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DEPARTMENT OF NATURAL RESOURCES

KNOWLEDGE, ATTITUDES AND PRACTICES (KAP) TOWARD THE USE OF BIOGAS BY RURAL COMMUNITIES. A CASE OF MREHWA DISTRICT WARD 28

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE BACHELOR OF ENVIRONMENTAL SCIENCE HONOURS DEGREE IN NATURAL RESOURCES MANAGEMENT.

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I hereby declare that the research project entitled "Knowledge, Attitudes and Practices (KAP) toward the use of biogas by rural communities. A case of Murewa District ward 28" submitted to Bindura University of Science Education, Faculty of Agriculture and Environmental Science, This work, which I submitted in part fulfilment of the requirements for the award of a Bachelor of Science Degree in Natural Resource Management, is an original work I completed under the direction and supervision of................... and is documented in the Department of Environmental Science. This thesis' findings have not been submitted to a university or institute for the conferral of any degree or diploma.

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DEDICATION

In dedicating this research to my parents and family, I hope to honour their unwavering support and express my profound gratitude for the countless ways they have shaped my academic journey. Their love, sacrifices, and encouragement have been the driving force behind my accomplishments, and I am forever indebted to them. This research project is a testament to their belief in me and a reflection of the values they have instilled within me.

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ABSTRACT

This study aimed to assess the knowledge, attitude, and practices (KAP) of rural communities in Murehwa District regarding the use and generation of biogas. The research utilized a mixed methodology approach, combining qualitative and quantitative methods. A sample of 50 participants was selected, and data was collected through semi-structured questionnaires and interviews. Data analysis involved descriptive statistics, regression analysis, and correlations using SPSS. The results revealed that a significant percentage of villagers had prior knowledge of biogas, and a majority were currently using biogas in their homes. Moreover, most villagers expressed interest and satisfaction in using biogas, demonstrating positive attitudes and safe practices. However, the study found no association between practices and the usage of biogas, as well as between KAP and socio-economic factors. The conclusions highlighted that knowledge was positively associated with biogas usage, while attitudes did not necessarily translate into adoption. Furthermore, the study emphasized the importance of raising awareness and understanding about the benefits of biogas within the community. Recommendations included promoting knowledge-sharing, showcasing successful biogas projects, and developing inclusive policies and guidelines for improved sanitation management. Overall, this study emphasized the need to consider not only technological aspects but also the KAP factors for the successful adoption of biogas solutions in Murehwa and similar areas.

Key Words: Biogas Knowledge Attitude Practice Pearsons's Socio-economic

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Energy plays a critical role in our daily activities by delivering essential services. Some of these services, particularly domestic ones, are regarded as being of a basic nature, such as the energy used for lighting, heating, and cooking. Moreover, energy is essential for the operation of industrial operations like food production and the transportation industry. However, there are regional differences in the production and delivery of energy. Energy availability is not a problem in urban areas, but it is problematic for communities in rural areas (FAO, 2020). Convention-Framework of the United Nations on Climate Change (UNFCCC, 2017:18) observed that many areas in Africa have climates that are among the most variable in the world on both the seasonal and decadal time scales. Thus providing the gap this research seeks to fill in Zimbabwean context. The use of biomass has contributed immensely to climate change in Zimbabwe (UNDP, 2021). In addition, heavy reliance on biomass has been acerbated by energy crisis being currently faced by Zimbabwe (Daily news, 2022). Following the above mentioned gap in energy between rural and urban areas, approximately 2.5 billion people in developing countries' mainly depends on biomass for basic energy (UNDP, 2022). Such biomass includes coal and animal dung cakes since they are readily available. Therefore, the purpose of this study is to determine knowledge, attitude and practices towards the use of biogas by rural communities using the case Murewa. This chapter serves as the study's introduction and is structured as follows: an introduction; the context of the study; the problem statement; the research objectives; the research hypothesis; the reason for the investigation; the study's delimitation; the study's limitations; and a chapter summary.

1.2 Background to the study

According to recent estimates, 2.8 billion people worldwide presently rely on onsite sanitation systems (OSSs), which include pit latrines and septic tanks, to meet their sanitary needs (Andriessen et al., 2022). According to estimates, over 50% of the faecal sludge (FS) produced in low- and middle-income countries (LMICs) is improperly managed, posing serious dangers to the environment and the general public's health (Strande 2019). In Zimbabwe, where more than 90% of the population utilises OSSs, up to 57% of FS is reportedly carelessly discharged into the environment without being treated (Brandes et al. 2019).

In Sub-Saharan Africa and several parts of Asia, a sizeable number of indigenous people use biomass as their main source of energy (IGAD, 2017). The International Energy Agency's most recent report on global energy trends demonstrates that demand for energy is currently outpacing supply by a wide margin (IEA, 2018). In regard to the aforementioned paper, two key global energy issues have been recognised. Among these difficulties is assuring an energy source that is produced sustainably.

Many homes in Sub-Saharan Africa still rely on biomass energy in its raw form as a cheap and basic source of energy to meet their basic energy requirements. The United States Department of Energy claims that the majority of energy utilised in Sub-Saharan Africa comes from wood and is primarily used for cooking. This problem poses a significant risk to both human and climatic security because it is predicted to worsen by 2030. This hinders economic development and the reduction of poverty in the area (KIPPRA, 2018). In Zimbabwe, both urban and rural residents consume a significant amount of biomass (GOZ, 2021; 2022).

