Perceptions of rural households about the role and effect of biogas production on rural household income in Raymond Mhlaba Local Municipality

By

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Together in Excellence

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June, 2017

DECLARATION

I hereby certify that this dissertation is the result of my own original work and has not previously been submitted to another university for the purpose of a degree. Where use has been made of the work of others, such work has been duly acknowledged in this text.

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DEDICATION

This work is dedicated to my late father C.M Ngcobo.

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ABSTRACT

Rural development efforts to reduce poverty and enhance food security and generally improve livelihoods in developing countries continue to be constrained by high energy cost. For that reason, renewable energy has been identified as a possible panacea to fill this gap. Renewable energy is cheaper, more accessible and environmentally sustainable and promotes inclusivity. Biogas is a renewable energy that is readily available and easy to use by poor rural households. The use of biogas digesters among households in rural areas of developing countries is a well-known technology. The potential for biogas in these areas has been demonstrated and a strong economic case has been made. However, its adoption and use have been lower than expectations possibly as result of non-economic considerations, including social issues about which rural people hold different perceptions.

Perceptions of rural households are important because they influence the behaviour to a large extent. Since limited access to affordable energy in rural areas has encouraged government and private organisations to initiate biogas projects to overcome the challenge, it is important to ascertain the factors that affect attitudes towards the technology. The present study sought to explore perceptions of rural households about biogas production towards rural household income in the Raymond Mhlaba Local Municipality. Specifically, this research investigated the state of biogas project being implemented by the University of Fort Hare's Institute of Technology (FHIT), the perceptions of respondents towards biogas production and determine the contribution of biogas consumption to rural income. The study also aimed to identify the factors affecting the adoption of biogas production in the study area.

The study was carried out in Melani village in Raymond Mhlaba Local Municipality in the Eastern Cape Province of South Africa and employed survey data obtained from 48 households who were enumerated to identify their perceptions on biogas production, with special emphasis on the role and effect contributed to rural income of Melani village. The study employed a cross-sectional research design and purposive sampling technique was used in data collection. Data were collected and captured in Excel and then analysed using *the statistical package for social sciences (SPSS) Version 24 Descriptive statistics was used to examine socio-economic characteristics of households and state of biogas production in the area, Bivariate correlation analysis was used to determine the relationships among the key elements of perceptions of household towards biogas adoption, binary logistic model was used to estimate factors influencing adoption of biogas technology by households.*

The results show that women were dominant for both adopters and non-adopters of biogas. The majority of households were young with mean age of 40 years while for non-adopters were 65 years old on average. The results showed high levels of literacy amongst household adopters. Majority of the households for both adopters and non-adopters of biogas technology were married and unemployed and household size ranged from one to five persons, with social grants being dominant source of income. The bivariate correlation analysis suggests a positive effect of green pepper production and livestock ownership on biogas technology adoption. Age and level of education were negatively correlated with adoption of biogas.

The cross tabulation analysis suggests that water scarcity, lack of knowledge about biogas technology, cattle ownership, lack of maintenance and repairing, flooded biogas digesters during rainy season are negatively associated with the uptake of biogas technology. The empirical results from binary logistic model suggest that land size was the key determinant of adoption behaviour towards biogas technology while age of the household head, source of income and level of education may have a negative influence on adoption of biogas technology.

Based on the findings highlighted above, the study recommends strategies to encourage households to adopt biogas technology. The study recommends introduction of technologies that are cheap such as the plastic tubular design through enhanced research. High investment costs are important for the biogas investment decision and subsequently information on the economic benefits of cheap biogas is an important topic to address.

***Keywords**: Biogas technology, Adoption, Households, Perceptions, knowledge, Income, Bivariate analysis, Binary model.*

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AAI	Action Aid International
CO_2	Carbon Dioxide
DoE	Department of Energy
DRDAR	Department of Rural Development and Agrarian Reform
FAO	Food and Agriculture Organization of the United Nations
GHG	Green House Emission
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
NDA	National Aid Internal
OECD	Food and Agriculture Organization of the United Nations
REIPPP	Renewable Energy Independent Power Producer Procurement
SMMEs	Small, Medium and Micro-Sized Enterprises

CHAPTER ONE

INTRODUCTION

1.1 Background

African countries are energy insecure and there is a need to invest in renewable energy technology to sustain energy (Teweldemedhin and Mwewa, 2013). The oil that most African countries import discourages economic growth. This showed that food security and energy security are interrelated. Energy is needed for production and distribution of food. Therefore, it is highly impossible to achieve food security without sufficient energy (Ogbonna *et al.,* 2013). In the face of the foregoing situation, researchers, including Maxwell (2014), have suggested that the adoption of biogas technology can be a sustainable approach to reducing energy insecurity at the local level. Smith *et al.* (2014) added that the biogas digesters would at that time contribute towards reaching Millennium Development Goals. It is believed that this will encourage socio-economic development, create job opportunities and a growth path that is dual thus environmental friendly and sustainable (DoE, 2015).

History reveals that the first time biogas production was systematically carried out was in India in 1897 where the Matunga Leper Asylum in Bombay used human waste to meet the lighting needs of the time (Abbasi *et al.,* 2012). However, through innovations and research, the process started to use manure in 1900, again in India, but it was not a complete success. Later, the successful attempt came in 1937 when an Indian microbiologist known as S.V Desai conducted studies that led to the commissioning of a plant which produced positive results, thereby resulting in several designs around the 1950s (Abbasi *et al.,* 2012). The process grew and was adopted by different countries such as China, Nepal, Vietnam, Bangladesh, Sri Lanka, among others (Abbasi *et al.,* 2012).

It is worth noting that the countries which were the first to adopt the biogas technology were in the developing world. Abbasi *et al.* (2012) argued that biogas technology has been relevant to the developing nations because energy supply is mostly limited. Moreover, in developing countries, energy cost is relatively more expensive on per capita and purchasing power basis. For example, cost of energy, transportation, agricultural inputs and the cost of food production in Africa is higher as compared to other nation (Ogbonna *et al.,* 2013).

In that regard, Teweldemedhin and Mwewa (2013) pointed out that some African countries are energy insecure and there is a need to invest in renewable energy technology to sustain energy. The oil that most African countries import from other countries discourages economic growth. This showed that food security and energy security are interrelated. Energy is needed for production and distribution of food. Therefore, it is highly impossible to achieve food security without sufficient energy (Ogbonna *et al.,* 2013). Hence, the adoption of biogas is a vital tool to enable these countries to overcome their serious energy deficits.

According to Vera and Langlois (2007), approximately one-third of the world's population still relies on the use of animal power and non-commercial fuels. Approximately 1.7 billion people have no access to electricity. This lack of access to modern energy services severely limits socioeconomic development (Vera and Langlois, 2007). In addition, Gwavuya *et al.* (2012) pointed out that limited success in promoting improved energy sources, such as biogas, in rural areas of developing countries has been partly blamed on insufficient understanding of household energy use patterns.

Vera and Langlois (2007) noted that energy is vital for eradicating poverty, enhancing human welfare and raising standards of living. However, most current patterns of energy supply and use are unsustainable. In that regard, Kaygusuz (2011) emphasized that circumstance in rural communities is considerably more critical as local demand interest for energy exceeds accessibility and most of rural communities rely on upon non-commercial energy supplies. A number of the regions globally have no dependable and secure energy supply, which limits economic development, while in other areas environmental degradation from energy use inhibits sustainable development (Vera and Langlois 2007).

In South African context, OECD (2015) revealed electricity generation has not kept pace with growing demand, and power outages are the result of insufficient investment in expanding and maintaining electricity generation capacity. In response to this, South African government has collaborated with relevant stakeholders like Sasol in developing the biogas programmes Griffiths (2013). Islam and Hossein (2014) added that renewable energy is cheaper, more accessible and environmental sustainable and promotes inclusivity. In addition, biogas is a renewable energy that is readily available and usable by rural poor households (Warget, 2009). Farms have been identified as best biomass producers. It is pertinent to note that a study on access to biogas in relation to rural households in South Africa is needful and paramount importance with the research results addressing issues relating to growth and development of South African agrarian economy.

1.2 Problem statement

Maxwell (2014) stated that although South Africa was the richest country in Africa, about 30% of its population lives below poverty line and have inadequate access to energy services. The inadequate access to electricity is largely a direct consequence of their unaffordability (Gets, 2013). In the year 2012, 1.45 million (11%) of households had no access to electricity, whereas 0.6 million (3.6%) households accessed electricity unlawfully. Out of the 3.6% without formal access to electricity, 73.1% were connected to an informal source paid for by the household (Pollet *et al.,* 2015).

Pollet *et al.* (2015) revealed that South Africa has been faced with serious energy challenges. The challenges include unplanned outages, energy shortages, blackouts, high energy tariffs, and many years of underinvestment in power infrastructure and energy poverty in low income households (Pollet *et al.,* 2015). It is worth noting that the electricity supply is lower compared to growing demand and this led unto energy insecurity. Energy demand is far greater than the energy supply. It is therefore not surprising that the energy generators, i.e., Eskom in South Africa, are unable to meet the energy demand of the whole population of South Africa (Rabobank, 2008).

Despite the investments on energy development, energy prices are still increasing (Department of Energy, 2012). The Department of Energy (2012) further explains that this energy price increase is capable of causing a lot of stress to the society with rural communities being worse hit.

In the face of the foregoing situation, researchers, including Maxwell (2014), have suggested that the adoption of biogas technology can be a sustainable approach in reducing energy insecurity at the local level. Smith *et al.* (2014) added that the biogas digesters contribute towards reaching the Millennium Development Goals (MDGs). It is believed that this will encourage socio-economic development, create job opportunities and a growth path that is both environmentally friendly and sustainable (DoE, 2015).

Consequently, Arthur *et al.* (2011) argued that it is important for the government to consider potential energy substitutes in response to high energy prices. It is further stated that biogas energy is found to be the most appropriate energy resource in addressing this challenge because it has been found useful by most rural communities (Simalenge and Maliwichi, 2011). But the fact that this type of energy comes from waste matter creates special problems. One is the obnoxious smell which may repel some people and therefore lead to less than desirable response and adoption. Technology adoption is a complex process, and can have both an uptake of technology dimension alongside attitudes towards the existing technology.

Traditionally, older farmers with considerable experience in farming are more risk averse (Meijer *et al*., 2015). Psychologically, adoption requires the use of the individual's capabilities to gain more awareness about their environment in an intelligent manner (Botha and Atkins, 2005).In that regard, a person and how he or she views or responds to the surrounding environment will have an effect on adoption process. The initiation of the adoption process is the point at which the person becomes aware and well informed about all the elements involved (Botha and Atkins, 2005). Rejection may follow or the adoption decision making may proceed. So, according to Botha and Atkins (2005), the context is important in any adoption process.Therefore, it is thought that perceptions, knowledge and demographic factors have an effect on the adoption of renewable (Islam and Hossein, 2014). Perception issues that are unresolved because they are not known precisely. Hence this study.

1.3 Objectives of the study

The broad objective of the study is to explore the perceptions of rural households on the role and effect of biogas production on rural household income in Raymond Mhlaba Local Municipality. Specifically, this study seeks to:

I. Describe the socioeconomic characteristics of the households in the study area.
II. Describe the biogas energy status in the study area
III. Identify the perceptions of rural households towards biogas production
IV. Determine contribution of biogas consumption to rural income
V. Identify the factors affecting the adoption of biogas production in rural households

1.4 Research questions of the study

The research sought to address the following questions:

I. What are socioeconomic characteristics of the households in the study area?
II. What is the biogas energy status in the study area?
III. What perceptions do households have towards biogas production?
IV. What contribution do biogas consumption have on rural income?
V. Which factors contributes to non -adoption of biogas production in rural households?

1.5 Hypothesis of the study

The hypothesis stated thus:

H0: $\mu=0$ Biogas users do not have positive perceptions towards the effect and the role of biogas production

H1: $\mu\neq0$ Biogas users have positive perceptions towards the effect and the role of biogas production.

1.6 Justification of the study

The study addresses concerns by different researchers with respect to the comprehension about the role and effect of biogas production towards rural household income. It is trusted that obtained through this study will contribute to knowledge and aid policy formulation. Further, the study will assist researchers in about what are the gaps, as well as what new information is needed. Hence, the study out ways in which people in rural areas can use the available natural resources to its best, profitable and feasible way, and all things remaining equal. This would expectedly influence the biogas technology in rural communities. The outcomes contributes into deeper understanding of the effect of biogas production on rural income. This is because renewable energy sources are believed to be positively contributing to agricultural production and improved social status and income in communities.

1.7 Limitations and delimitation of the study

The sampling frame was limited to one village (Melani village) because it has people practicing biogas production. Melane village was chosen because it is more convenient as it demanded less of the limited resources such as finances and time. The use of a bigger study area would allow for a larger sampling frame which would be more representative of the effect of biogas production on rural households in meeting their livelihoods needs in the Eastern Cape. This study did focus to all rural households under Raymond Mhlaba Municipality but focused only in Melani village. The findings of this study did not generalize the whole rural communities of the Raymond Mhlaba Municipality.

1.9 Outline of the dissertation

This dissertation comprises five chapters with each chapter starting with a brief introduction and ends with a summary. Chapter one which introduced the study gave background information, as well as statement of the problem. This was followed by chapter two which is the review of related literatures on the biogas status in South Africa, Eastern Cape and in Melani village, identifying the perceptions of rural households towards biogas production. Moreover, the chapter gave insight on barriers that limit the adoption of renewable energy in rural communities. Lastly, it afforded deeper understanding of the contribution of biogas production to rural livelihoods and provided an opportunity to draw lessons from other initiatives of biogas production in Africa. Chapter three presented the methodology employed for the project. Chapter four presented the results and discussions. Chapter five summarizes the key findings and concludes as well as making the necessary recommendations based on the perceptions of rural households on the role and effect of biogas production towards rural livelihoods, focusing on income.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review of previous research and policy work on the theme of this study. It begins by presenting and clarifying the key concepts and definitions related to the theme. The chapter then goes on to provide an overview of biogas production in rural areas, the perceptions on biogas production and synthesizes the linkages among biogas production and household's income. Constraints that influence and affect the adoption of biogas are also discussed. Since biogas production is the main concern in the study, it is valuable to throw some light on the role and effect of biogas production towards rural income.

2.2 Energy status and renewable energy overview in South Africa

Pegels (2010) stated that South African electricity sector is a vital part of the economy and at the same time contributes most to the greenhouse emissions problem. The coal consumption indicator is found to be the highest compared to other indicators. This is evidenced by Roopnarain and Adeleleke (2016) which emphasized that South Africa heavily depends on coal for energy production. In that regard, South Africa is amongst top emitters of greenhouse gases South Africa is not fully contributing to social and economic goal. Coal constitute about 70% of overall energy supply including more than 90% of the electricity generation (GIZ, 2015). In addition, Roopnarain and Adeleleke (2016) stated that the country consume 45% of energy produced in Africa, and about 95% of electricity utilised in South Africa is acquired from the state owned national electricity utility company, Eskom.

