2008). *Assessing the impact of renewable energy deployment on local sustainability : Towards a theoretical framework*. *12*, 1325–1344. https://doi.org/10.1016/j.rser.2007.03.004

Costa, H., Foody, G. M., & Boyd, D. S. (2015). Integrating user needs on misclassification error sensitivity into image segmentation quality assessment. *Photogrammetric Engineering and Remote Sensing*, *81*(6), 451–459. https://doi.org/10.14358/PERS.81.6.451

Cushion, E., Whiteman, A., & Dieterle, G. (n.d.). *Bioenergy Development*.

Erick, M. K., Kirubi, G., & Muriuki, S. (2018). Key Factors Influencing Adoption of Biogas Technology in Meru County, Kenya. *IOSR Journal of Environmental Science*, *12*(3), 57–67. https://doi.org/10.9790/2402-1203015767

Fuels, S. (2020). *BIOENERGY IN GERMANY FACTS AND FIGURES 2020*.

Godfrey, A. (2012). Dairy Farming and the Stagnated Biogas Use in Rungwe District, Tanzania: An Investigation of the Constraining Factors. *Biogas*. https://doi.org/10.5772/32012

Guide to Biogas From production to use. (n.d.).

Jan, I., & Akram, W. (2018). Willingness of rural communities to adopt biogas systems in Pakistan: Critical factors and policy implications. *Renewable and Sustainable Energy Reviews*, *81*, 3178–3185. https://doi.org/10.1016/j.rser.2017.03.141

Juma, I., & others. (2020). *Assessing the uptake of biogas as a source of clean energy for cooking by low income households in Kibera slum, Kenya*.

Maiyah, J. I. (2019). *Assessing the uptake of biogas as a source of clean energy for cooking by*

low income households in Kibera slum , Kenya.

Marambanyika, T., Sakarombe, S., Musasa, T., & Defe, R. (2020). *Biogas Technology Adoption as an Alternative Source of Energy in Domboshava Communal Area of Zimbabwe: Benefits and Challenges*. *03*(03), 23–32.

Momanyi, R. K. (2018). *Social-Economic Factors Influencing Biogas Technology Adoption among Social-Economic Factors Influencing Biogas Technology Adoption among Households in Kilifi County- Kenya*. *July 2016*.

Mshandete, A. M., & Parawira, W. (2009). *Biogas technology research in selected sub-Saharan African countries – A review*. *8*(2), 116–125.

Nina, P. (2020). *VALUING BIOGAS PRODUCTION FROM SOCIO-ECONOMIC AND*. *March*.

Patricia Tarlue J.V, R. N., J.O1, E. K., Ali1, N. U., Nur1, A.-L. A., LastName, P. C. and P. M. N., & LastName, P. C. and P. M. N. (2019). Assessing Rural Communities' Prospects for Biogas Technology Adoption As Clean Energy Source in Wakiso District, Uganda. *African Journal of Economics and Sustainable Development*, *2*(1), 1–8. https://www.researchgate.net/profile/Pius-Nina/publication/331707213_ASSESSING_RURAL_COMMUNITIES'_PROSPECTS_FOR_BIOGAS_TECHNOLOGY_ADOPTION_AS_CLEAN_ENERGY_SOURCE_IN_WAKISO_DISTRICT_UGANDA/links/5c88f4f5a6fdcc38174fd782/ASSESSING-RURAL-COMMUNITIES-PROSPECT

Shallo, L., Ayele, M., & Sime, G. (2020). Determinants of biogas technology adoption in southern Ethiopia. *Energy, Sustainability and Society*, *10*(1), 1–14. https://doi.org/10.1186/s13705-019-0236-x

Sigamoney, R. (2008). *Commercialisation of biofuel industry in Africa : A review*. *April*. https://doi.org/10.1016/j.rser.2006.10.019

Tarlue, P., Nakanwagi, R., Kutiote, E., & Umar, N. (2019). *ASSESSING RURAL COMMUNITIES ' PROSPECTS FOR BIOGAS TECHNOLOGY ADOPTION AS CLEAN ENERGY SOURCE IN WAKISO DISTRICT , UGANDA*. *February*.