5.9% of all land is made up of the 3.456 million hectares of the Gazette Zimbabwean Forest. The minimum suggested coverage is 10%, and this coverage is thought to be far less than that (GOZ, 2022). The loss of vegetation due to the intensive use of biomass poses major risks to the environment's long-term viability and undermines attempts to reduce hunger and poverty (UNDP, 2021). Both on municipal and private areas, the proportion of native vegetation to the overall area has significantly decreased (KFS, 2019).

In Zimbabwe, the amount of vegetation has a significant impact on the economy, the environment, society, and culture. It contributes roughly 1% of GDP in monetary terms, meets a sizable portion of local energy needs, and will continue to be a significant source of fuel into the foreseeable future (Mugo and Gathea, 2019). Further evidence from Mugo and Gathea showed that a significant amount of biomass was used for energy in 2019, primarily in the form of firewood. Studies, according to Masinde and Karanja (2019), showed that an over reliance on biomass energy has resulted in the exploitation of forest cover, which has had a negative influence on the ecosystem.

Because to this threat, the nation's vegetation cover has decreased to 1.7%, considerably below the minimum ten percent suggested globally (UNDP, 2022). A fall in water levels in water bodies as a result of the aforementioned problem has led to an unstable power supply. However, there hasn't been a long-term solution despite using energy produced from petroleum to lessen the usage of biomass because of issues including volatility in the price of crude oil on the world market and the climate effects of increased GHG emissions. Additionally, it has been noted that carrying petroleum over long distances is risky and that leaks from this fuel can contribute to an increase in greenhouse gas emissions (IEA, 2018).

To the best of the researcher's knowledge, only a small number of study projects aiming at promoting faecal sludge (FS) resource recovery reuse (RRR) have been carried out in Zimbabwe so far (Katuwal and Bohara, 2019; Mwenje, 2020; Mariga et al., 2018). According to Mariga et al. (2018), one involved building 33 urine diversion toilets at the household level to collect urine meant for urban agricultural activities. Building decentralised wastewater treatment systems (DEWATS) to utilise treated wastewater for aquaculture and recover biogas for power generation was another RRR goal (MoW 2020) needs for cooking at home. However, both programmes have run into serious technical problems that have produced subpar results. As many as 80% of the urine diversion toilets were found to be ineffective 1 year after installation, and a recent monitoring study of the DEWATS revealed that 38% of the toilets had poor maintenance and improper operation, and 29% had no biogas production (McGranahan 2017; MoW 2020).

Using the knowledge, attitudes, and practises (KAP) framework (Muleme et al. 2017), this study aims to fill this research vacuum by examining locals' opinions on FS-RRR. However, because there are currently few active FS-RRR projects in DSM, the examination of practises in this study is restricted to examining the potential for practises by evaluating the availability of FS-RRR infrastructure and the supportive environment for FS-RRR promotion. The study aims to give stakeholders in sanitation, including policymakers and future innovators, a better understanding of the obstacles to advancement and promotion of the FS-RRR concept and adoption of FS-RRR practises in Zimbabwe by focusing on the perspectives of potential users of FS-RRR.

1.3 Statement of the Problem

Environmental issues have arisen in Zimbabwe as a result of the country's ongoing overreliance on biomass as the primary source of energy to supply the basic energy demands of rural populations (Masinde and Kanjanda, 2020); this has resulted in the clearing of vegetative cover (Okello et al., 2021; Ngwende, 2021). This reduction in plant cover has influenced climate change and erratic rainfall patterns (UNDP, 2019). To the best of the researcher's knowledge, only a small number of studies have been conducted in Zimbabwe with the goal of promoting faecal sludge (FS) resource recovery reuse (RRR) (Katuwal and Bohara, 2019; Mwenje, 2020; Mariga et al., 2018). Although the construction and performance of the advertised FS-RRR technologies were the main focus of these studies, little is known about how the public views these technologies and the products they produce. Despite the fact that it has already been demonstrated that the acceptability of an innovation by the general public is crucial for successful technology adoption (Davis 2018). More specifically, people's decisions to accept new innovations are influenced by their level of familiarity with and favourable views towards those innovations (Meena et al. 2019), as well as the possibilities provided to potential users to test those innovations out (Rosly & Khalid 2018). Utilising the knowledge, attitudes, and practises (KAP) framework, the aim of this study is to fill this research gap by examining residents' opinions on the 0FS-RRR.

1.4 Significant of the study

The results of this study will have a significant impact on whether biogas fuel is chosen as an alternative energy source in Zimbabwe and rural areas generally. This is because the fuel is regarded as clean and the production's raw ingredients are easily accessible in the area. By improving their comprehension of the attitudes, knowledge, and practises impacting adoption and usage of biogas fuel as well as their decision-making and strategic actions, the study's findings will be helpful to proponents of biogas fuel and other stakeholders in the energy industry. The researcher believes that adoption of biogas fuel will help mitigate environmental challenges, reduce the cost of cooking fuel, and also provide an alternative, clean source of energy that is sustainable, so the study's findings were to be used to recommend the use of biogas fuel among rural communities. Since understanding the attitudes impacting the adoption of biogas fuel is crucial for decision-making and strategic actions of individuals and rural communities, the study's findings will be essential to promoters and other stakeholders in the energy industry.