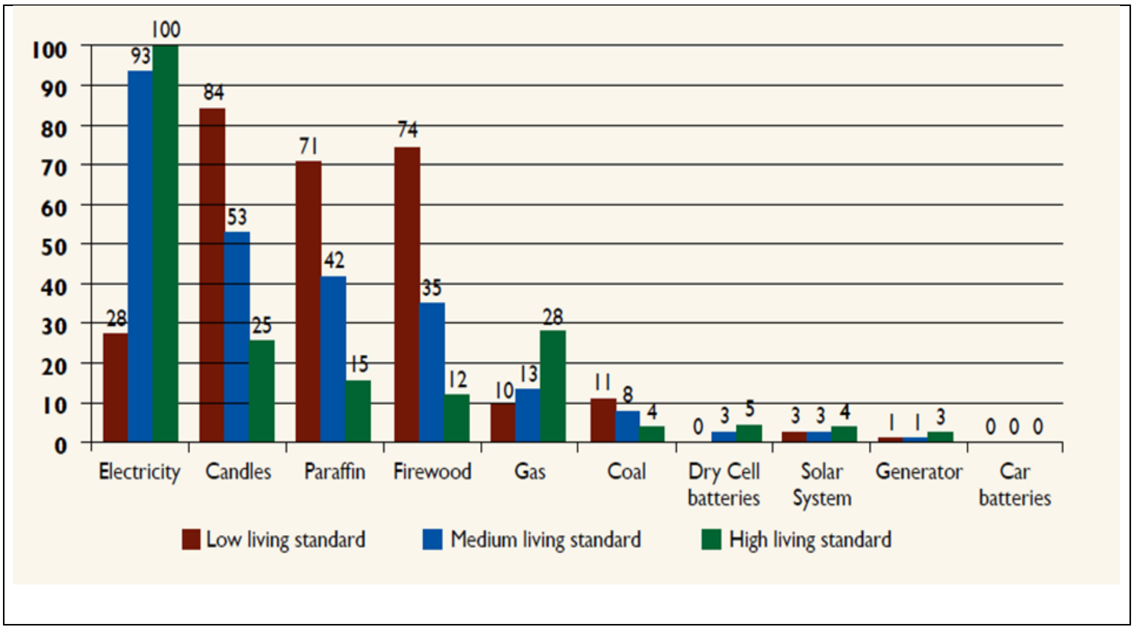

Figure 2. 1: Types of energy sources in relation to standard of living

Source: OECD, 2015

Gets (2013) stated that the renewable energy independent power producer procurement programme (REIPPPP) is limited to 9% renewable energy by 2030, this will not only limit Carbon dioxide emissions but will contribute to social problems, health effects and substantial water wastage and environmental pollution.

Pollet *et al.* (2015), noted that South Africa is going through a rapid period of change and growth, it plans to spend $50 US billion on renewable energy in the future in an effort to reduce dependence on coal-fired power plants, which provide 85% of its electricity with the highest levels of CO_2 emissions. Moreover, DoE (2015), highlighted that South Africa is capable of producing renewable energy and has set a goal of 17.8 Giga Watt of renewable energy generating capacity to be installed by 2030. Renewable energy includes solar, wind, hydro etc. (Wargert, 2009). Figure 2.1 shows sources of energy in relation to living standard. The results shows high dependency on electricity by medium and high living standards while low living standards depends on candles and firewood.

Renewable technologies are well suited in specific areas based on the available natural resources available in the community, and are associated with expensive initial capital costs and rely on foreign finances and expertise (Wargert 2009).On other hand, Maxwell (2014) argued that South African government depends on grid scale fossil fuel suppliers. Hence, DoE, (2015) emphasized that rural communities are not connected to the grid due to geographic locations. This is a barrier in reducing energy insecurity in rural communities (Maxwell, 2014).

In response to the mentioned issues, Pollet *et al.* (2015) stated that government has initiated programs to ensure that there is sufficient energy in the country. However, Pegels (2010) argued that programmes implemented to enhance energy efficiency and promote renewable energy fail to show large-scale effects. Roopnarain and Adeleleke (2016) argued that after national energy crisis in early 2015 the government created the energy war room to immediately and systematically implement the cabinet's five-point energy plan. Importantly, DoE (2012) concluded that South Africa needs development in the energy sector which will positively contribute to economic growth in a reliable, affordable and sustainable manner. DoE (2015) mentioned that the motive behind implementation of the programme moving away from using coal as a source of energy:

- Dependence to coal makes the country to be one of top GHG emitters
- The single failure risk of a one fuel reliant power system
- Financial rise, due to South African’s coal prices that are not reflecting the international traded prices for coal.

In another perspective, Stafford (2013) pointed out that about 20% of South Africans lack access to electricity. While 40% is not serviced with water. In that view, Von Bormann and Gulati (2014) emphasized that South Africa is a water scarce country with water intensive energy production. Von Bormann and Gulati (2014) further explained that increase in agricultural production due to growing demand will have an effect in availability of water, since commercial South African agriculture production relies heavily on irrigation. Energy production and electricity supply plan are hampered by water scarcity. The means of moving away from coal through renewable energy technology services could be limited due to water scarcity (Bormann and Gulati, 2014). In that regard, Smith *et al.* (2013) argued that most remote areas in South Africa continue to experience poverty and this poses a question if whether the use of biogas digesters as a source of energy can be a resolution to basic needs of remote communities.

2.2.1 The progress of biogas production in the Eastern Cape

In South Africa, rural communities especially from the Eastern Cape Province, are characterized by two things, i.e., high rate of unemployment, and the majority greatly depends on social grants (Phogole, 2011). In addition, up to 14% of the monthly income of the rural people is spent on energy purchases, which is said to be higher than the international benchmark of 10% for energy power (DoE, 2012). Eastern Cape is one of provinces with number of households having no access to electricity. This backlog was noticed in formal settlement set. In every 10 households paraffin is used for cooking and few are using gas (DoE, 2012).

Majority of remote areas use electricity lighting since they can not afford to use it for heating and cooking. In response to the above issues, According to Adekunle (2013), Eastern Cape Province is accounts significantly to the high level of poverty in the Country. In that regard, DoE (2012) mentioned that in 2012 Eastern Cape adopted Eastern Cape sustainable energy strategy, with the aim of improving aimed to improve provincial energy security and self-sufficiency and improve access to energy for all and the need to stimulate a green and low carbon economy that create job.

2.2.2 Biogas production in rural communities and its benefits

Livestock farming plays an important role in the rural households of the Eastern Cape Province (Eastern Cape Rural Development and Agrarian Reform (DRDAR), 2013). As a result the Eastern Cape has the highest percentage of agricultural household owning livestock (Nowers *et al.,* 2013), with about 5% of the rural cattle owned by the smallholder farmers (Nowers *et al.,* 2013). However, these smallholder farmers of the Eastern Cape earn far less from their livestock assets due to a variety of reasons such as subsistence oriented mind-set, unstable prices and market constraints (Obi, 2011). This therefore adds to the prevailing poverty levels in the entire Province of the Eastern Cape. du Toit (2011) stated that the because livestock assets in the province help relieve the poverty., it becomes imperative to set programmes that will help smallholder farmers to earn reasonable income from their livestock assets.

One of the programmes which is easy to set up to earn consistence income and reduce the energy cost is the biogas technology. This biogas is produced through anaerobic process when organic waste has been allowed to rot in huge piles, the results will be a combustible gas (Abbasi *et al.,* 2012). Kossmann *et al.* (1997) added that the organic material undergoes a process of bio-degradation, allowing bacteria to produce the combustible gas which is known as biogas. This process is known as anaerobic digestion, or biogas production (Kossmann *et al.,* 1997).

Rural communities use biofuel for household purposes such as cooking, lighting, heating and agricultural purposes (FAO, 2012). They use agricultural wastes as a source of energy. Agricultural waste consists of crop stalks, sawdust, wood, coconut photo and cow dung cake (Hasalkar *et al.,* 2012). Nonetheless, cow dung cakes have been found to be the most appropriate energy resource in biogas production (Simalenge & Maliwichi, 2011).

Okudoh *et al.* (2015) stated that biogas production in South Africa has a market potential of R10 billion (about1.1billion USD) and can create 2.5 Giga watts (GW) of electricity and thousands of jobs for at least 300,000 rural households. The different categories of biomass are estimated to contribute to realization of the renewable energy target by 2050.For example cropped biomass such as cassava and other energy crops are estimated to produce biogas equivalent to 1350 Peta-joules of electricity while biogas from solid waste in landfills is estimated at 9000 gigawatts electricity equivalent. GIZ, (2015) indicated that Tanzania follow an integrated programme approach through large scale biogas production from organic waste to produce grid connected electricity and organic fertiliser. In Tanzania biogas projects has thus provided income for poor women.

GIZ (2015) stated that the use of biogas in South Africa will reduce dependency on electricity, especially in rural areas. However, current exploitation of biogas as a viable energy source in South Africa is limited. It is only recently that Eskom (South Africa's electricity public utility) and The Department of Trade and Industry have approved rebates and grant schemes that will increase the use of biogas as an alternative source of renewable energy (GIZ, 2015). GIZ (2015) further explained that the appropriate functioning of biogas systems could have multiple benefits for the communities by providing cheap renewable energy, manure provision, and a reduction in the need for Land-fills, waste removal and disposal activities.

In South African rural context, Maxwell (2014) stated that biogas has specific benefits when it is used for cooking and heating purposes. Firstly, it would help to decrease the amount of fuel wood being used for these activities and thus reduce deforestation and desertification. Secondly, because burning biogas is cleaner than burning biomass, it would help mitigate respiratory health issues associated with fuel wood cooking. Biogas could also address health issues associated with improper management of cow dung. Thirdly, biogas could reduce the workload for those who collect fuel wood, an activity which many women engage in daily. In addition, Maxwell (2014) stated that if the slurry from the digester is utilised effectively, soil depletion and erosion could be combated. Economically, biogas could create much needed income sources and cost reductions in rural areas (Maxwell, 2014).

2.2.3 Environmental benefits of using biogas

According to Arthur *et al.* (2010), the pollution of environment is associated with health issues and social effects. Arthur *et al*.(2010) further stated that this has encouraged the growing interest in the search for cleaner source of energy worldwide. In addition, Wargert (2009) noted that the use of firewood by rural area contributes to soil erosion, degradation soils and water resources. Hence, Arthur *et al.* (2010) postulated the adoption of converting biomass into energy is thought to increase standard of living, health and local environment. Smith *et al.* (2014) added that the bio slurry is not toxic to the environment. It can be used as a fertiliser for crop cultivation while improving soil fertility. In addition it discourages deforestation by substituting thermal fuel (fuel wood), it saves time to collect the wood.

2.2.4 Waste management

Stafford *et al.* (2013) stated that about 40% of South Africans have inadequate access to water and sanitation services. According to Mannie (2014), waste management in South Africa poses a serious challenge in most municipalities. Firstly municipalities are challenged with illegal developments of open dumps which are not properly handled. Secondly, the massive expense of the rural local municipality's landfills are not favourable (Mannie, 2014). In addition, Nkosi (2015) emphasized that there is a change in consumption patterns due to increase in population growth, economic development and urbanisation has led into rapid increase in waste volume. Proper management is believed to prohibit the pollution of the environment that threaten health of the surrounding communities. In light of the above mentioned statements South African's constitute states that municipalities are accountable to manage waste services.

In light of the above, Muvhiwa et al. (2016) stated that the adoption of using waste to produce biogas can improve the health of users, offers a sustainable source of energy, benefits the environment and provides a way to treat and re-use various wastes (agricultural, industrial and municipal waste). About ten million tonnes of food is lost to waste yearly from produce in South Africa (Von Bormann and Gulati 2014). Agricultural by-products which are regarded as waste can provide economic and ecological benefits to biogas generation (Tar and Azibo, 2015). In addition, GIZ (2015) stated that there are few biogas digesters in South Africa that process organic waste streams to produce methane as an energy source. GIZ (2015) further explained that it is estimated that biogas can contribute 2.5 GW generation capacity using waste streams from water waste treatments, food waste, animal waste, agricultural residues and industries.

In that regard, Momanyi *et al.* (2016) mentioned that livestock keeping result in generation of high quantity of animal waste that can be used to generate energy. In addition, waste management companies generate biogas from organic waste and this industry acts as motivation for a sustainable system that combines sewerage management and biogas production (GIZ, 2015).Table 2.1 shows different sectors which can provide suitable substrate for biogas production.

GIZ (2015) highlighted that crops with high sugar content are degraded faster compared to others. On one hand, Okudoh *et al.* (2014) mentioned that some energy crops are estimated to produce biogas equivalent to 1350 peta-joules of electricity while biogas generated from solid waste in landfills is estimated at 9000 giga electricity equivalent. On other hand Stafford *et al.* (2013) stated that energy generated from water waste has shown a promise as a technology that will approximately produce 3200-9000 Mw potential which constitute 7% of the nation power supply.

It is worth noting that the practice of biogas production on farms with the use of animal waste as a substrate to recover energy can be an affordable source of energy and a good waste management source. In that regard, Manyi-Loh *et al.* (2015) pointed out that anaerobic digestion is key in addressing waste management. The biomass waste generated by increase in industrial and agricultural activities can be recycled as a substrate to generate heat needed for cooking (Manyi-Loh *et al.,* 2013). Momanyi *et al.* (2015) added that agriculture has a potential adding value to the production of energy. The practice of generating energy from waste water project have a potential in targeting essential sources and the needs of communities, and is the best tool in managing waste (Stafford,2013).

2.3 Perceptions of rural households towards biogas production

Energy crisis emerging from rising electricity prices and reduction of resources lead to energy insecurity in many rural areas of less developed countries. According to Rajendran *et al.* (2012) energy demand is a result of extensive climate change, resource exploitation, and also restricts the living standards of humans. It is believed that by the time fuel and fertilizer achieves rustic ranges, the end cost is moderately costly because of high transport costs, leaving individuals to discover elective assets other than oil (Rajendran et al., 2012). In that regard, perceptions, knowledge and demographic factors have an effect on the adoption of renewable (Islam and Hossein, 2014). Abdulkarimm *et al*. (2013) added that the decision of energy sources to look over depends to a great extent of a household’s level of income, size and enlighten on the different energy sources available. Thus most people rely on electrical energy for household's chores (Abdulkarimm *et al.,* 2013).

Based on a study conducted by Singh and Maharjan (2003), the household's perception regarding the biogas use was mostly positive in the study area. The households gave reasons like reduced cooking time, easy vessels cleaning, and pollution free and helping to reduce hardship. Likewise, in a study conducted by Akram *et al*. (2013), 50% respondents mentioned that they chose biogas because its clean energy thus escaping from pollution caused by other sources of fuel found.

Akram *et al.* (2013) discovered that the respondents were satisfied with biogas digesters since it saves time. One of the reasons was that their work load was reduced with availability of biogas. Time saved can be used in crop projects (Chakrabarty *et al.,* 2013). In connection to this, a study conducted by Akram et al. (2013) revealed that subsidies that are given to household by government encourages them to install biogas digesters. Moreover, Akram *et al.* (2013) mentioned that few of participants perceived social benefits and decided to install digesters, highlighting that the gas is affordable.

2.4 Contribution of energy consumption to rural income

Agriculture also plays an important part in rural development, especially due to land use, in countries where the sector is of less economic significance .According to Mehra and Rojas (2008), subsistence agriculture is one of the basics in generating income and food access in most of rural communities nationally. Agriculture in less developed nations contributes to poverty alleviation. Similarly, Musemwa *et al.* (2013) added that it is a vital sector that contributes to employment creation, income growth, socioeconomic development and environmental sustainability. It is believed that in 2009, about 2.5 up to 3 million individuals were active in smallholder agriculture (Hart and Aliber, 2009). Moreover, du Toit (2011) pointed that agricultural practice has been increased in South Africa.. The reason for most of them practicing agriculture is that it serves as the source of food.

From Table 2.3, it can be seen that the various causes of households engaging in agricultural activities forms the basis of dietary foods which are highly possible in experiencing severe and insufficient access to foods compared to households that had other reasons. Households engaging in agricultural activities give the opportunity as well as the chances of producing more foods are as second resort in experiencing severe as well as insufficient food access compared to households that practice agriculture as a hobby thereby enjoying its best access.

Table 2. 1: Various causes that households are engaged in agricultural activities

Household reasons' for being involved in agriculture	Adequate access to food	Inadequate access to food	Severely inadequate access to food	Total
As a main source of food for the household	66.2	15.7	18.2	100.0
As the main source of income/earning a living	73.5	20.2	6.3	100.0
As an extra source of Income	71.3	24.1	4.6	100.0
As an extra source of food	73.0	19.3	7.7	100.0
As a leisure activity of a hobby	84.3	13.1	2.6	100.0

Source: Lehohla, 2012

However, Hart and Aliber (2009) argued that increase in number of households that are participating agricultural activities as an extra source of food has been at the expense of households that engage in agricultural activities as the main source of food. Households treat agriculture as a residual activity to be engaged in when needed.

While it is clear that subsistence agriculture can play a vital role in the creation of livelihoods, this can only be achieved if the productivity of subsistence agriculture can be developed. According to Chakrabarty *et al.* (2013), biogas production contributes indirectly to rural household income. This is achieved by substituting other energy sources with biogas. Chakrabarty *et al.* (2013) further stated that time saved from collecting and preparing previously used fuel material can be also used to generate income.