Thi, N., Truc, T., Nam, T. S., Vo, N., Ngan, C., & Bentzen, J. (2017). *Factors Influencing the*

Adoption of Small-scale Biogas Digesters in Developing Countries – Empirical Evidence from Vietnam. *10*(2), 1–8. https://doi.org/10.5539/ibr.v10n2p1

Wamuyu, M. S. (2014). *ANALYSIS OF BIOGAS TECHNOLOGY FOR HOUSEHOLD ENERGY , SUSTAINABLE LIVELIHOODS AND CLIMATE CHANGE MITIGATION IN KIAMBU COUNTY , KENYA A Research Thesis Submitted in Fulfillment of the Requirements for the Award of Degree of Doctor of Philosophy , in the School of Environmental Studies of Kenyatta University*.

Yu, L., Kuang, Y., Ningsheng, H., Wu, Z., & Lianzhong, X. (2008). Popularizing household-scale biogas digesters for rural sustainable energy development and greenhouse gas mitigation. *Renewable Energy*, *33*, 2027–2035. https://doi.org/10.1016/j.renene.2007.12.004

Ziegel, E., Alreck, P., Settle, R., Fink, A., & Kosecoff, J. (1999). The Survey Research Handbook. *Technometrics*, *41*, 83. https://doi.org/10.2307/1271017

APPENDIX

QUESTIONNAIRE

MAKERERE UNIVERSITY

I am Musaasizi Grace Hope, an undergraduate student from the College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University, pursuing a Bachelors of Animal Production Technology and Management. As a requirement by the university, am conducting research on renewable energy and my topic of study is, **"FACTORS HINDERING BIOGAS TECHNOLOGY ADOPTION IN MASULIITA SUBCOUNTY, BUSIRO IN WAKISO DISTRICT, UGANDA."** I will ask you a few questions to collectdata which will be used academically and treated with utmost confidentiality. Your cooperation is highly appreciated.

SECTION ONE

RESPONDENT DETAILS

Farmers identity……

Parish……

1. Gender
   a) Male
   b) Female
2. Age
   a) 0-18yrs b)19-35yrs c) 36-55 d) above 55yrs
3. Level of education
   a) Primary
   b) Secondary
   c) Tertiary
   d) None
4. What is your household size?
   a) 1-3
   b) 4-5
   c) Above 5

SECTION TWO

NUMBER OF PEOPLE USING BIOGAS ENERGY IN MASULIITA SUB COUNTY

5. Are you using biogas energy?
   a) Yes b) No

SECTION THREE

SOCIO-ECONOMIC FACTORS

6. What do you use as a source of cooking in your household?
   a) Firewood b) Charcoal c) Kerosene d) Electricity e) Biogas
7. What is the most used source of energy in your household?
   a) Charcoal b) Firewood c) Kerosene d) Electricity e) Biogas
8. What is your average monthly income for your household in Uganda shillings?
   a) Under 100,000
   b) 110,000-300,000
   c) 310,000-600,000
   d) 610,000-900,000
   e) Above 1 million
9. What is the average amount of money do you use for energy needs per month?

a) Under 50,000 b) 50,000- 100,000 c) 110,000-200,000 d) Above 200,000

10. What affects the choice of energy source used in your household?

a) Cost

b) Availability

c) Does it suit my needs?

d) Others

SECTION FOUR

CHALLENGES ASSOCIATED WITH BIOGAS TECHNOLOGY ADOPTION

BIOGAS – NON USERS

11. Why don't you use biogas as a source of energy in your household?

a) Cost of construction is high b) Not aware of the technology c) Inadequate funds

d) I don't see the benefits of using biogas

12. Which aspects that need improvement?

a) Educating masses on the advantages compared to other energy sources.

b) Government support through incentives and constructing regional biogas plants

c) Proper marketing of the gas and battery delivery

d) Educating masses on how the gas is actually produced

BIOGAS- USERS

13. What are the common challenges associated with biogas technology?

a) High maintenance costs b) Inadequate supply of raw materials c) Lack of technical expertise on how to maintain/repair biogas d) Not easily accessible in the area

14. How can biogas adoption be improved?

a) Involve masses in the production and marketing of the gas.

b) Educate masses on the benefits of biogas to the household and environment

c) Involvement of the government through improving the renewable energy policies.