1.4 Research Objectives

The main objective of this study is to assess knowledge, attitude and practices towards the use of Biogas by rural communities.

1.4.1 Secondary Objectives

The secondary objectives of this study are;

1. To assess rural people’s knowledge towards generation and use of biogas
2. To assess rural people’s attitude towards generation and use of biogas
3. To assess rural people’s practices towards generation and use of biogas
4. To relate KAP to socio-economic factors

1.5 Research questions

1. What is the rural people’s knowledge towards generation and use of biogas?
2. What is the rural people’s attitude towards generation and use of biogas?
3. What is the rural people’s practices towards generation and use of biogas?
4. What is the impact of KAP on socio-economic factors?

1.7 Delimitations of the study

The study will only focus on Murewa rural communities in Zimbabwe. No other study area outside of this will be taken into consideration. Assessing knowledge, attitude and practices towards the use of Biogas by rural communities is the aim of the study. From January 1, 2021, through December 31, 2022, the study will be conducted.

1.8 Limitations of the study

The approach to be employed for the research study may be constrained by the respondents' accessibility during the administering or interviewing processes, which could pose a problem for this study. Due to the researcher's commitment to other academic objectives, time may also be an issue. Due to her lack of a formal job, the researcher is also likely to experience financial difficulties. To overcome these restrictions, the researcher will create a budget and enlist the assistance of a colleague.

1.9 Assumptions

The following suppositions form the foundation of this research investigation.

- The researcher made the assumption that during the study period, there wouldn't be any significant changes to Zimbabwe's national or international policy framework with regard to environmental issues and reporting.
- The research study will maintain its complete independence without having any negative effects on the research.

1.10 Chapter summary

The context, problem statement, aims, research questions, justification or significance, assumptions, delimitations, and constraints guiding this investigation are provided in this first chapter. The following chapter will review the study-related literature.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The previous chapter, which served as an introduction to the study, explained its purpose, highlighted its problem, and provided justification for why a study on this topic was necessary. The primary goal of this chapter is to assemble published and relevant research on rural communities' knowledge, attitudes, and practises (KAP) on the production and use of biogas. By examining what previous researchers have found in their numerous studies on relevant topics, it establishes the foundation for the study. The theoretical foundation for this investigation will once again be discussed in this chapter. Additionally, the researcher will consider encounters in various settings where the topic is present. To provide is the fundamental objective.2.1 Theoretical framework

Adom et al. (2018) claim that the theoretical framework clarifies the direction of a research project and grounds it solidly in theoretical frameworks. The main goal is to combine the ideas of experts in your field of study as they apply to your own research (Kijunva 2018). This gives context to the research findings and provides a basis for the study's reasoning.

The Reason Action theory (Fishbein 1980; 2001; 2011)

This theory contends that volitional behaviour is determined by intentions (Hom, 2017). The essential idea is that two factors—individuals' attitudes towards that action and the subjective norm—are predictive of whether they will elect to do a particular action, in this case, utilise biogas.

Attitude towards the action- This highlights an individual’s evaluation towards an action, (Screwker 2017). According to Bardakoglu (2017) individuals are reasoning beings who weigh options whether use of biogas is a good decision or not. Sabudi et al (2018) posits that individuals psychologically evaluate their choices and if the choice offers favourable outcomes the thought to abandon the choice is less likely.

The subjective norm- According to Hom (2017) this refers to the normative and social factors that lead to one to decide to act.

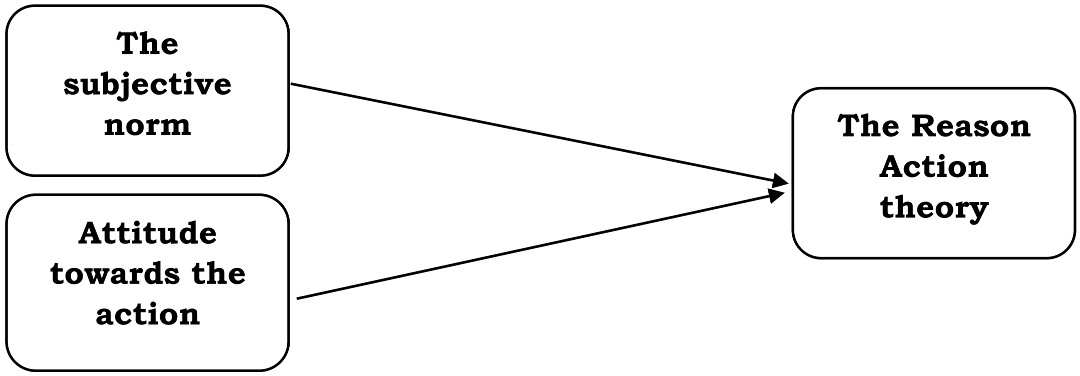

Figure 2. 1: Reason action theory

Source: Jiang (2020)

Strengths of the Reason Action theory

According to Jiang (2020) this theory is useful in predicting KAP towards biogas as it encompasses one's cognition and judgments. The theory exposes the KAP process, how it all begins; in the mind and how attitudes are formed thereafter leading to actual adoption, (Malek 2018).

Weaknesses of the Reason Action theory

This theory does not explain or take into account the fact that persons who intend to use biogas occasionally might not do so exactly as the theory predicts (Jahya 2020). Santoni (2018) claims that this theory disregards the impact of non-volitional elements that emphasise a person's perceived behavioural control.