Therefore, biogas production can directly contribute to increase crop yield (Singh and Maharjan, (2003). In connection with this, Wargert (2009) mentioned that slurry that has been digested is a high grade fertilizer. In fact the processed substrates are better fertilizer than before the procedure. Slurry from 1 kg digested dung can yield up to an extra 0.5 kg nitrogen compared to fresh manure. This can solve problems of soil degradation in areas where earlier dung has been used as a burning fuel. It can also mean that less artificial fertilizer have to be bought which bring revenue to the household (Wargert, 2009).

According to Wargert (2009), biogas not only helps to reduce the use of fuelwood for energy, but also helps to reduce the burning of biomass that provides manure for farmland. Importantly, Chakrabarty *et al.* (2013) emphasized that the use of biogas digesters in farms daily for ten hours is viable with return investment. This can be achieved by producing only electric energy or combined with carbon credits. Agriculture will limit power outage associated with climate factors or accidents where energy is transmitted for long distances. In addition, Hegan *et al.* (2011) supplementing expense of utilizing chemical fertilizer by slurry, can also generate income from the sale of slurry.

Manyi Loh (2015) stated that view, use of biogas digesters in farms can help to decrease production costs thus increasing the income. Anushiya (2010) added that the use of biogas saves time, this encourages communities to be involved in income generating activities. Anushiya (2010) further explained that the adoption of biogas technology by households can reduce their expenses on fuel purchase, in that regard they will be saving their income. In addition, Muvhiwaa *et al.* (2016)

added that the use of biogas will reduce reliance on electricity, particularly in rural communities. However, current exploitation of biogas as a viable energy source in South Africa is limited. It is only recently that South Africa's electricity public utility (Eskom) and The Department of Trade and Industry have approved rebates and grant schemes that will increase the use of biogas as an alternative source of renewable energy (Muvhiwaa *et al.,* 2016).

On one hand, Tah and Azibo (2015) pointed out that proper management of biogas digesters result in positive impact on the social welfare of the owners of biogas digesters. Also, it is believed that the household income can increase by 73% yearly if the owners properly manage the digesters (Tah and Azibo, 2015). On other hand, Wargert (2009) argued that irrespective of the possibility that small biogas digesters are thought to be affordable source of energy they are still coupled with an initial investment that can be hard to manage the cost for poor communities.

Despite controversy around biogas management in rural communities, Wargert (2009) stated that most local jobs are created around biogas projects. Warget (2009) further discussed that skilled labour is required in the building of biogas digesters and many local companies usually emerge. Importantly, GIZ (2015) indicated that biogas technology creates job opportunities for both skilled and unskilled work. In particular, in an efficient biogas, biogas innovation extension opens job opportunities for artisans, handymen, structural specialists, and agronomists.

Momanyi *et al.* (2016) mentioned that biogas technology result to enhanced financial status of the community as the energy and time saved from collecting firewood might be redirected to different activities like cultivating which will decrease hunger. Momanyi *et al.* (2016) further stated that globally, rural development in less developed nations face the challenge of inefficient and affordable energy technology. On other hand, that technological advancement in providing basic energy need in an effective manner is key for rural areas, where most of farmers are living in subsistence level (Singh and Maharjan, 2003).

2.5. Factors affecting adoption of renewable energy in South Africa

Pegels (2010) noted that while there are some natural barriers, such as the limits to biomass use, and specific technology needs, such as waterless cooling systems owing to the scarcity of water, the main barriers are to be found in the South African energy innovation system and in the economics of renewable energy technologies. On the hand, Bormann and Gulati (2014) stated that water needed to generate electricity is expected to be more. This will be a challenge in water allocation trade-offs between energy and agriculture.

South Africa relies on domestic coal (OECD, 2015).Similarly, Pegels (2010) stated that coal is the main source of energy in South Africa, both electricity and fuel are produced from coal. The two main energy providers, Eskom (electricity) and Sasol (fuel), are responsible for the bulk of investment in energy research and development. At the same time, they are almost monopolistic employers of university graduates in the relevant fields. These patterns have led to an extreme bias in innovative capacity towards fossil fuel innovation. Renewable energy technologies, on the other hand, lack the capacity basis at all levels of education. As monopolistic energy providers, both Eskom and Sasol wield considerable power. They use their influence to protect those of the energy market's features suited to their core competencies

Uyigue and Archibong (2010) stated that lack of awareness of Renewable Energy Technology (RET) has led to underdevelopment in the energy sector. Majority of policy makers and government officials were not well informed about RET, as a result policies could not be formulated clearly in favour of RET. Importantly, Wargert (2009) noted that local communities need to be knowledgeable about the technology to ensure long term competence in monitoring biogas digesters. Wargert (2009) further highlighted that the motive behind this initiative is for government to implement pilot biogas projects in agricultural areas to identify the importance of biogas technology.

In rural community's context, Wargert (2009) mentioned that it is often cattle owning farmers who have profited from biogas. The rural poor who do not own cattle have not benefited from biogas production. This is caused by unavailability of primary resource (cow-dung) required to produce biogas. The rural poor depend on fuel wood. According to Sibisi and Green (2005) LP gas, paraffin and grid electricity are expensive for low income communities.

According to Sibisi and Green (2005), rural electrification can be a key tool in addressing inadequate access to electricity in rural communities. However, provision of electricity is more focused in urban than in rural areas, hence rural communities depend on more expensive, less available, energy sources, thus wood, paraffin or LP gas. Sibisi and Green (2005) further explained that non-rural electrification is caused by high investment require for the installation from service providers. Long distances between main roads and rural communities require more power lines. This make it to be expensive for the supplier to connect few consumers along a particular length of line (Sibisi and Green, 2005).

2.5.1 Renewable energy policies, strategy and regulatory framework

According to DoE (2015), South Africa is progressing in renewable energy through the financial and technical support from the international community and several aid agencies. Moreover, DoE (2015) further explained that government has established excellent policy foundation to enable optimum utilisation of the abundant renewable energy policies. The successful introduction of renewable technology began in 1996 constitution which has been translated in at least three policy documents thus 1998 white paper on energy policy, 2003 white paper on renewable energy and the 2011 climate change response white paper policy and the national development plan (DoE, 2015). Figure 2.2 in the next page shows various government initiatives implemented in promoting renewable technologies in South Africa. Figure 2.2 presents key enabling policy for renewable energy.

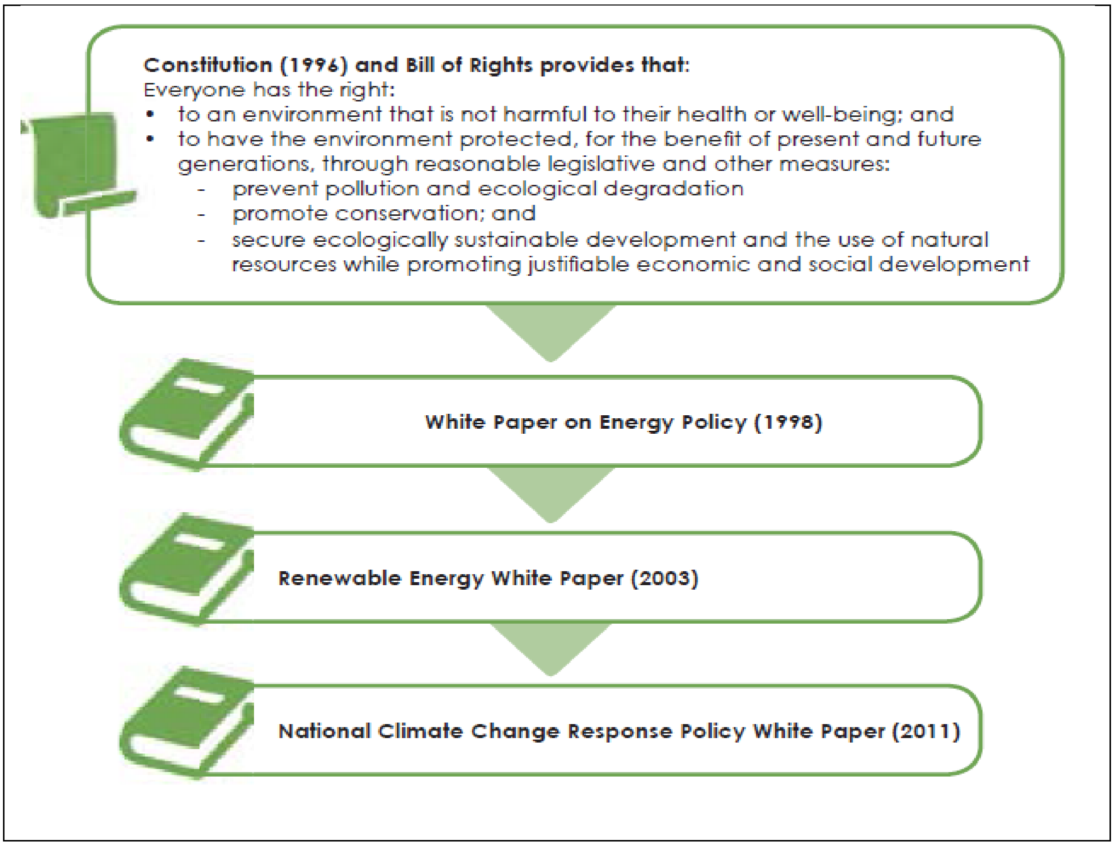

Figure 2. 2:Key enabling policy for renewable energy

Source: DoE, 2015

According to GIZ (2015), motive behind 1998 white paper energy policy was to recognise as early as 1998 that there was rapid development in renewable energy technology, and that these technologies would be cost competitive and cost effective in time. The 1998 white paper clearly indicates that all households should have access to electricity. In 2001 there was an implementation of non-grid electrification programme to complement measure for addressing backlog in areas that could not be electrified due to high fixed costs of grid extension and challenging geographic terrain that makes unlikely that the electricity grid might be available to all locations in the medium term (GIZ 2015).

The 2003 white paper renewable energy aimed to make developments in financial instruments, legal instruments technology development, governance and awareness raising capacity and education (GIZ, 2015). In spite of the initiatives government has put to overcome energy insecurity, energy crisis was experienced in 2008 with emergencies in supply (Trollip *et al*., 2014). In the same financial year, Pegels (2010) stated that Eskom applied 60% electricity tariff increase, however National Energy regulator of South Africa eventually allowed 27,5% rise.

Pegels (2010) stated that the renewable energy initiative and the tariff rises induced not by environmental concerns but financial necessities. The 2011 national climate change response white paper played a key role in motivating and monitoring implementation of climate change mitigation programme across the key priority sectors (GIZ, 2015). National development plan brought significance of energy to society's livelihoods and the economy to the fore. Integrated resource plan 2010-2013 aims to provide a long term plan for electricity supply. It encourages mix of energies to increase energy capacity.it is carried out through mini serial determinants which are regulated by electricity regulation on new generating capacity. The electricity regulation act (ERA 2006) and the new generation capacity regulation are legal driving instruments adopted by government to unlock the renewable energy independency power producer procurement programme (REIPPP).The ERA and its regulators allows the ministerial of energy to dictate what new capacity is required (GIZ 2015).

According to GIZ (2015), small- scale biogas production is practiced in rural communities where there is no electricity supply from national grid. In terms of legislation the owner need not to be licensed however one is required to register with national energy renewables South Africa. Between year 2011 and year 2015 only 200 biogas operation have been registered. Trollip *et al.* (2014) had contra views stating that that the future of upcoming energy is predicted to be insecure. In-addition, the gap between renewable energy policy statements and the actual implementation is wide (Pegels, 2010).

In light of the above, Uyigue and Archibong (2010) argued that in African context lack of implementation of existing policy is common. The policies are driven by government officials without considering views of the society. In addition, Trollip *et al.* 2014 noted that South Africa has not reached the adequate investment needed for energy infrastructure. Pegels (2010) added that it is vital for government to be hands on in setting policies that promote biogas usage and encourage collaboration with governmental organisations and non-governmental organisation to close the gap lack of communication. Even when definitive statement have been formulated at the level best, implementation remains problematic (Pegels, 2010).This is evidenced by coal shortage by 2015, shortage in electricity generating capacity and less investment in the infrastructure (GIZ, 2015).

In spite of challenges mentioned above, Gets (2013) revealed that South Africa confronts power value climbs to fund new form. Gets (2013) further explained that in the event that South Africans are to back Eskom's ability development program, then Eskom ought to put resources into renewable vitality hotspots for a maintainable future. The 8% expansion permitted by the National Energy Regulator of South Africa right now does exclude the proposed carbon assess, nor does it incorporate the negative externalities connected with coal-let go power era, including wellbeing effects and water shortages (Gets, 2013). Moreover, putting resources into atomic as proposed by the Department of Energy, would drive the cost of power much higher than the figures incorporated into Eskom's duty increment application (Gets, 2013).

2.5.2 Possible barriers that affect the uptake of renewable energy in South Africa.

According to Bond and Templeton (2011), since 1970 there has been spread installation of biogas digesters in India, Nepal, German and China, respectively. These countries have been involved in development of biogas projects and programmes for some years. However in other less developed countries the digesters are not functioning. This is due to the lack of maintenance and repairing of existing facilities (Bond and Templeton 2011). However, the involvement in less developed nations has been limited to small scale application of anaerobic digestion in remote areas.

In light of the above, Uyigue and Archibong (2010) highlighted that lack of skilled man power and skilled local labour to develop energy sector often depend on expatriates from developed nations to ran some other operation. In addition, grid connected to large scale biogas programme are rare to find in developing nations. Also, farmers from remote areas face the lack of financial capabilities to invest in biogas plants (Wargert, 2009).

On other hand, Wargert (2009) mentioned that during rainy season biogas digesters that are installed underground get flooded and this leads to maintenance time and costs. In that regard, Terero (2015) added that rural electricity schemes are usually more expensive compared to urban, this is led by low income which contributes to unaffordability. Secondly, long distances result in great electricity losses on high cost customer support and equipment maintenance. With regards to the mentioned issue, it is thought that failure of municipalities in financial planning result in infra-structure not being planned for, in the financial period (Mannie, 2014).

Amigun (2012) viewed biogas technology the as key tool in addressing energy insecurity and environment problems. In rural context, Taele *et al.* (2006) mentioned that in rural areas animals are kept in different areas seasonally. Wargert (2009) added that it is difficult to collect animal dung in an extensive farming. This prevents collecting enough animal waste needed to feed the biogas digesters and disrupts steady generation capacity (Taele *et al.,* 2006). Lack of communication thus information and experience on what works and does not within and between the countries contributes to non-adoption of biogas technology. Based on the study conducted by Smith *et al. (*2014) biogas digester is not a financial feasible investment for rural households, however it can be a valuable investment from a broader societal view.

2.6 Conceptual framework of the study

The conceptual framework demonstrates the interrelationships in the study area, the key variables and how they are involved and how they affect the uptake of biogas energy.