Relevance to the study

This theory is very much relevant to this study. It traces back withdrawal intentions to dissatisfaction with biogas usage which is manifested through attitudes. If an individual psychologically evaluates their choices and they are not happy it means they will not adopt alternative energy source as they see it not a good move. Hence a recurring theme in this study keeps coming up, that is, the need to create knowledge, favourable and harness best practices such work, such that attitudes of rural people remain positive and they do not think of not using biogas. A clear link between KAP towards generation and use of biogas is unveiled making his theory much important in this study.

2.2 Biogas Technology Theories and Concepts

Rural Kenyans have access to and can afford the raw materials for the alternative renewable energy source known as biogas. The primary uses of biogas are for cooking and lighting. Cooking consumes 90% of the total energy used in rural African households (Rajendran et al., 2018; Rowse, 2019). In the absence of oxygen, microorganisms break down organic materials in anaerobic digestion to create methane (70%) and carbon dioxide (30%) (Justus K. Laichena & Wafula, 2017; Rowse, 2018). According to Karanja and Kiruiro (2016), methane (CH4) is a colourless, odourless gas that is low in weight and does not emit smoke. Methane has a GWP that is twenty-one times greater than that of carbon dioxide, according to Rowse (2018). The components of which biogas is made are displayed in table 2.1 below.Table 2. 1: Composition of Biogas

Compound	**Molecular**	**Percentage content**
Methane	CH_4	50-75
Carbon dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen sulphide	H_2S	0-3
Oxygen	O_2	0-0

Source: Sanbarial (2015)

Animal and poultry manure, human waste, food waste, and agricultural waste are the typical feedstock (substrate) items digested to produce energy in the form of biogas. According to Rowse (2018), a substrate is "the carbon source electron donor in the biochemical events that occur in anaerobic digestion." The generated biogas is utilised to power devices like chaff cutters and is also used for heating, lighting, and cooking. According to Amigun, Aboyade, Badmos, Musango, and Parawira (2017), the digester's residue is a biofertilizer known as slurry that is rich in nitrogen, phosphorus, potassium, and other nutrients and is therefore suitable for increasing food production and yields.

There are three common types of biogas digesters. These are the fixed dome, the floating dome and the tubular plastic digesters (Nzila et al., 2017; Rowse, 2018). The common sizes for these digesters are 4, 6,8,10 and 12 m3 (Ghimire, 2013). The main components of the biogas system and the installation materials required are well defined by previous researchers (Cheng et al., 2017; Mulinda et al., 2018; Rajendran et al., 2017; Ullrich, 2018). The spherical shape of the biogas digester has been described as having more stability than any other shapes (Justus K Laichena & Wafula, 2017). However, adequate knowledge of biogas system design methodologies is lacking in poor nations (Rowse, 20). The gas storage dome and the digestion chamber are both included in the fixed dome biogas digester as a single component (Mulinda et al., 2018). The structural components, the piping system, the biogas utilisation system, the wastewater disposal system, and the anaerobic digestion system make up the five sections that make up a comprehensive biogas system (Cheng et al., 2018). Because tree roots can harm the biogas digester, the location of the digester should be far from trees (Ullrich, 2018). According to Rajendran et al. (2017), the building materials utilised to install a biogas system are mostly determined by the geological and hydrological soil qualities. The essential elements of a fixed dome biogas system are as per the figure 2.2 below).

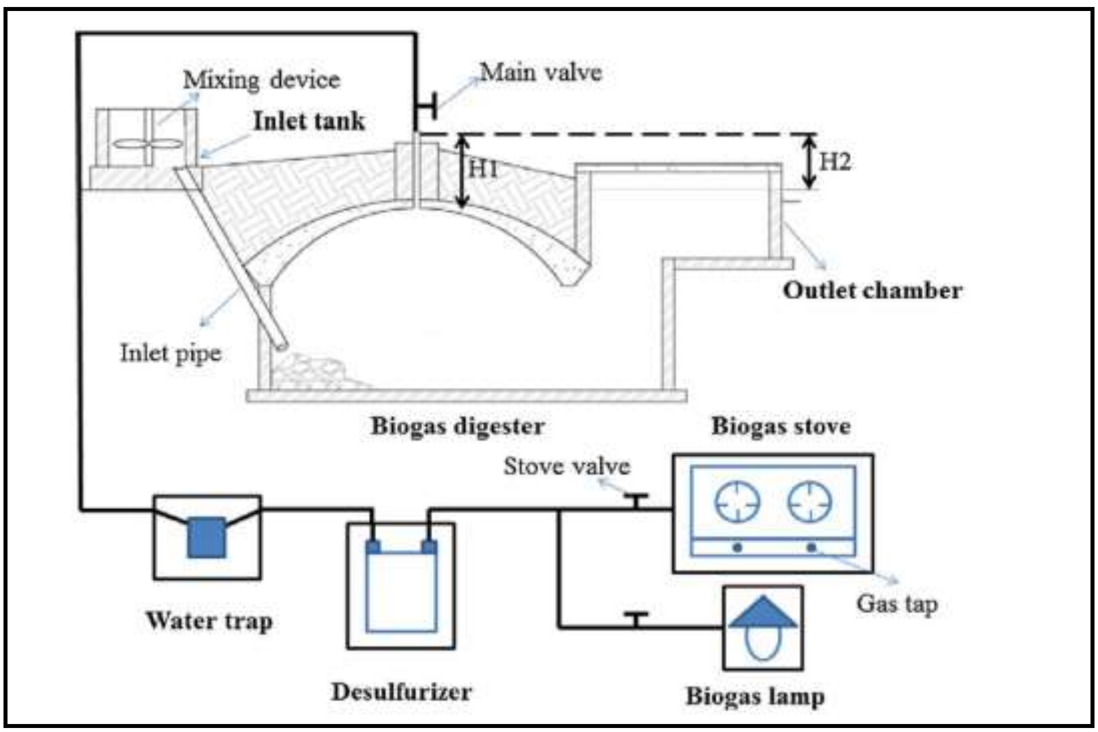

Figure 2. 2: The Fixed Dome Biogas System

Source: Rajendran et al., 2017

2.3 Conceptual framework

This section establishes the groundwork of the study by looking at what other researchers have discovered in their various studies on related subject. This related literature is presented in unison with the major variables namely knowledge, attitude and practices (KAP) and biogas usage. Figure 2.2 shows the conceptual framework of the study.

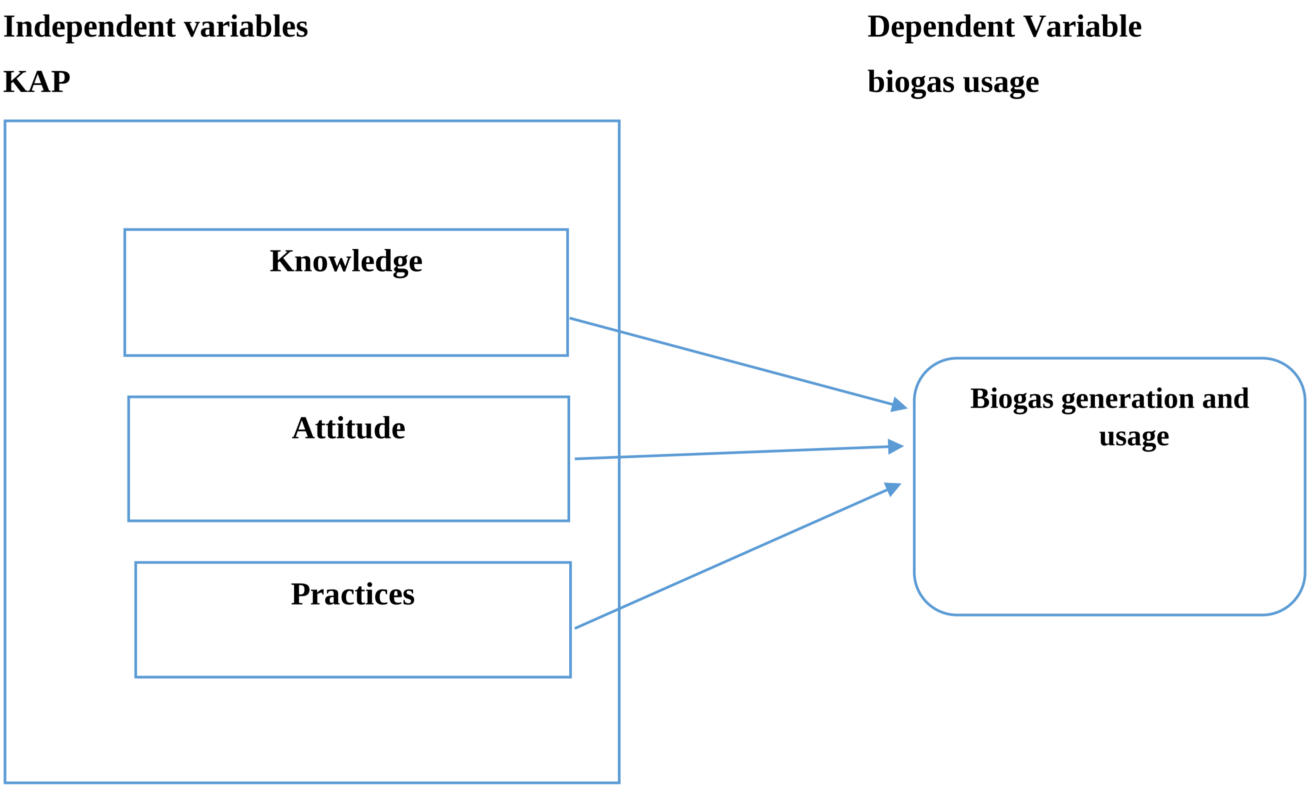

Figure 2. 3: Conceptual framework of the study.

Source: Researcher's own construct, 2023

2.4 Knowledge, attitude and practices (KAP)

Demonstration units should place an emphasis on displaying finished goods that are already well-liked by the general public to provide consumers the chance to observe how things are created and used. Third, organisations in charge of sanitation management should host stakeholder meetings to encourage the development of inclusive laws and regulations that will improve FSM and guarantee a steady supply of raw materials for FS-RRR. In conclusion, the study shows that more than just functioning technology will be needed to scale up FS-RRR acceptability in Murewa and beyond. In reality, knowing what people need to know, how they feel, and what it takes for them to utilise it is just as crucial if we want it to be successful.