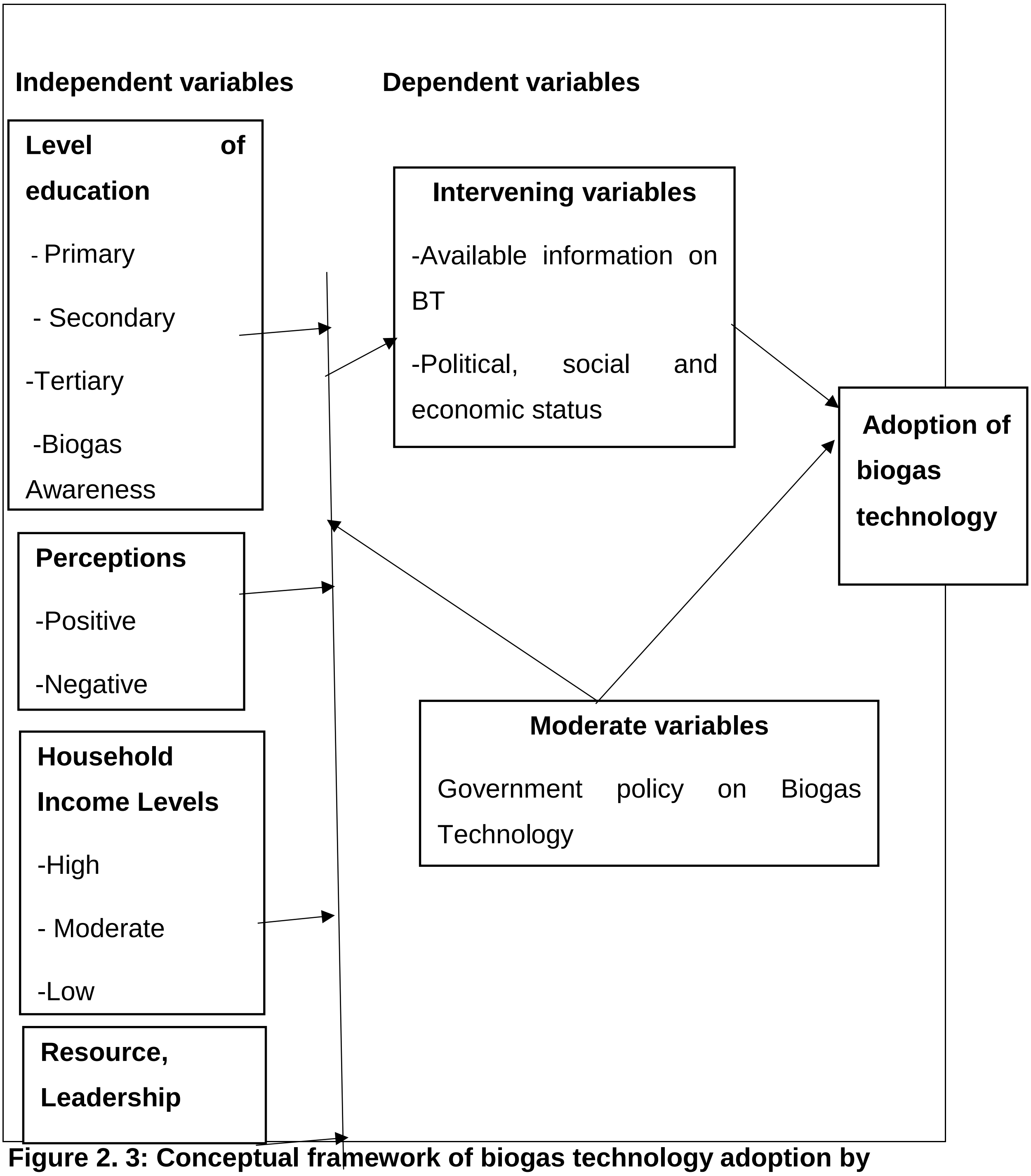

Figure 2. 3: Conceptual framework of biogas technology adoption by households.

Source: Adapted from Gakuu *et al*., (2013)

The above figure 3.2 illustrate the conceptual framework of biogas technology adoption by households. This study was steered by the conceptual framework which has the following independent variables: level of education, perceptions of households, household income levels as well as resource and leadership. Other intervening variables included government policy on energy and investments in biogas technology.

The conceptual frame work indicates that level of education of the respondents is bound to affect their adoption of biogas technology as those with formal education have access to information, knowledge and are, therefore, more likely to invest in biogas unlike those respondents without formal education. Knowledge about the technology and maintenance of the biogas plants could affect adoption. Perceptions are also important in adoption of biogas technology.

According to Gakuu *et al*. (2013) argue that how people react when presented with biogas technology solely depends on their attitudes or perceptions regarding its use and cost, among other factors. Perceptions may either be positive prominent to their investing in the technology or negative which may mean their deteriorating to invest. Household incomes plays a crucial role in determining the decision to either invest or not based on the amount of disposable income available in the household and priorities that require allocation of scarce resources within the household. There more the household have high household income, there more the household invest in biogas while low income will make households decline the investment in biogas technology.

Momanyi *et al.,* (2016) argued that resources owned by households in terms of size of land, number of cattle and size of household could influence the decision to adopt biogas technology. Further, Level of education plays an important role in Biogas adoption through the knowledge acquired from school. Leadership role is important and it play a role of being the gate keepers and innovators in the community which is an important aspect in technology adoption as their decision to take up or not an innovation influences the other community members positively. The study was carried in a consistent environment where the political leadership, economic status and social status are the same for all the people involved in the study area

2.7 Chapter summary

This chapter reviewed relevant literature on biogas technology. Primarily, an indication of the meaning of biogas technology was discussed. The chapter further explored the importance of biogas, especially its contribution to the household income and livelihoods. It portrayed the evidence of the contribution of biogas production to agricultural production. The factors that influence the uptake of biogas technology was also reviewed. Finally, the chapter presented the conceptual frame work of the study

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section displays a portrayal of the Melane village in terms of its geographic location and resource availability. It additionally considers model specification, research design, and reconnaissance of field observation, sampling techniques and sampling size, data collection procedures, data, data analysis. The first section describes the geographic location of Melani village. It also physical setting, socioeconomic setting shows industries found in Melane and resources available. The second section deals with the methodology, highlighting on the techniques‟ and data collection methods used. Insufficient energy under study reflect the significance of the biogas production mainly using cheap resources (cow dung). Justification of the use of data analysis tool will be based on previous studies that focused on perceptions of rural households on the role and effect of biogas production towards rural household income.

3.2 Description of the study area

According to Nkonkobe Municipality, (2011) Melani is a rural community located in the Raymond Local Municipality, previously Nkonkobe Local Municipality. It was established in year 2000.It is located in the Eastern Cape, which is the second largest province of South Africa and is regarded, as the poorest province .It is a local municipalities operating under the Amatole District Municipality of the Eastern Cape. The Amatole, which means “the calves of the Drakensberg” in Xhosa, is a municipal district, which is situated in the central coastal part of the Eastern Cape. The Raymond Mhlaba municipality is described as “a countryside municipality that sits on the foot of mountain range of the Winterberg (Nkonkobe IDP, 2010/11). It covers 3 725 km2 and makes up the R63 road of the surface areas of the Amatole District Municipality. The study employed information in the literature review and suggested that the research site should be in the Raymond Mhlaba Municipality, specifically in Melani village which is located in Alice town. Melani was chosen because it is the only village in the Municipality where biogas plants are in operation. The study was conducted in all biogas users and selected non-biogas users.

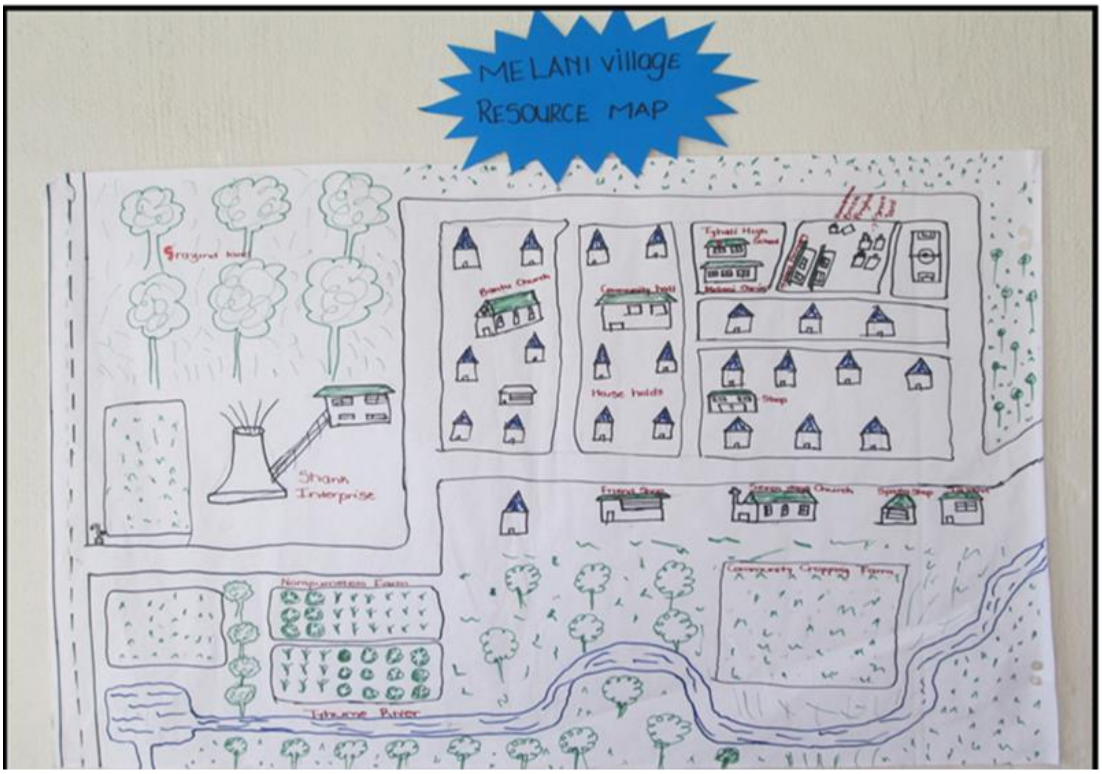

Figure 3. 1: Melani resource map Source: Makhado et.al (2013)

A resource map is a tool used to identify all main characteristics of the village such as residential area, natural resources and land usage as understood by the households. In this study households who use biogas with the help of the Fort Hare Institute of Technology members constructed a resource map. The resource map was later redrawn based on the rough sketch. The purpose of redrawing the map was to show a clear picture of the village by substituting symbols such as stones and sticks into the resources that they represent.

3.2.1 Physical setting

The study was conducted in Melani, a rural village located in the Raymond Mhlaba Municipality, about 12 km north of the University of Fort Hare and Alice town (Nkonkobe Municipality, 2012). It is situated at 32^0 43' 29'' S latitude and 27^0 07' 35'' E and the area is 771.6 ha in size (Manona, 1998). The village has a population of approximately 500 households, housing about 3000 residents (Nkonkobe Municipality, 2012). Annually, Alice receive about 386mm of rain, with most rainfall during rainy season thus summer. Alice receives the lowest rainfall (8mm) in July and the highest (59mm) in March. The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Alice range from 19°C in June to 27.6°C in February. The region is coldest during the month of July when the temperature drops to 5°C on average during the nights

3.2.2 Socio-economic setting

According to the Nkonkobe Municipality (2006), about 70% of its households are food insecure and does not have any source of income. In addition, approximately 6531 individuals in Raymond Mhlaba Municipality receive income between R401 and R800 monthly. Those earning below R800.00 raise concerns as their purchasing power is very low. The municipality is highly dependent on government job creation. Of all sectors in Raymond Mhlaba Local Municipality, only manufacturing and wholesale/ retail sector have been performing well. The wholesale/retail sector consist of Small Micro Medium Enterprises (SMMEs) which are essential in developing Raymond Mhlaba Municipality.

3.2.3 Poverty situation

Raymond Mhlaba Municipality characterised by a series of impediments to human welfare due to high unemployment levels (Nel and Davies, 1999). The situation is worsen by the presence of low industrial activities (Nel and Davies, 1999). Amongst these obstacles facing the area include high poverty level resulting from high unemployment rate, low income and lack of basic skills required to spur local economic development, inadequate infrastructure and social services, low agricultural productivity, high dependence on government grants, inadequate and inefficient income generation strategies to improve the economic base of the municipality (Nkonkobe Municipality, 2004). De Wet (1993), as cited by Neland Davies (1999), states that income derived from agriculture does not exceed 10% of the average rural income. Many rural people rely on gifts, state pensions and migrant labour remittances for household survival (Nel and Davies, 1999).

Levels of electrification in Raymond Mhlaba area have improved by more than 95%. The number of people who depend on electricity for energy is high. Despite the increment in access to electricity, there is still a considerate number of people who still use paraffin their source of energy. In rural context, the majority of households use electricity for lighting and continue using paraffin for cooking and heating.

3.2.4 Agricultural production

The rural communities nearby Alice have a high agricultural potential projected on the Tyume river floodplain with alluvial soils suitable for agriculture. In terms of the veld type, Alice is dominated by Dohne Sourveld of the Eastern Cape Sourveld and it is not conducive for livestock farming. Due to its nutritional deficiency especially during the winter season, it does not generally tolerate high grazing pressures. This area has been recognized as a potentially valuable resource for research into sustainable agriculture.

Agriculture in Raymond Mhlaba is not well developed. However, there are chances in citrus farming and forestry, which are developing. Decreasing activity in subsistence farming seemed to be the major constraint. University of Fort Hare’s Department of Agriculture had launched Nguni farming cattle project with the aim of increasing beef production in the area. Crop farming is the common practised agricultural activity in Melani village. The commonly grown crops are cabbage, potato and beetroot.

3.3 Research design

The study adopted a quantitative approach. A survey approach was further employed with a cross-section of the relevant population reflected in such a way that the key residential, asset owners, educational and other demographic categories are represented accordingly. The study adopted cross sectional research design. Although certain disadvantages are outweighed in the approach, these were inherently the advantages which are less time-consuming than case-control or cohort studies and inexpensive.

3.4 Data and variable definition

The variables examined in the study are presented in Table 3.1. Previous studies have shown that household biogas production is strongly influenced by such factors as the physical conditions of the nature of production, access to production.

Table 3. 1: Variable measurement and a priori expectations

Variable	**Description and unit of measurement**	**Expected Sign**
Income	Amount of income generated by a household	+
Age	Age of household head in years	+/-
Level of education	Number of years spent in school by household head	+
Marital status	The farmers maybe single, married or widow	+/-
Occupation	The employment status of the household head	+
Household size	Number of family members	+
Technology adoption	Level of understanding of biogas production	+
Cattle ownership	Number of cattle owned by household	+/-
Water availability	Availability of water in the study area	+/-
Biogas equipment	Availability of biogas equipment in the study area	+
Biogas digesters monitoring	The safety and monitoring of the functioning of biogas digesters	+

Source: Field Survey, 2016

Household size: The number of people living together in one house influences the activities occurring in the house. Having a large household means more hand available to perform household duties including more people available for farm work. Therefore, more labour will result to high agricultural production for the household with reduced labour costs.

Education level (standard obtained): High levels of education could probable make it easier for them to understand many things regarding new techniques of production and information workshop trainings, especially new technology adoption. People who are illiterate have difficulties in understanding and so they need extra care.

Employment status: This variable is expressed as the head that brings income to a family. This determines the state of income the family has to survive, and consequently the time the family devotes to own production, If they are employed they will devote less time to mown production and vice versa.

Marital Status: This variable determines the level of support one has from his partner has compared

Age: Older people are less energetic, illiterate and unease to comprehend technological advances.

Technology adoption: Training and education of householders is needed in relation to the maintenance of digesters, feedstock suitability and the environmental and potential livelihood benefits of digesters.

Cattle ownership: Households who owns cattle are likely more to have access to biogas compared to households who do not have the herd.

Water availability: Biogas operations consist of a fixed dome plant that uses bio-digesters to produce biogas from waste material and water. So, the availability of water will matter as this will create a competition between drinking water and irrigation water.

Income: Income generating activities, both agricultural and non-agricultural, of rural households

3.5 Sampling technique and sample size

According to Kumar and Ranjit (2005), sampling is the process of selecting a few (a sample) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen. The sample consist of 48 respondents who are biogas users and non-biogas users. Convenience or availability sampling was used which is a non-probability sampling method, respondents were interviewed with questionnaires until the desired sample size of (48) was reached. Sample size of 48 was used because the research focused only in the Nkonkobe municipality, which is with many numbers of farmers.

A sample of 48 households will be selected to participate in the research survey. The households will be selected to represent the population under the study. According to Bless *et al.* (2007), a sample of at least 48 units will capture the characteristics of the population. Choice of sampling size depends on budget for travelling costs, and time availability.

3.6 Data collection

Before data collection, the researcher conducted a survey with Fort Hare Institute of Technology officials to familiarize with the study area. Communal areas were visited in order to explore the income levels, biogas production projects, agricultural status, water availability and water sources and resource conservation techniques practiced. After identifying the resources in the area, the researcher planned activities of the field study. Later on the planning of the field study, interviews were held in communal areas on matters relating to biogas production programs, income levels and agricultural activities in the study area.