When referring to FS-derived products, which are manufactured end products after various treatment processes to safely remove harmful bacteria and pollutants from raw FS (Kengne et al. 2014), Muleme et al. (2017) define practises as the observable actions that individuals or collective groups have engaged in or envision to engage in linked to a specific phenomenon, in this case FS-RRR promotion or use of end products.

Diener et al. (2017) divide these goods into the following five groups: (1) FS-briquettes, a solid fuel made from carbonised and dried FS; (2) biogas fuel made from digested wet FS; (3) proteins made from FS for use as animal feed; (4) dried FS for use as construction material, here referred to as bricks; and (5) composted FS for use as a soil conditioner, here referred to as compost. Vegetables were also included in this study as another agricultural end product that was produced after the application of FS-derived soil conditioner.

2.5 Rural people's knowledge towards generation and use of biogas.

Biogas Energy Production Process

Bacteria that break down organic material produce biogas as a fuel. This procedure occurs in an anaerobic setting that is favourable for the production of biogas. According to Gautam and Ghimire (2019), the metabolic processes occur in four stages: hydrolysis, acidogenesis, acetogenesis, and metabolism.

Hydrolysis

Anaerobic bacteria use this mechanism to break down big molecules of proteins, carbohydrates, lipids, and cellulose into smaller molecules like amino acids, fatty acids, and (Grady et al., 2017).

Acidogenesis

In this process, bacteria speed up the degradation of organic molecules. In order for further transformation to take place, the bacteria here cause chemicals to enter the bacteria cells. Methane is produced when organic material undergoes breakdown in the absence of oxygen.

Acetogenesis

After that, acid-forming bacteria react with organic acids to produce acetic acid, carbon dioxide, and hydrogen, which are the precursors of methane generation. Stable temperature mode is crucial for these hydrogen-eating bacteria's essential operations. The chemical reactions that occur involve the conversion of butanoic acid to ethanoic acid and hydrogen as well as the conversion of acetic acid to ethanoic acid, carbon dioxide, and hydrogen gas.

Methanogenesis

In the final phase, methanoic acid is converted into methane, carbon dioxide, and water as depicted in the chemical reactions below. When anaerobic conditions are present, methane-producing microbes can grow. 90% of the methane output from acetic acid occurs at this point. According to Ivet (2018), the third step of the process, the creation of acetic acid, determines how quickly methane is produced.

The aforementioned reactions describe how ethanoic acid is converted into methane gas under anaerobic conditions. In some research, such as Santosh et al.'s (2018) and Xinshan et al.'s (2017), biogas fuel is viewed as the byproduct of organic material breaking down in the absence of oxygen. By putting organic waste from agriculture and animals via aerobic or anaerobic processes, biogas fuel can be produced. Methane and carbon dioxide are combined to create the biogas fuel (Woodard, 2017). According to Gassanova et al. (2018), this kind of fuel can be used directly to generate energy for home consumption. In addition, the energy from biogas can be transformed into other beneficial kinds of energy (Jenssen et al., 2019). This is because many experts believe that energy is a great instrument for.

Wrapai (2019) asserts that biogas fuel from sewage treatment facilities can be utilised to generate electricity for cooking, heating sewage treatment facilities, and water heating. The basic elements needed to produce this fuel are easily accessible and it is a sustainable fuel. Slurry, another byproduct of biogas systems, is rich in nutrients and outperforms synthetic fertilisers in terms of performance. Due to the nutrients contained, the residue that is produced as a by-product in the digester can also be fed to livestock and poultry. There is no need for trained staff when managing the slurry (Mwakaje, 2018).

2.5 Rural people's attitude towards generation and use of biogas

This technology is a very good solution to local energy needs and provides significant benefits to human and ecosystem's health (Raskovic et al., 2019); it is also considered as a means leading to rural development.

In addition to providing solutions to current environmental issues, biogas facilities also come with a number of unanticipated benefits (Drabez et al., 2019). In other research, developing human and financial capacity through the delivery of electricity that is both inexpensive and reliable is a crucial aspect for rural communities to adapt to climate change consequences (Casillas and Kammen, 2018).

Bioenergy, which comes in the forms of biomass, biodiesel, bioethanol, and biogas, has been gaining popularity due to its potential environmental and economic benefits. It has been suggested that if developing economies actively invest in the spread of these renewable energy technologies, the benefits will include sustainable energy production, improved livelihoods, and food security. Specifically, biogas technology has the potential to enhance sanitation, lower greenhouse gas emissions, provide nutrient-rich organic fertiliser, and replace traditional fuels in cooking, improving indoor living conditions and reducing deforestation. Additionally, the technology is financially appealing in that the investment costs can be repaid quickly when good design, operation, and maintenance conditions are followed (Brown, 2017).

Saving time and money, reducing workload, improving health and quality of life are all advantages of biogas. According to numerous studies (Amjid et al., 2017; Ghimire, 2018; Justus K. Laichena & Wafula, 2017; Rajendran et al., 2018; Sankarlal, 2018; Sovacool et al., 2018), women are the primary beneficiaries in families. 90% of the energy consumed in rural regions goes towards cooking. Cooking is typically done by women (Rajendran et al., 2018; Rowse, 2018). Firewood use drops by 53% on average in rural families that use biogas (Rowse, 2018). Sovacool et al. (2018) used emotional reactions to guide their research, which involved showing rural residents pictures of the most popular goods made from faeces and telling them what they contained and how to use them.