Data were collected through administering close-ended questionnaires. The questionnaires were administered by researcher in order to reduce the problem of misrepresentation, or misunderstanding of some words or questions. It therefore, ensured that all the questions will be considered without respondents omitting the seemingly difficult ones. During interviews, questions were translated to the Xhosa language in order to enhance respondents' understanding and comfort in responding to questions. A qualitative approach was used, whereby both primary and secondary data shall be utilised.

Furthermore, interviews were conducted at household level to get individual farmer's opinions. Table 3.2 represents the research objectives, hypothesis and how the objectives were achieved. This is shown by analytical tools.
Each objective was considered separately as follows:

Table 3. 2: Summary of a study objectives and analytical tools

Research Objectives	Research Questions	Analytical Tool
To describe the socioeconomic characteristics of the in the households study area.	What are socioeconomic characteristics of the households in the study area?	Descriptive Analysis
Describe the renewable energy status in the study area	What is the renewable energy status in the study area?	Descriptive Analysis
Identify the perceptions of rural households towards biogas production	What perceptions do households have towards biogas production?	Binary Regression Analysis
Determine contribution of biogas consumption to rural income	What contribution do biogas energy consumption have on rural income?	Bivariate analysis
Identify the factors affecting adoption of biogas production in rural households	What are factors affecting adoption of biogas production in rural households	Bivariate analysis

3.6.1 Socio-economic characteristics

The first objective which is to describe the socio-economic characteristics of the households in the study area requires the primary data only. The data were collected using the questionnaires.

3.6.2 The description of biogas energy in the study area

The second objective which is to describe the renewable energy status in the study area requires the primary data only. The data were collected using the questionnaires.

3.6.3 The perceptions of rural households towards biogas production

The third objective which is to identify the perceptions of rural households towards biogas production in the study area requires the primary data only. The data were collected using the questionnaires.

3.6.4 The contribution of biogas energy to rural income

The fourth objective which is to determine the contribution of biogas energy consumption to rural income in the study area requires the primary data only. The data were collected using the questionnaires.

3.6.5 The factors affecting the adoption of biogas production in rural households

The fifth objective which is to identify the factors contributing to non -adoption of biogas production in the study area requires the primary data only. The data were collected using the questionnaires.

3.6.6 Reconnaissance and field observation

3.7 Model

This section describes the analytical tools used to assess the perceptions of rural household production on rural household income in Raymond Mhlaba Local Municipality. The analytical tools used in the study include the descriptive and inferential statistics. Descriptive statistics made use of frequencies and cross-tabulations while the inferential statistics made use of bivariate and logit analyses.

3.7.1 Socioeconomic characteristics and biogas status in Melani village

The study adopted descriptive statistics to describe the describe biogas status with the special reference to biogas adoption. Descriptive statistics is defined as a set of brief descriptive coefficients that summarizes a given set of data, which can either be an illustration of the entire population or a sample. Measures that descriptive statistics uses to describe the data set of biogas status will be measures of central tendency and measures of variability or dispersion, whereby measures of central tendency comprises of mean, median and mode, while measures of variability consist of the standard deviation, the minimum and maximum variables and skewness (Gujarati, 1992). Descriptive statistics grants a useful summary of safety returns when performing empirical and analytical analysis (Mcata, 2013). Mostly the descriptive statistics will be commonly used to describe the basic features of the data in a study such as demographic and socio-characteristics of biogas user. It provides simple summaries about the sample and the measures (Research Methods Knowledge Base, 2008). Descriptive statistics uses graphical and numerical summaries to give a 'picture' of a data set (Research Methods Knowledge Base, 2008). According Gujarati (1992), descriptive statistics is a combined name for a variety of statistical methods used to organize and sum up data in a significant manner, therefore augmenting appreciation of the properties the data offer. This illustrates the essential features of the data and it gives a straightforward summary as well as the procedure involves in analysis the data. The mathematical symbol for the frequency proportion was estimated by this expression

$$\sum \boldsymbol{f} = \boldsymbol{f1} + \boldsymbol{f2} + \boldsymbol{f3} + \cdots \ldots \ldots \ldots \ldots \ldots . \boldsymbol{fn} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where:

$\sum \boldsymbol{f} =$ Sum of the frequency of the biogas users and non-biogas users

$\boldsymbol{n}$ is the number of biogas users and non-biogas users distinct values taken by the variable $\boldsymbol{f}$

$\boldsymbol{f1} + \boldsymbol{f2} + \boldsymbol{f} + \cdots \ldots . \boldsymbol{fn}$ are the frequencies of the biogas users and non-biogas users?

To describe the average distribution and standard deviation of the households by age of household head, gender, farming experience, number of years in school and farm size, the mathematical symbol for mean and standard deviation were estimated by this expression:

$$\boldsymbol{\mu} = \frac{\boldsymbol{1}}{\boldsymbol{n}} \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \boldsymbol{x_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots...(2)$$

$$\boldsymbol{\sigma} = \frac{\boldsymbol{1}}{\boldsymbol{n}} \sqrt{\sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} (\boldsymbol{x_i} - \boldsymbol{\mu})^{\boldsymbol{2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where

$\boldsymbol{\mu}$ is the population mean of the biogas users and non-biogas users, and it is calculated by adding up the values for each household and dividing by the total number of households.

$\boldsymbol{\sigma}$ is the standard deviation of the, biogas users and non-biogas users and it is a measure that is used to quantify the amount of variation of the data collected. A low standard deviation indicates that the sample tend to be close to the mean, while a high standard deviation indicates that the sample are spread out over a wider range of values.

$\boldsymbol{n}$ is the number of biogas users and non-biogas users distinct values taken by the value of $\boldsymbol{x}$

$\boldsymbol{xi}$ is the value of *x* for a particular biogas users and non-biogas users.

Moreover, a Likert rating scale was used to analyse household perception of biogas production. In this method, a sampled household head will indicates his or her degree of agreement for a variety of statements related to the perceived changes of a given variable over time. An important assumption of this scaling method is that each of the statement measures some aspect of a single variable so as to legitimately apply summation.

The study adopted a Likert scale to rank perceptions. A Likert scale usually consists of two parts, the item part and the evaluative part. The item part is essentially a statement about a certain product, event, or attitude. The evaluative part is a list of response categories ranging from “strongly agree” to “strongly disagree” (Statistics help for students, 2008). Accordingly, a number of variables/statements that are capable of measuring the perception of households towards the biogas adoption have been developed and will be presented to households on a five point Likert scale. Finally, appropriate statistical will be applied to reach a conclusion.

The study adopted cross tabulation analysis to identify factors affecting the adoption. Cross tabulation analysis is a two or more dimensional table that is most often used to analyse categorical data. A cross tabulation is a two dimensional table that records the number of respondents that have specific characteristics described in the cells of the table. The study adopted cross-tabulation analysis to identify the factors affecting the adoption of biogas production in the study area. Cross-tabs were used to establish relationship between factors influencing and the perceptions on adoption and to test for significance of the relationship using chi-square. The identified factors were analysed according to the number of occurrences using the frequency percentage distribution table.

Chi-square is a statistical technique used to measure statistical significance influence between variables.

However it does not measure the causal relationship between the tested variables. Chi-square method is used when:

- The sampling method used collect the data is purposive sampling method.
- The population of the studied sample is at least ten times larger than the sample surveyed
- The variables under consideration are categorical in nature
- The expected value of the number of sample observation in each level of the variable is at least 5

The formula for chi-square test is represented as follows:

…

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

Where x^2 denotes a chi-square value,

O=observed values

E = expected values

∑ = this denotes the summation of observed values minus expected values divided by the expected values

K-1= degrees of freedom

Therefore, only 2*2 test applicable where possible due to the nature of my research data. The tested variables include the demographic characteristics of the household such age, education.

3.7.2 Perceptions of rural households on biogas production

The study utilized a binary logistic model to analyze factors that influence household perceptions on biogas adoption. Binary logistic regression is a type of regression analysis where the dependent variable is a dummy variable (coded 0, 1). The logistic regression model is simply a non-linear transformation of the linear regression. The logistic distribution is an S-shaped distribution function (cumulative density function) which is similar to the standard normal distribution and constrains the estimated probabilities to lie between 0 and 1. The dependent variable was coded 0 if the household adopted biogas technology and 1 Otherwise. According to Greene (2003) the logit model takes the form:

$$\log(P_i\ /(1-P_i)\ = logP_i = \beta_0 + \beta_1 X_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where P_i is the probability of being a biogas user and X_1 is a predictor variable. Therefore the parameter β_0 gives the odds ratio of the dependent variable.

The probability of the occurrence of an event relative to non-occurrence is called the odds ratio and given by the following equation:

$$P_i\ /(1-P_i)\ = \exp(\beta_0 + \beta_1 X_1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Or in terms of probability outcomes

$$P_i = \exp(\beta_0 + \beta_1 X_1)/(1 + exp(\beta_0 + \beta_1 X_1)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6$$

The model is set as follows

$$P_I = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots.\beta_n + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (7)$$

Where: β_0=intercept term

$\beta_1, \beta_2, \beta_3 \ldots \beta_n$= slope of the parameters or regression coefficients of the model which measures a unit change in explanatory variables.

X_1, X_2....X_n = Explanatory or independent variables or factors that explain perceptions about biogas adoption the probability that a household is knowledgeable about biogas technology

U_i = Error or disturbance term

The model was estimated to identify the perceptions of households on biogas production.

3.7.3 Contribution of biogas consumption to rural income and factors affecting adoption

Bivariate analysis was used to determine the contribution of biogas consumption to rural income as well as to identify factors affecting the adoption of biogas production in rural households. Spearman's rho (*r*) was used to examine the relationship between the outcomes as defined by the following:

a. Relationships between perceptions held and adoption or non-adoption
b. Relationship between perceptions held and socio-economic/demographic characteristics
c. Relationships between perceptions held and production of principal crops

$$r_s = \frac{6\sum d^2}{n(n^2-1)}$$

Where d the difference in the perceptions of each individual while is n is the number of participants. The spearman's correlation coefficient denoted by $\boldsymbol{rs}$ measures the strength of the association between two ranked variables for the same individual (Gujarati, 2003). This correlation test statistic was used to describe the existence of relationship as well as the strength and direction of the association.

3.8. Ethical considerations

The main ethical issues that were considered in this research are:

- Informed consent

The study will explain into detail as to what the research is about and why it is important before they give their consent about participating in the research.

- Respect for persons

  As the individuals have the right to decide not to participate in the study.

- Confidentiality

The data collection was carried out by the researcher in person through face-to-face interviews during which all the foregoing ethical issues were taken into account.

3.9 Chapter summary

The purpose of this chapter was to describe the research methodology of this study, explain the sample selection, the study area. Also discusses the statistical procedures used to analyse the data and the limitations and delimitations of the study. Moreover, the study included the limitations and delimitations of the study. Data was collected from 48 households in Melani Village. The research focused on perceptions of rural households towards biogas production, focusing on biogas role and effects on rural livelihoods within the study area. Random sampling was applied in order to select a sample from both biogas users and non-biogas. Data analysis was made by means of the Multiple Regression model to analyse food status within the study area. The results of the research follow in the next chapter.

CHAPTER FOUR

PRESENTATION OF RESULTS

4.1 Introduction

This chapter presents the results of the study. The objective was to explore perceptions of rural households on the role and effect of biogas production on rural household income in Melani village. The first section presents the descriptive statistics of the socio economic characteristics of the sampled respondents. The second section provide the correlation between perceptions held and adoption or non-adoption of biogas, and relationship between perceptions held and production of principal crops. Following that, the third section examine causal relationships on factors influencing perceptions held. Lastly, the factors that influence adoption are examined and presented based on, -the empirical analysis using binary regression and Chi-Square analysis to test the significance of the variables.

4.2 Socio-economic and demographic characteristics of biogas users and non- biogas users

The demographic characteristics such as gender, age, household size, income, education level and occupation are very important determinants of household decisions in terms of the technologies they employ in their farming operations, the way they allocate resources, and how much they want to produce as well as decision as to what to eat and what to sell. Table 4.1 presents the basic demographic/socio-economic characteristics of the sampled households in the study area. The results are grouped according to the status of adoption of biogas technology.

Table 4. 1: Demographic characteristics of respondents (n= 48)

Variable	Biogas user		Non-biogas user	
	Frequency	Percentage	Frequency	Percentage
Gender				
Female	7	53.8	25	71.4
Male	6	46	10	28.6
Total	13	100.00	35	100.00
Age of respondents				
20 – 40	6	46.2	6	17.1
41 – 60	5	38.5	14	40
61 – 80	2	15.4	12	34.3
>61	0	0	3	8.6
Total	13	100.00	35	
Marital status				
Married	4	30.8	13	37.1
Single	7	53.8	13	37.1
Widowed	2	15.4	7	20
Divorced	0	0	2	5.8
Total	13	100.00	35	100.00
Educational level				
No formal education	0	0	9	25.7
Primary education	4	30.8	18	51.4
Secondary education	9	69.2	8	22.9
Total	13	100.00	35	100.00
Household size				
1 – 4	7	53.8	20	57.1
5 – 8	5	38.5	14	40
9 – 12	1	7.7	1	2.9
Total	13	100.00	35	100.00
Employment status				
Unemployed	8	61.5	29	82.9
Formally employed	1	7.7	2	5.7
Self employed	3	23.1	4	11.4
Part time farmer	1	7.7	0	0
Total	13	100.00	35	100.00
Source of income				
Agricultural activities	0	0	1	2.9
Salaried employment	3	23.1	3	8.6
Trading/business	2	15.4	2	5.7
Social grants	8	61.5	29	82.9
Total	13	100.00	35	100.00

Source: Based on SPSS processing of field data, 2017

4.2.1 Distribution of household by gender

Gender of the household head may be female or male, all things remaining equal. Gender role is a set of societal norms dictating what type of behaviours are generally considered acceptable, appropriate or desirable for a person based on their actual or perceived sex. According to Action Aid International (2011), women have always been engaged in producing food crops, processing food and marketing. For most less developed nations, women have taken a lead in soil and water conservation programs (AAI, 2011). The study sought to determine the distribution of the sampled participants based on their gender. Information on gender of the household respondent is presented on the Table 4.1.

Results from the study indicated that 66.6% of the respondents were females and 33.4 were males. The results further showed that 53.8% of women from sampled participants were engaged in biogas production. Based on the results more females are engaged in biogas production than men. This implies that women are more active in biogas project than men. In most cases men leave their homes to search for or get work in cities or other towns outside the village. This results in women being more numerous within the village and being responsible for most of the key household decisions on family matters as well as productive activities. The results are consistence with findings from AAI (2011), which revealed that it is women's responsibility to prepare food and do home chores, and therefore it becomes their responsibility to provide fuel for cooking.

4.2.2 Distribution of household by age

Age is a vital factor in relation to individual's personality and composition, since the needs and individual intelligence are related to the number of years an individual lived. In that regard, Romuld and Sandham (1996) believed that youths are more adaptable and willing to change than elder people in the attempt to try out new innovations. On other hand, elderly people believe in their cultural practices and are not easily convinced by new innovations. Moreover, most people who practice agriculture as a means of livelihood are often the old and uneducated, this delays their capacity to accept advanced technologies (Oni *et al, 2*010). Contrary, Hoffern (2003) argued that old people are better experienced than the youth. The respective ages of the respondents in relation to technology adoption is displayed in Table 4.1.

Table 4.1 revealed tha age groups with the highest ratings in terms of adopting biogas rated 46.2% of the sampled participants, coming from age group 20 to 40 years. The findings contrast with the relavite low ratings of 15.4% in the age group

61 to 81. The results contra with Hoffern (2003) findings, which that indicated that older people are likely to adopt to new techonology innovations.The adoption of biogas technology in Melani village seems to be hindered by unexposure to technology advancement. Traditionally, household do not share cow dung.Older people beliefs might limit their interest in biogas production.

4.2.3 Distribution of household by marital status

Marital status is a person's state of being single, married, separated, divorced, or widowed. Pote (2008) stated that single person cannot behave as a married person in terms of the commitments and household responsibilities.This was analysed and the findings presented in table 4.1.

The results indicated that majority of biogas users are single and rated at 53.8%, followed by married 30.8%. Widowed respondents counts for 15.4%.This meas that single respondents do not have responsibility as a married people,they have time to invest in biogas projects. They do not have commitments, they took decisions on their own.Importantly, the results are in line with descriptive analysis in table 4.1 that indicated that majority of biogas users were female. On that note, AAI (2011), stipulated that women's livelihood strategies targets on meeting basic needs for their children and their vulneribility of women is often matched by the vulneribility of their children because they share respondibility in the their household.

4.2.4 Distribution of household by education level

According to Weldegiorges (2014), the level of education is very important regarding technology adoption level. Different studies have shown that the level of education is strongly associated with the diffusion of technology. The level of formal education is described as the vital determinant of increased agricultural production. In addition, education is said to allow household in making better decisions on the use of new farming techniques and technologies (AAI, 2011). Results demonstrated that basic education has a strong effect on biogas technology adoption. Table 4.1 is said to display information on the education level of respondents.

Moreover,Table 4.1 suggested that minority of the sampled participants 27.08% were engaged in the biogas production. A large subdivision of biogas users had secondary education 69.2%.Followed by those who had primary education (30.8%). On other side, those who are not engaged in biogas with no formal education rated 25.7% followed by 51.4% with primary education. Based on the results, it is clear that the lesser the person is educated, the lesser chances she/he might decide to adopt biogas technology . So , it can be concluded that the literacy rate is high in Melani village.This is evidently supported by only 27.08% of household that have adopted biogas technology in the study area.

4.2.5 Distribution of household by household size

Household size refers to all members of the family living in one house. The household size consists of children and adults. The household size determines the number of individuals engaged in agricultural practices, and how responsibilities are shared amongst them. Labour availability is an important factor in influencing the household decision to participate in household labour activities (Asayehegn *et al.,* 2011). A larger family size means that the required labour for agricultural production is well provided. The information on the household size is displayed in Table 4.1.

Results in Table 4.1 suggested that biogas users and non-biogas users with the highest ratings in terms of small household size (1 to 5 members) counted for 53.8% and 57% respectively. These results are statistically insignificant signifying that household size is not a vital factor influencing household decision to be engaged in biogas production. These findings are consistence with Wamunyu (2014), which noted that household size variable is not important variable that influences biogas adoption. This was based on results from both adopters and non-adopters of biogas had least household size.

4.2.6 Distribution of households by employment status

The employment status of respondents is related to the time spent on biogas production activities, and therefore, it can be concluded that if a person is gainfully employed, he/she can spend less time in biogas production activities, and can only utilize the weekends and holidays. Note was taken regarding the retired old respondent who are no longer fit to perform biogas production activities. Table 4.1 presents this information with a special reference to the employment status of the respondents.

Employment status is one of the important factors in determining the rate of adoption of any kind of technology. The employment status presented in Table 4.1 is categorised into four different groups, i.e. Unemployed, formally employed, self-employed and part-time farmer, measured as dummy variables, that is, as an adopter or non-adopter. Amongst the biogas users, unemployed respondents were about 61.5%, formally employed respondents 7.7%, self-employed 23.1% and part-time farmers were about 7.7%. Considering the demands of biogas production such as gathering of waste, these results are reasonable enough. For an individual to enjoy the full benefits of biogas technology he/she must be hands-on, especially when it comes to gathering of organic waste. So, unemployed individuals are best-fit for the biogas production technology. To them, biogas adoption also encourages self-employment, hence some of the biogas users are self-employment.

On the other side, when considering the individuals that have not adopted the biogas production, unemployed respondents were about 82.9%, formally employed respondents 5.7%, self-employed 11.4% and part-time farmers being 0%. These results are inconclusive because of various factors such as high employment status in rural areas of the Eastern Cape Province, being risk averse, and being without farm animals.

4.2.7 Distribution of household by source of income

In many rural communities, majority of people depend on social grants as a source of income. In South African context where in most circumstances employment opportunities are minimal, the major sources of income of households are government grants and food aid. Government grant include child support, disability and old age pension grants. The study aimed to determine whether household income levels have influence in biogas production information regarding source of income is presented in Table 4.1.

The study indicated that 61.5% household rely on social grants followed by 23.1% participants who generate their income from salaried employment. Furthermore, the findings indicated that from sampled participants majority of households are not engaged in biogas production and dependent on social grant as their main source of income. In rural context, the unemployment rate is high and most communities depend on social grant, results showed that 61.5% of biogas users rely on social grant. Based on the results, it is evident that there is a relationship between source of income and biogas adoption.

4.2.8 Distribution households by biogas adoption in relation to monthly income

The initial construction of biogas digester is expensive, therefore if a household is adopting biogas technology it needs to afford the costs of material and labour required. According to Momanyi *et al.* (2016), biogas adoption is probably rated high in households with high income. On other hand, while the level of income is indicative of household socio economic status, it does not tell much about the potential of households to adopt biogas technology. It was therefore decided to make comparison analysis on biogas adoption in terms of monthly income. The results are presented in Table 4.2.

Table 4. 2: Distribution of monthly income by biogas production adoption

Income category	**Adopters**		**Non-adopters**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
0 - 1500	7	54	8	23
1501 - 3000	4	30.7	23	66
3001 - 4500	2	15.3	4	11
Total	**13**	**100.00**	**35**	**100.00**

Source: Based on SPSS processing of field data, 2017

Results in Table 4.2 suggest that majority of households earning below R1500.00 a month adopted biogas technology. Government intervention could be the reason for adoption. Government pay for initial construction costs, therefore those who do not afford to buy electricity chose to be engaged in the biogas projects. The reasons are that biogas is cheap and they do not need to pay for material since the biogas installation is done by government. The findings contradicts with findings by Templeton and Bond (2011), who postulated that households with high income are likely to adopt biogas technology. In this case biogas adoption by low income is relatively dependent on government support. With results shown, it is clear that biogas is relevant to low income earning households.

4.2.9: Distribution of biogas adoption in relation to principal crops

The study sought to examine the principal grown crops in relation to biogas adoption. According to Wargert (2009), digested end product in biogas production is a fertiliser with high nutrient content. This encourage increased yield. Therefore, it is believed that biogas adopters might be more engaged in crop production. The findings of the study point to range of principal crops grown by both adopters and non-adopters of biogas technology. According to the results the following crops were grown by sampled household. The results of comparison of principal grown crops are shown in Table 4.3.

1. Beetroot
2. Green pepper
3. Spinach
4. Cabbage
5. Onion
6. Tomato
7. Potato
8. Butternut
9. Maize
10. Bean

Table 4. 3: Distribution of households in relation to biogas adoption by principal crops

		BEETROOT	GREEN PEPPER	SPINACH	CABBAGE	ONION	TOMATO	POTATO	BUTTERNU	MAIZE	BEAN
Biogas user	Mean	9.62	.38	4.62	7.31	4.62	1.31	30.38	35.38	3.85	.77
	Std. Deviation	22.404	1.387	6.199	22.231	9.674	3.250	31.256	72.297	13.868	1.878
	Minimum	0	0	0	0	0	0	0	0	0	0
	Maximum	80	5	15	80	30	10	80	250	50	5
Non-biogas user	Mean	8.86	1.40	8.06	28.57	1.71	1.71	6.43	5.49	8.43	.00
	Std. Deviation	15.758	4.110	13.271	84.223	4.012	7.065	15.028	15.868	21.719	.000
	Minimum	0	0	0	0	0	0	0	0	0	0
	Maximum	60	20	50	470	15	40	50	65	100	0

Source: Based on SPSS processing of field data, 2017

Table 4.3 revealed that the most grown crops by biogas adopters are butternut and potatoes with an average of 35.38 and 30.38, respectively. Households who have adopted biogas technology have higher yields of potatoes and butternut compared to those who have not adopted biogas technology. This implies that butter and potatoes require fertile fertilizer hence it rare to find famers growing butternut and potatoes in rural communities. The results are in line with Gitonga (2014) bio slurry is economical feasible, this means it contributes to increased yield.

The research sought to examine the extent to which household's perceive biogas technology projects and its influence on their decision making related to biogas adoption. The respondents were therefore asked to respond to a range of general statements that were geared to measure their perceptions towards adoption of biogas technology. The responses were based on three point Likert scale that was rated as follows: disagree with score of 0, neutral with a score 1 and agree with score of 2.The items were presented to both adopter and non-adopter whose responses were analysed and presented in Table 4.4

Table 4. 4: Distribution of households in relation to biogas adoption by state of biogas energy

State of Biogas projects	Category	Biogas User		Non-Biogas User		Total	
		Freq.	**Percentage (%)**	**Freq.**	**Percentage (%)**	**Freq.**	**Total**
Biogas energy is sustainable	Disagree	0	0	1	2.9	1	2.08
	Neutral	7	53.9	18	51.5	25	52.08
	Agree	6	46.2	16	45.7	22	45.8
	Total	**13**	**100.00**	**35**	**100.00**	**48**	**100.00**
Biogas projects are profitable	Disagree	7	53.8	16	45.7	23	47.9
	Neutral	0	0	14	40	20	41.7
	Agree	6	46.2	5	14.3	5	10.4
	Total	**13**	**100.00**	**35**	**100**	**48**	**100.00**
Biogas sites are all functioning	Disagree	3	23.1	17	48.6	20	41.7
	Neutral	2	15.4	2	5.7	4	8.3
	Agree	8	61.5	16	45.7	24	50
	Total	**13**	**100.00**	**35**	**100**	**48**	**100.00**

Source: Based on SPSS processing of field data, 2017

The results in relation to biogas sustainability indicated that 52.08% of both adopters and non-adopters scored neutral on the perception scale, while 45.8% agreed. Those who did not agree that biogas contributes directly to increase in crop yield constituted 2.08%. Likewise, the scale shown that out of those respondents that agree that biogas contributes directly to crop production 46.2% had adopted the biogas technology, while 45.7 had not. This indicated that the adopters were well informed about the technology.

Notably, the scale revealed that those who rated high neutral number were non-adopters of biogas technology. Therefore, it can be concluded that one can have positive or negative perception towards innovation programme based on knowledge and experience they have. Additionally, neutrality and the low rate adoption of biogas technology can be caused by lack of information. On that note, results suggested that 53% of biogas users disagree that biogas projects are profitable. It is important to note that the main cause is triggered by faulty digesters. This is evidenced by 23% of biogas users who indicated that they disagree that biogas digesters in all sites are functioning. The results are rationale with finding of Momanyi *et al.* (2016) which stipulated that lack of technical services are major constraints which seems to hinder profitability and sustainability of biogas project.

The research sought to examine the extent to which households perceive the state of biogas in the study and its influence on their decision making related to biogas adoption. The respondents were therefore asked to respond to a range of general statements that were geared to measure their views towards adoption of biogas technology. The responses were based on three point Likert scale that was rated as follows: disagree with score of 0, neutral with a score 1 and agree with score of 2.The items were presented to both adopter and non-adopter whose responses were analysed and presented in Table 4.5

Table 4. 5: Analysis of contribution of biogas to rural income based on difference on household adoption

State of renewable energy	Category	Biogas User		Non-Biogas User		Total	
		Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
Biogas contributes directly to increase crop yield	Disagree	1	7.7	9	25.7	1	22.2
	Neutral	0	0	10	28.6	14	20.8
	Agree	12	92.3	16	45.7	33	58
	Total	**13**	**100.00**	**35**	**100.00**	**48**	**100.00**
Biogas saves time that can be redirected into other income generating activities	Disagree	2	15.4	6	17.2	8	16.7
	Neutral	5	38.5	13	37.1	18	37.5
	Agree	6	46.8	16	45.7	22	45.8
	Total	**13**	**100.00**	**35**	**100.00**	**48**	**100**

Source: Based on SPSS processing of field data, 2017

The analysis of data showed that 58% of both biogas users and non-biogas users agreed that biogas contributes directly into increased yield, followed by 22.2% of those who disagreed while 20.8 were neutral. A larger number segment of those who practise biogas production 92.3% agreed that the fertiliser was effective to them. The reason could be that slurry is highly fertile fertilizer, and the household might have seen difference on their farm produce, since they have experience on growing crops with cow dung and using the biogas end product. The fertilizer is believed to be better than a cow dung which is normally used in rural areas. These results are rationale with literature, Abbasi *et al.* (2012) stated that slurry is a fertile fertiliser that can used improve increase crop yield.

4.2.11 Distribution of households in relation to biogas adoption by water scarcity

Water is one of required resources in biogas production. However, Pegels (2010) argued that natural barriers including water hinder the adoption of biogas. Importantly, Musemwa *et al.* (2013) noted that climate extremes in Eastern Cape mostly affect rural communities. An analysis of extent to which water scarcity influences adoption was done. This was established through cross tabulating the responses given by sampled households. The results are shown in Table 4.6.

Table 4. 6: The effect of water scarcity on biogas adoption

	Biogas user		Non biogas users	
Response	**Frequency**	**Percentage**	**Frequency**	**Percentage**
No	6	46.2	6	22.9
Yes	7	53.8	29	77.1
Total	**13**	**100.00**	**35**	**100.00**

Source: Based on SPSS processing of field data, 2017

Table 4.6 revealed that unavailability of water was the most vital factor in biogas adoption as majority of respondents of both users (53.8%) and non-biogas users (46.2%) agreed that unavailability of water was the major constraint. The study findings are similar to those of Mamponye and Mpandeni (2012) who noted that Eastern Cape weather is likely to experience droughts and floods, with high temperature and low rainfall. This implies that water scarcity seems to hinder biogas adoption in Melani Village.

4.2.12 Distribution of biogas adoption in relation to lack of awareness

Informing rural communities about biogas and its positive effect is vital. In that case people will be knowledgeable about the technology might trigger their decision making. The results are shown in Table 4.7

Table 4. 7: Lack of awareness of biogas technology

	Biogas user		Non biogas users	
Response	**Frequency**	**Percentage**	**Frequency**	**Percentage**
No	6	46.2	15	42.9
Yes	7	53.8	20	57.1
Total	**13**	**100.00**	**35**	**100.00**

Source: Based on SPSS processing of field data, 2017

Table 4.7 indicated that lack of awareness of biogas technology was the important factor in biogas adoption as most respondents both users (53.8%) and non-biogas users (46.2%) agreed that lack of awareness was the major constraint that influence the adoption of biogas technology in the study area.

4.2.13 Distribution of biogas adoption in relation to lack of knowledge about operation of biogas digesters

From view of progressive communal innovation programme, knowledge counts as one of most vital variable in the analysis. In that regard, Wargert (2009) emphasized that biogas project are sustainable if people are well knowledgeable about the technology. Interestingly, if this is maintained no technical errors will be incurred. The situation with respect to knowledge and influence on adoption were examined. It is vital to spread the knowledge locally about biogas technology to ensure the sustainability in construction and maintenance of biogas digesters (Wargert, 2009), the results are presented in Table 4.8.

Table 4. 8: Lack of knowledge about operation of biogas digesters

	Biogas user		Non biogas users	
Response	**Frequency**	**Percentage**	**Percentage**	**Frequency**
No	6	46.2	17	48.6
Yes	7	53.8	18	51.4
Total	**13**	**100.00**	**35**	**100.00**

Source: Based on SPSS processing of field data, 2017

According to Table 4.8 majority of respondents both biogas users and non-biogas users agreed that lack of knowledge about operation of biogas digesters influence the adoption of biogas by 53.8% and 51%, respectively. The reason could be that biogas users did not get proper training. These results are rationale with Momanyi *et al.* (2014) who indicated that lack of knowledge in relation to technical services are the major constraint in biogas adoption.

4.2.14 Cattle ownership in relation to biogas adoption

The primary resource used in biogas production is cow dung. Cattle or poultry owned by household are likely to be determinants of biogas adoption. Traditionally, households with livestock have the major substrate (cow dung), this is indicative that these households are more likely to be engaged in biogas technology. In spite of pros of owning cattle in relation to biogas production, owning cattle does not influence biogas adoption (Momanyi *et al.,* 2016). In that regard, it is not clear if whether the household might be engaged on not in biogas production. It was therefore decided to ask the respondents if whether or not cattle ownership hinder their participation in biogas production. The results are presented in Table 4.9.