Figure 2. 4: Faecal Sludge-derived products

Source: Sovacool et al., (2018)

(a) FS-briquettes, (b) biogas, (c) compost, (d) vegetables, (e) proteins for animal feed and (f) bricks

2.6 Rural people's practices towards generation and use of biogas

The Norwegian Institute of Bioeconomy Research, NIBIO (previously Bioforsk), conducted a study in China in 2022 to determine whether there are any more advanced and practical biogas digesters available today than the conventional fixed dome and floating dome digesters constructed of brick and concrete. The research's findings suggested the fibreglass digester, which might function well in Africa and other tropical nations; this is already the norm in Africa.

By pouring resin solution into a mould (a hollow flame), which gives the digester the desired shape as the resin hardens, fibreglass digesters are created. As a result, the weight, shape, and size of every digester are uniform. Before being introduced to the market, they undergo airtightness and guaranteed quality control tests. The Chinese fibreglass biogas digester's production flow chart is depicted in the image below.

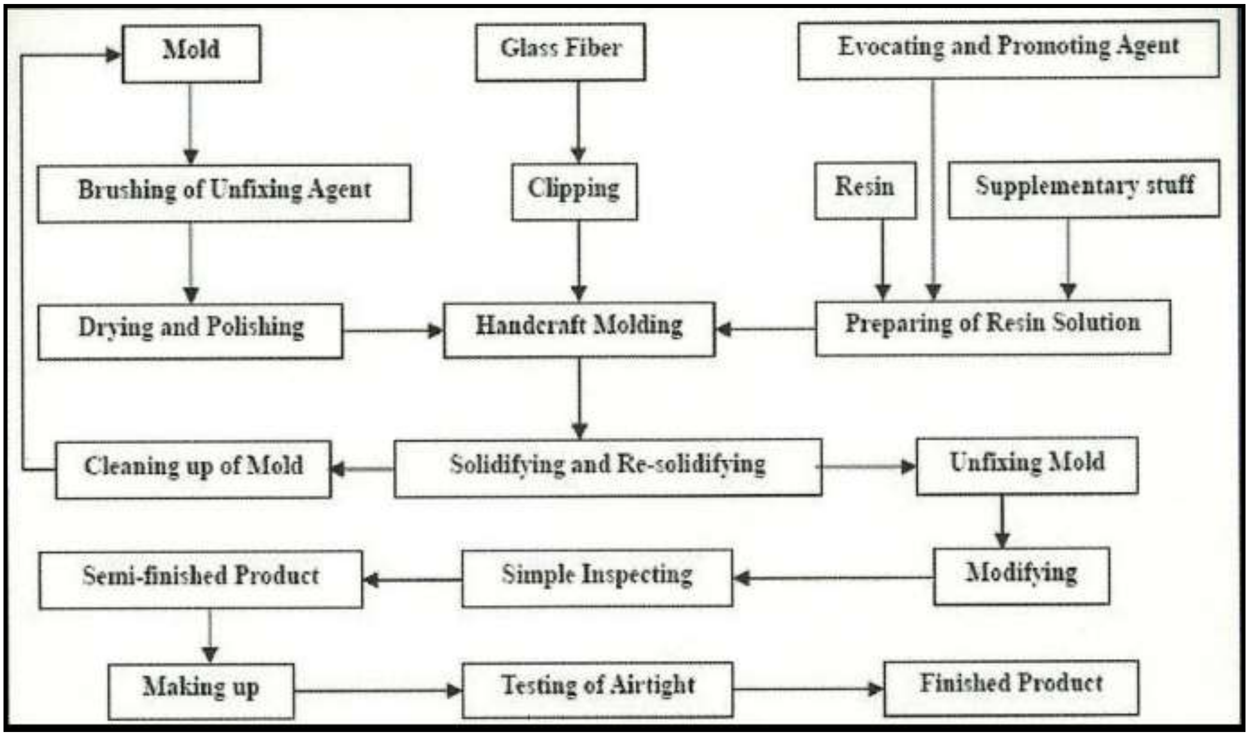

Figure 2. 5: The current practice of biogas digester

Source: NIBIO (2022)

According to NIBIO (2022), the fibreglass digesters are characterized by the following: -

- They come in four parts, that is, the inlet, the outlet, the gas chamber and the digester.
- The digester sizes are 4, 6 and $8m^3$.
- They are commercially manufactured according to set quality standards.
- They are strong and can withstand pressure.
- They have a lifespan of 20 years.
- They are light in weight.
- They are easier to install and require less labour.
- They are airproofing and water tight which ensures that biogas does not escape through leakages.
- Only one skilled worker is required to install the digester as compared to 15 workers for the brick and concrete digesters.
- Installation takes 3-5 hours as compared to 7-10 days for the brick and concrete digesters.
- After installation, the digesters are almost repair and maintenance free.

- If supplied in bulk, the total purchasing and installation costs can reduce to less than a half of the brick and concrete digesters

The fibreglass digesters were therefore found to be more convenient in terms of purchasing costs, labour costs, management, strength, being airtight, installation time and service time (lifespan). The digesters have been successfully tested in China and Africa (NIBIO, 2022).