Table 4. 9: Impact of cattle ownership on biogas adoption

	Biogas user		**Non biogas users**	
Response	**Frequency**	**Percentage**	**Frequency**	**Percentage**
No	6	46.2	12	65.7
Yes	7	53.8	13	34.3
Total	**13**	**100.00**	**35**	**100.00**

Source: Based on SPSS processing of field data, 2017

According to Table 4.9, 46.2% of biogas users did not agree that cattle ownership negatively affects biogas adoption while 53.8% agreed that the cattle ownership affects the biogas technology. In non-adoption view, majority non-adopters of biogas did not agree that cattle ownership influence the biogas adoption but majority of them are not engaged in biogas technology. Therefore, it can be concluded that even though cattle ownership was one of predicting factors for adoption of the technology, a number of other factors might be influential.

4.2.15 Lack of maintenance and repairing

The study sought to determine whether or not lack of maintenance and repairing of biogas technology influence the adoption of biogas. Bond and Templeton (2011) argued that in less developed nations like South Africa, maintenance and repair of biogas digesters hinder biogas technology and its progressive impact on rural households. For this reason, many biogas digesters are not functioning. The results of grouping of the households into biogas adoption in relation to the perception that lack of knowledge about operation of biogas digesters affect the adoption of biogas technology results are shown in Table 4.10.

Table 4. 10: Lack of maintenance and repairing

	Biogas user		**Non biogas users**	
Response	**Frequency**	**Percentage**	**Frequency**	**Percentage**
No	7	46.2	13	37.1
Yes	6	53.8	22	62.9
Total	**13**	**100.00**	**35**	**100**

Source: Based on SPSS processing of field data, 2017

Another crucial perception in relation to biogas adoption is the availability of biogas technology skilled workers in community where they practice biogas production. Theoretically, workers with high quality skills will be more productive and deliver services effectively. For this reason, programmes initiated will be sustainable; therefore non-adopter will perceive the significance of the programme and choose to be engaged. However, lack of background on biogas technology and unavailability skilled workers seems to be the major constraint, resulting in unfixed technical errors on digesters and material used. According to OECD (2010), skilled development is vital in a work place. It contributes to people's capacity to deliver effectively. Likewise, OECD (2010) further stated that good quality skills increases productivity for both workers and enterprises. The findings in respect of the availability of skilled workers are presented in Table 4.

4.2.16 Flooded biogas digesters during rainy season

The analysis of extent to which flooded biogas digesters influences biogas technology was done. This was established through cross tabulating the responses given by the respondents. According to Wargert (2009), underground biogas digesters are likely to get flooded during rainy season. From the findings 54% of biogas users have fixed dome plant. This implies that these users are likely to experience flooded digesters constraint during rainy season. In that regard, it is clear that those who use fixed dome are better off informed about cons of fixed dome plants compare to others and non-adopters. This is further explained in Table 4.10.

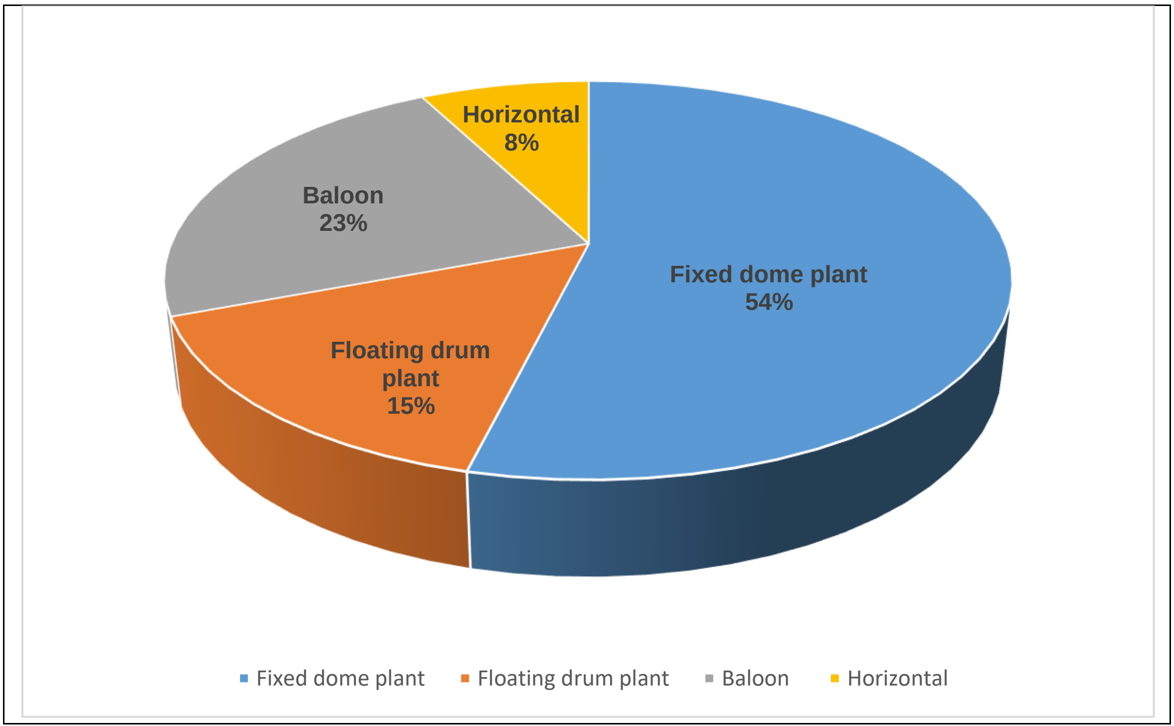

Figure 4. 1: Types of biogas digesters used in the study area

Source: Based on SPSS processing of field data, 2017

Fixed dome plants are not reliable. In a case where by a biogas digester is flooded, the process of generating gas will not take place. Consequently, uptake of biogas technology might be delayed. Under these circumstances people might not invest in source of energy that require additional costs in rainy season. The results are presented in Table 4.11

Table 4. 11: Flooded biogas digesters during rainy season

	Biogas user		Non biogas users	
Response	**Frequency**	**Percentage**	**Frequency**	**Percentage**
No	1	7.7	28	80.00
Yes	12	92.3	7	20.00
Total	**13**	**100.00**	**35**	**100.00**

Source: Based on SPSS processing of field data, 2017

On one hand, results indicated that 92.3% of biogas adopters agreed that flooded biogas digesters during rainy reason. On other hand 80 percent of non-adopter did not agree that non-adoption is led by flooded digester during rainy season. Controversy in relation to the matter is mainly due to two reasons. Firstly, adopters are knowledgeable about the cons of the technology. So they suggest that the technology is not effective in rainy season, therefore limited responds to this technology might be triggered by this technical service. Secondly, non-adopters are not well informed about the technology, so they are not aware of this technical error. This implies that flooded digesters are an important variable that delays production of biogas production. However, in this case it is not relevant to non-biogas adopters, as they indicated that it is not a major constraint that influences the uptake of biogas technology.

4.3 Contribution of biogas consumption toward rural income

The study sought to determine the contribution of biogas consumption toward rural income, bivariate analysis was used in testing simple hypotheses of association. Therefore, examining relationships among key variables was established. Firstly, the test was done between perceptions held and production of principal crops. Secondly, the test was done between perceptions held and adoption or non-adoption. Lastly, the test was done between perceptions held and socio-economic/demographic characteristics.

In addition, Statistics help for students (2008) stated that if the significant value is less than .05, you can conclude that there is a statistically significant correlation between your two variables. That means, increases or decreases in one variable do significantly relate to increases or decreases in your second variable (Statistics help for students, 2008). The results are analysed and compared in Table 4.11.

4.3.1 The correlation between perceptions held and the principal crops

The study sought to determine whether or not biogas adoption is related to the particular principal crops grown. The respondents were asked to indicate whether or not the slurry contributes to their yield as well as if creates job opportunities. The results are presented in Table 4.12.

Table 4. 12: Correlation matrix on principal crops and perceptions

			ENDFERT	BIOPJOB	BIOPDIN	GRYYLD	ONIOYLD	POTYLD
(Spearman)		Sig. (2-tailed)	.	.040	.000	.024	.480	.481
	BIOPJOB	Correlation Coefficient	.297*	1.000	.597**	.313*	-.049	-.106
		Sig. (2-tailed)	.040	.	.000	.030	.742	.472
	BIOPDIN	Correlation Coefficient	.501**	.597**	1.000	.118	-.012	-.252
		Sig. (2-tailed)	.000	.000	.	.424	.937	.084
	GRYLD	Correlation Coefficient	.326*	.313*	.118	1.000	-.180	-.078
		Sig. (2-tailed)	.024	.030	.424	.	.221	.596
	ONION YLD	Correlation Coefficient	-.105	-.049	-.012	-.180	1.000	.333*
		Sig. (2-tailed)	.480	.742	.937	.221	.	.021
	POTATO YLD	Correlation Coefficient	-.104	-.106	-.252	-.078	.333*	1.000
		Sig. (2-tailed)	.481	.472	.084	.596	.021	.

***. Correlation is significant at the 0.05 level (2-tailed).**
****. Correlation is significant at the 0.01 level (2-tailed).**

Listwise N = 48

LEGEND:
ENDFERT=Biogas end product is used as fertilizer
BIOPJOB = Biogas production creates job opportunities
BIOPDIN = Biogas production contributes to disposal income
GRYLD = Green pepper yield
ONIOYLD = Onion yield
POTYLD = Potato yield

Source: Based on SPSS processing of field data, 2017

Table 4.12 revealed that the relationship between green pepper production and adoption of biogas is significant. The relationship is significant at p= 0.24 in relation to slurry use According to the results, the use of end product (fertilizer) increases the crop yield by 32.6%. Majority of the respondent agreed that the end product of biogas is a fertile fertilizer. This means the adopters have seen the differences before and after the use of slurry. In addition, the green paper farming increases job opportunities by 31.3%. The relationship between green pepper crop and the creation of jobs was significant at p= 0.30.The reason could be that very few farmers grew green peppers in the rural area due to its high production costs. So, these farmers have no competition in the local market, hence creation of jobs.

4.3.2 The correlation between perceptions held and demographics

The study sought to examine the extent to which Age, Education and livestock ownership are linearly associated with the uptake of biogas technology. Characteristics were tested using Spearman’s. Variables were selected based on previous studies (Momanyi et al., 2016).The results on relationship between perceptions held and socio-economic characteristics are presented in Table 4.13.

Table 4. 13: Correlation matrix exploring demographics and adoption

			AGE	EDUC[i]	VOWN[ii]	DUB[iii]
Spearman's rho	AGE	Correlation Coefficient	1.000	-.632**	-.007	.305*
		Sig. (2-tailed)	.	.000	.964	-.035
		N	48	48	48	48
	EDUC	Correlation Coefficient	-.632**	1.000	-.175	-.452**
		Sig. (2-tailed)	.000	.	.234	.001
		N	48	48	48	48
	VOWN	Correlation Coefficient	-.007	-.175	1.000	.410**
		Sig. (2-tailed)	.964	.234	.	.004
		N	48	48	48	48
	DUB	Correlation Coefficient	.305*	-.452**	.410**	1.000
		Sig. (2-tailed)	.035	.001	.004	.
		N	48	48	48	48

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

LEGEND:

EDUC = Education
VOWN = Livestock ownership
DUB = Do you use biogas

Source: Field, 2017

Contrary to expectations, Age is statistically significant (p= 0.0035) however it seems to be associated with the biogas adoption negatively, this translate to a 30.5% decrease in the adoption of biogas, for every year a person gets older. This probably means that the more they become less active in community project and focus on their health issues the less they get involved in biogas production and use.

The level of education is statistically significant (p=0.01) and has a negative relationship with adoption of biogas. This translates to a 45.2% decrease in biogas adoption. More uneducated households are not aware of the emerging technologies and will tend not to engage with them as they are less knowledgeable about them. Also, they are not aware of their advantages. Therefore, they will not make informed decisions in relation to biogas adoption. Livestock ownership is one of the important variables in the study and is shown to have statistically significant (p= 0.004) relationship with biogas production. This implies that the higher the number of livestock an household owns, the more likely the chances of adopting biogas, The reason could be that one has enough animal waste which is primary requirement for biogas production .This is supported by Momanyi *et al.* (2014) who had similar view stating that the adoption of biogas is subject to availability of cow dung, the more the household increases the number of cattle owned the more cow dung is available. For every livestock increased in a household, the chances of biogas adoption increases by 41%.

4.3.3 The correlation between perceptions held and adoption

The study sought to determine whether or not biogas adoption is related to certain perceptions held and which could possibly influence biogas adoption. The respondents were asked to indicate whether or not the type of biogas digester adoption is an important consideration for them, as well as if informant influences their adoption. They were also asked to indicate whether or not the biogas saves time for them. The results concerning the discussed issues are presented in Table 4.14.

Table 4. 14: Correlation matrix exploring perceptions held and adoption

			TYPBIOD[iv]	KNBIO[v]	BIOHAH[vi]	WATSC[vii]	BIOSAVT[viii]	DUB[ix]
Spearman's rho	TYPBIOD	Correlation Coefficient	1.000	.388**	-.330*	.259	-.329*	.986**
		Sig. (2-tailed)	.	.006	.022	.076	.022	.000
		N	48	48	48	48	48	48
	KNBIO	Correlation Coefficient	.388**	1.000	-.221	-.094	-.095	.334*
		Sig. (2-tailed)	.006	.	.131	.526	.521	.021
		N	48	48	48	48	48	48
		Sig. (2-tailed)	.076	.526	.208	.	.015	.031
		N	48	48	48	48	48	48
	BIOSAVT	Correlation Coefficient	.329*	.095	.121	349*	1.000	.325*
		Sig. (2-tailed)	.022	.521	.411	.015	.	.024
		N	48	48	48	48	48	48
	DUB	Correlation Coefficient	.986**	.334*	-.364*	.311*	-.325*	1.000
		Sig. (2-tailed)	.000	.021	.011	.031	.024	.
		N	48	48	48	48	48	48

****. Correlation is significant at the 0.01 level (2-tailed).**
***. Correlation is significant at the 0.05 level (2-tailed).**
LEGEND:
TYPBIOD = Type of biogas digester
KNBIO = Knowledge about biogas
BIOHAH = Biogas is hazardous to health
WATSC = Water Scarcity in the study area
BIOSAVT = Biogas saves time
DUB = Do you use biogas

Source: Field survey, 2017

According to the results, there is a significant positive correlation between biogas adoption and a type of biogas digester (*p*=0.00). The type of the biogas digester is related to the adoption of biogas digester. The more the digester can function will less complicated technical services, the more household will be engaged in the biogas technology. People prefer durable resources with less technical services costs. Rural communities cannot afford to service or build new digester frequently due to financial constraints. These results are consistent with Bond and Templeton (2011) whose findings stipulated that technical services required by biogas digesters are expensive. This means the more the advanced type of biogas digester the more adoption of biogas adoption.

As expected, the presence of a knowledgeable key informant is associated with biogas adoption positively. The knowledgeable informant, increases biogas adoption by 33.4%. There is a significant correlation between biogas adoption informants (p=0.021). It is believed that a knowledgeable facilitator will convey information about biogas technology to communities effectively.

The correlation between the perception that biogas saves time and biogas adoption is significant (*p*=0.024). The more time saved during biogas production the more time is saved. The time saved might be used to other income generating activities. This means households can use the saved time in agricultural activities. In traditional view, collecting wood is a women's wok and minors, in this case the time save can be used to attend school.

4.4. Factors influencing perceptions held

This section presents the results obtained from the logistic regression model and these results are based on factors influencing biogas adoption. Number of factors influencing the biogas adopter were tested using the Binary regression Logistic Model. Measures of the significance were at 1% and 5%. Variables were selected based on previous studies. Factors influencing biogas adoption included age, source of income, land size and education. The results are presented in Table 4.15

Table 4. 15: Factors influencing perceptions held

	β	S.E	Sig
Constant	-5.139	3.291	.118
Age	-0.082	0.042	0.052**
Source of income	-0.837	0.356	0.019***
Land size	1.301	0.617	0.35**
Education	-0.315	0.537	0.001***
Likehood	45.577		
Pseudo R2	0.325		
R^2	0.440		
N = 48			

***** and ** represent significance levels at 1% and 5%**
Source: Field survey, 2017

The variables which include age, source of income, and education were identified as significant from the study results. On one hand, age and land size variables were significant at 5% on other hand source of income and education variables were significant at 1%.

Age: The variable was statically significant at 5% level, in reference with results presented in descriptive statistics. The coefficient was negative and was agreement with a priori expectations. The negative coefficient indicates that biogas adoption decreases as the age increases. This reason for such is that older people are pensioners and they do not have time to spend on community projects, they are only focusing on their health, however young household heads are active and willing to work. These results are in line with descriptive statistics results. The results revealed that majority of households were unemployed.

Source of income: The variable was statistically significant at 1 percent level. The empirical results from binary model indicate that source of income has an influence in biogas adoption. As shown in descriptive statistics majority of households in Melani village depends on social grants, this indicates that they are not able to stand with the ever increasing energy prices (Phogole, 2011). So, biogas is cheaper and affordable hence most of them will choose to save and opt for biogas adoption. Moreover, the time that they spend to fetch wood will be redirected to other income generating activities (Tah and Azibo, 2015). Lastly the money that they spend on electricity will be reduce therefore they can use it to other household needs.

Education: The variable was strongly statistically significant at 1 percent level. However the coefficient was negative it is clear that younger people are more knowledgeable about biogas technology than the elderly people. The main reason for variation in adoption is led by literacy amongst age groups. Number of older non-biogas adopters without formal education is much higher compared to younger non-biogas adopters.

4.5 Chapter Summary

Descriptive analysis revealed that number of factors has influence on the perceptions of households towards biogas adoption. Low levels of education and knowledge on operation of biogas digesters seemed to hinder the adoption of the biogas technology in the study area.

The perceptions towards biogas production in Melani was analysed with the use binary regression analysis. The results revealed that biogas adoption is influenced by age, education, source of income and land size. Moreover, results showed that the older the people are less active in biogas project in Melani village. This could be triggered low levels of education and average household income as the findings have shown. The empirical results of this research suggest that biogas adoption has a significant effect on households' income. However, the results showed that there is a lack knowledge about the biogas technology.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

5.1 Introduction

This chapter gives a brief summary of the results drawn on perceptions of rural households, on the role and effect of biogas production towards rural household income in Raymond Mhlaba Local Municipality. Aims of the study stated in the introductory chapter are outlined so as to bring the conclusion which shall be followed by the recommendations on the basis of the empirical results. The chapter discusses the extent to which the objectives and hypothesis discussed in chapter one of the study have been addressed by the analysis.

5.2 Summary

This chapter covers the chapters that were dealt with in the study, which include background of the study, literature review, methodology and results of the study. The chapter starts with a summary of background and the problem statement. In addition it also consist of summarized methodology, sampling procedure, data collection methods and instruments, variable of specification and method of data analysis. The summary of presentation of the results includes the socio economic characteristics and demographics of the respondents in the study area, the estimation of the model that was used in factors that influence the adoption of biogas technology.

5.3 Background and problem statement

Continued dependence on fossil fuel as the primary source of energy has contributed to energy shortage in South Africa (OECD, 2015). Therefore, electricity generation has not kept pace with the increase of energy demand. For this reason electricity prices are increasing gradually, and this mostly affects rural communities (Stafford, 2013).

Rural communities rely on social grants and cannot afford to buy required electricity. To overcome the problem, Tar and Azibo (2015) revealed that rural households have an advantage of producing energy cheaper as well as producing organic fertilizer. Consequently, this technology will increase the crop yield and decreases energy expenses.

The literature discovered further of advantages of biogas technology. However, there is little discussion on how biogas production contributes to household income. The extent to which household perceive the biogas production is not clear. Therefore, this dissertation will elaborate more on the household perceptions towards biogas adoption. Moreover, the dissertation will discuss the possible responses by policy makers to biogas adoption.

5.4 Literature review

The review of literature is presented in chapter two of the dissertation in relation to the specific objectives of the study. Advantages and barrier that hinder the uptake of biogas technology were discussed. There is a continued lack of knowledge in relation to biogas energy regardless of its existence since 1950s.Biogas technology is adopted at a very slow rate. To begin with, it has been noted that biogas technology saves time that women spent in fetching fire wood for better use in other income generation activities. Remarkably, the slurry which is used as organic fertilizer saves household funds allocated for fertilizer; the funds might be used for other developments in the household and also increases productivity. Therefore, biogas technology is a vital tool in increasing household income. With all of biogas worth, it is interesting that majority of rural households are not engaged in the initiative despite government support.

5.5 Methodology

This section reviewed the methods and techniques that were followed during data collection. The structured questionnaires were used as a tool for data collection. This was followed by a survey with Fort Hare Institute of Technology officials to familiarize with the study area. Availability sampling was used to get the sample size for the survey. A sample of 48 respondents were drawn with the help of biogas researcher in Fort Hare Institute of technology. From the sampled respondents, 13 respondents were biogas users and 35 were non-biogas users. Descriptive statistics was used to describe demographics of the rural household in Melani village. Furthermore it also consists of correlation analysis that was used to examine the relationship amongst key variable, while binary logistic regression model was used to identify the perceptions of rural households towards biogas production.

5.6 Results of descriptive statistics analysis

The results of the first objective revealed that non-biogas user have primary education at most and some have no formal education at all. Household size was found not relevant to the adoption of biogas. The study further, discovered that unemployment rate is high in the community and most of villagers depend on social grants. In this case, most of biogas adopters chose biogas so that they can save funds allocated for electricity and use them to other household's needs.

In respect to biogas sustainability, majority of non-adopter were neutral, this could be indicating lack of information about the technology. The study further established that majority of non-adopters have primary education with some having no formal education and that might have impact on their decision making. Similarly, on profitability of the technology non-adopters did not agree that biogas projects are profitable while majority of users agreed. The reason for this could be that some of biogas sites are not functioning. There is a lack of technical services as some biogas adopters have indicated. This might discourage others who may have interest in the initiative.

Two main statements were asked to the respondents. Firstly, they were asked if whether or not biogas contributes directly to increase crop yield. Secondly, they were asked if whether or not biogas saves time that can be redirected into other income generating activities. The result concerning the statements showed that both biogas and non-biogas users agreed that the technology contributes directly into the increased yield and it save time that can be redirected to other communal generating income projects.

Lastly, the cross tabulation analysis suggests that water scarcity, lack of knowledge about biogas technology, cattle ownership, lack of maintenance and repairing, flooded biogas digesters during rainy season negatively influence the uptake of biotechnology.

5.7 Relationships between biogas adoption and key variables

A number of variables were used to examine relationships between perceptions held and adoption or non-adoption, relationship between perceptions held and demographic characteristic and relationships between perceptions held and production of principal crops. The results showed that there were vital correlation relationships, which were significant. Firstly, it was found the there is a positive correlation between green pepper and the slurry. Households agreed that the end product is fertile manure. This is evidence by they participation in green pepper vegetable which is rare to be grown in rural areas. Secondly, there was a positive correlation between green pepper farming and job opportunities created. This was an indicative that during the ploughing and selling season of the crop people get jobs.

5.8 Factors influencing biogas adoption

In relation to objective five, various variables were used to identifying factors affecting the adoption of biogas production in the study area. Age, education, source of income, land size and household size emerged significant variables. The findings show that the younger households participate more than the older household in biogas projects. The results indicated that the level of education increases the chances of the household to adopt biogas technology. This implies that the more educated the household the more is exposed to technological advances.

The household income which is found significant increases the chance of household to participation in biogas production, meaning that households mostly depend on social grants, hence their involvement in the technology increases their access to energy. Owning bigger land is an important factor influencing the adoption of biogas, one unit increase in land increases the chances of adoption. Household size was found not relevant to the study.

5.9 Conclusions

Taking into consideration that biogas technology has many advantages to improve rural livelihoods of Melani village. Yet, its adoption has not increased since the anticipation of the project. This study tried to explore household's perceptions towards role and effect of biogas production.

In addition, majority of households have primary education and some of them had no formal education. This contributes to lower levels of biogas adoption. This is evidently supported by the high rate of unemployment and dependency on social grants. This resulted in a negative impact on the judgement decision making in relation to biogas technology. This is supported by the information of survey that respondents are not knowledgeable about the technology. Therefore, this implies that the study area is not aware of the biogas technology and its benefits.

5.10 Policy implications and recommendations

In response to the negative perceptions towards biogas adoption in Melani village. It is vital to support a framework allowing non-biogas users to evaluate biogas expenses in contrast to electricity, due to misperception regarding sustainability of the technology.

Slurry should the promoted mostly to smallholder farmers, since its effects are supported by literature and user experience. It is correct that government acts to intervene in the interest of the rural communities to promote biogas adoption. Notably, it is vital for communities to get extension services, supporting their own energy production. This discourages dependency on the electricity that requires economic access.

Household, especially in rural areas need to be thought of new technological advancement that can be of help to them. This ca be attained through awareness campaigns by government in collaboration with the private sector. Government should employ more facilitators to train the communities about technical errors of the technology.

5.11 Areas of further research

There are still cultural and socio economic effects that still need to be assessed among rural households. The study did not cover all aspects regarding biogas production in rural communities. There is a need to conduct a survey in energy security among households who have adopted biogas technology, and those who did not adopt the biogas technology.

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APPENDIX: QUESTIONNAIRE

University of Fort Hare
Together in Excellence

FACULTY OF SCIENCE AND AGRICULTURE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

QUESTIONNAIRE ON THE PERCEPTIONS OF RURAL HOUSEHOLDS ABOUT ROLE AND EFFECT OF BIOGAS PRODUCTION ON RURAL HOUSEHOLD INCOME IN RAYMOND MHLABA LOCAL MUNICIPALITY

Please be aware that the survey is completely non-discriminatory and the information that you are about to give merely helps in the interpretation of the results. There is no right or wrong answer to the questions. We just want to find out your honest opinion.

1. Date of interview	
2. Interviewer/enumerator	

Please mark X

Biogas user	
Non-biogas user	

No	**Socioeconomic Characteristics**	**Responses**	**Codes for Options**
1.1	Gender		**0** = Female, **1**= Male
1.2	Age(Years)		Write your age (or year of birth)
1.3	Marital Status		**0** = Married, **1** = Single **2** = Widowed/er; **3** = Divorced **4** = other(specify)
1.4	Family type, if married		**0** = Polygamous, **1** = Monogamous 2. Not married
1.5	Household size		Total no of people living and eating together in the household
1.6	Please indicate the number of people living in your household within each age group below	**Number A+B+C+D = 1.5**	
A	0-15 years		Write actual number (e.g. 2,3,4 etc.)
B	16-40 years		Write actual number (e.g. 2,3,4 etc.)
C	41 – 65years		Write actual number (e.g. 2,3,4 etc.)
D	Above 65 years		Write actual number (e.g. 2,3,4 etc.)
1.7	Highest Educational Qualification attained		**0** = No formal education;**1**=Primary education;**2**= Secondary education **3** = Tertiary education
1.8	Are you engaged in biogas production		**0**=Yes,**1**= No
1.9	What was your major reason to be involved in the biogas production		**0**= Domestic consumption,**1**=Demonstration purposes**,2**=Commercial purposes
1.10	What was the source of initial capital for constructing the biogas digester		0=Own savings,1=NGO support,2=Government support,3=Community resources
1.11	Pick the source of income you are engaged in options listed.		**0**= Agricultural activities;**1**=Salaried employment;**2**=Trading/Business;**3**=Social grants e.g. child support , foster care, old age; disability ;**5**=Remittances;6=Other(Specify)………………..
1.12	Which of the following best describes your household monthly income?		**0**= < R500;**1** = R500-R1000; **2** = R1001-R2,000;**3** = R2,001-R5,000; **4** = R5,001-R10,000; **5** = R10,001-R20,000; **6** = R20,001-R30,000 **7** = R30.001-R50,000; **8** = >50,000
1.13	Employment Status		**0**=Unemployed;**1**=Formally Employed;**2**=Self-employed;**3**=Part time farmer;**4**=Full time farmer

1.14	Do you have animals? Which and how many of each?	**0**=Cattle		**2**=sheep		**4**=Chickens	
		1=Goats		**3**=Pigs		**5**=Ducks and Geese	
		6=Horses		**7**=Donkey		**8**=Does not have livestock	

Section 2: Production, Land Ownership And Allocation To Different Crops

2.1	Indicate the land tenure system		**0**=Communal;**1**=Rent/Lease;**2**=Sharecropping;**3**=Inherited;**4**=Resettled
2.2	Which farming activities are you undertaking at the moment?		**0**=Crop production only;**1**=Livestock production only;**2**=Mixed farming
2.3	How much land do you own/ have access to?	………………………………………….**Ha**	
2.4	Which farming system do you use?	**0** = Dry land:……………Ha; **1** = Irrigation:…………...Ha;	

2.5	Indicate the production assets you have		**0**=Tractor ; **1**= Animal traction ; **2**= Hand tool/Implements**;3**=Storage facilities; **4**=Land; **5**= Other: Specify
2.6	Indicate household assets you have		**0**=Car;**1**=TV;**2**=Cellular phone;**3**=Radio; **4**=Other: Specify
2.7	Which crops did you grow this season, the yield quantities produced, consumed and sold?		

	Crop Grown	Area Planted (Ha)	Yield(Tonnes)	**Consumed (Tonnes)**	**Price (R/unit)**	**Quantity Sold**	**Income (R)**

Section 3: Farmer's Knowledge and Perceptions about biogas production

3.1	Do you know about biogas digesters?		**0** = No ; **1** = Yes
3.2	How did you come to know about this/ biogas digesters?		**0**=Extension Officer ;**1**=Biogas researcher ;**2**=Media ;**3**=Family; **4**=friends; **5**=Politician; **6**=Biogas project stuff; **7**=Farmer's groups; **8**=Other (specify)
3.3	How do you rate the information you were provided about biogas digesters?		**0** = Not adequate ; **1**= Adequate ; **2** = None
3.4	Do you think biogas digesters are beneficial or disadvantageous to you?		**0** = No ; **1** = Yes If **Yes**, explain…………………………………………………………
3.5	Do you think biogas projects are beneficial		**0**=No;1=Yes
3.6	The following statements measure perceptions of rural households on the role and effect of biogas production on rural livelihoods: *Using the scale in the table, please indicate with a tick in the appropriate box against each perception.*		

Type of Perception	**Perception on biogas production**	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
Environmental	Biogas could reduce deforestation					
	Biogas production causes unfavourable odour around the village					
	End product is used as fertilizer					
	Biogas production aids in waste management					
Economical	Biogas production project created job opportunities					
	Biogas contributes to disposal income					
Health	Biogas use is not hazardous to health					

Section 4: Factors affecting the adoption of biogas technology (*Please tick*)

Constraints	Yes	No
4.1 Water scarcity		
4.2 Lack of awareness of biogas energy technology		
4.3 Lack of knowledge about operation of biogas digesters		
4.5 Cattle ownership		
4.6 Lack of maintenance and repairing		
4.7 Availability of Skilled workers		
4.8 Flooded biogas digesters during rainy season		

Section 5: Contribution of biogas on rural income (*please tick*)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
5.1 Biogas contributes directly to increase crop yield					
5.2 Biogas production create job opportunities					
5.3 Biogas saves time that can be redirected into other income generating activities					

Section 6: State of renewable energy

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6.1 Biogas energy is sustainable					
6.2 Biogas energy adoption is profitable					
6.3 Biogas energy sites are all functioning					

[i] EDUC- Education
[ii] VOWN- Livestock ownership
[iii] DUB- Do you use biogas
[iv] TYPBIOD-Type of biogas digester
[v] KNBIO-Knowledge about biogas
[vi] BIOHAH- Biogas is hazardous to health
[vii] WATSC- Water scarcity in the study area
[viii] BIOSAVT-Biogas saves time
[ix] DUB- Do you use biogas