2.7 Relationship between KAP and socio-economic factors

By weighing the whole costs and advantages of implementing the biogas technology for society as a whole, an economic analysis is conducted. Economic advantages do not always equate to financial advantages. Biogas has economic advantages in terms of a healthier environment, the preservation of forests, increased food production, decreased carbon emissions/global warming, improved health, economic growth, poverty alleviation, increased employment opportunities, more free time for women, and increased happiness due to a better lifestyle and food security (Rajendran et al., 2017; Roubk et al., 2017). The advantages that using biogas has for the environment and society are depicted in the graph below.

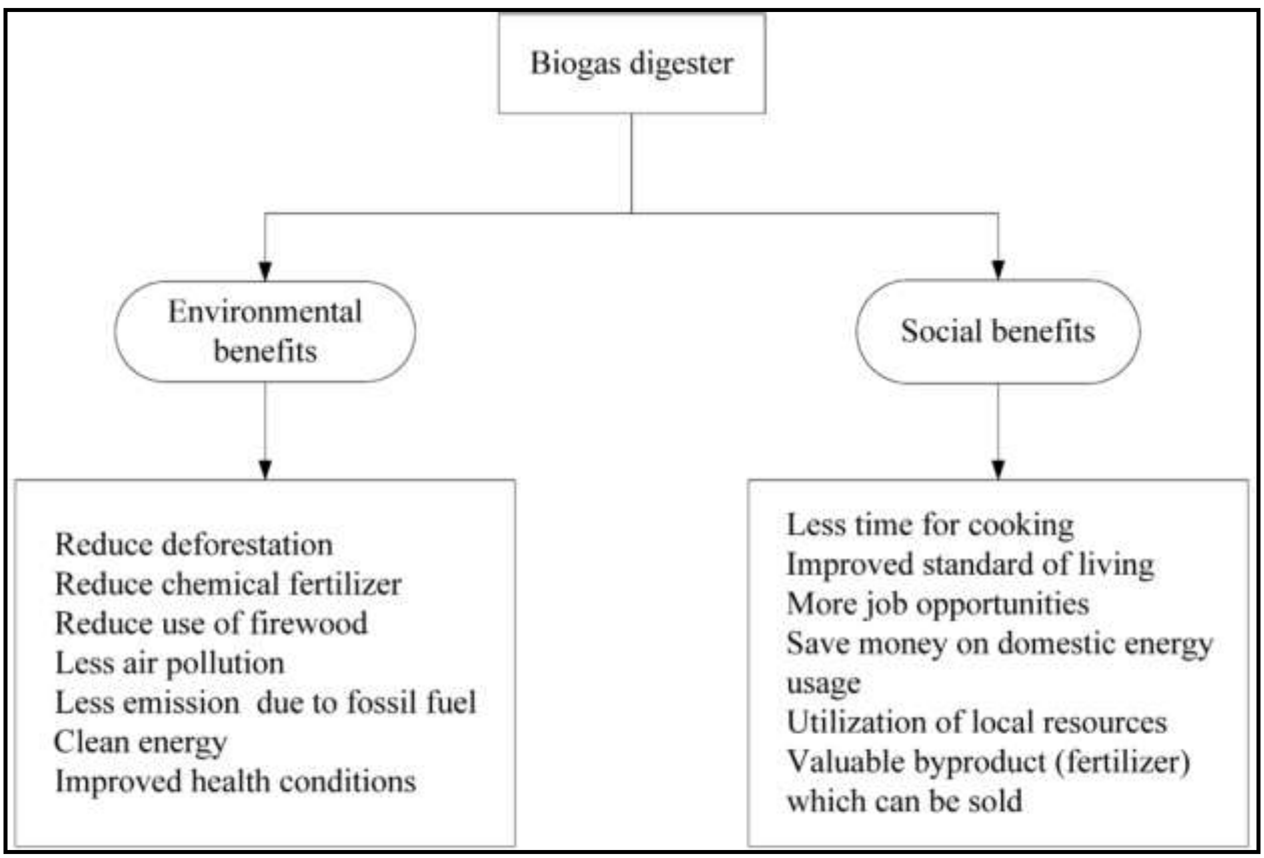

Figure 2. 6: Environmental and social benefits derived from using biogas

Source: Rajendran et al., (2017

Respiratory infections in infants, unfavourable pregnancy outcomes, chronic lung and heart disorders, and cancer are the four main ailments brought on by exposure to indoor smoke. Women in underdeveloped nations spend, on average, three-fifths of their time indoors, particularly in the kitchen, making them more susceptible to smoking particulate matter exposure than men. Fuel types with lower indoor air pollution levels are increasingly common as household socioeconomic status rises. According to Rowse (2018), this is known as moving up the "energetic ladder."

Biogas technology has a number of socio-economic and environmental advantages while being a high-cost and capital-intensive undertaking. When it comes to producing environmentally friendly, clean, and safe energy, biogas technology is crucial. By incorporating biogas technologies, dairy producers may be able to lower indoor air pollution and the prevalence of respiratory disorders (Katuwal and Bohata, 2019). According to Mwakaje (2018), research show that using biogas technology at the household level helps to empower women by easing the burden of collecting wood fuel. This technology also supports gender equity and empowers women. Mwakaje's study found that households in Tanzania using biogas energy were able to save more time each day than. This time would be used to carry out tasks that would create income, so enhancing community livelihoods. Additionally, the trees that are left standing as a result of the farms' decreased reliance on wood fuel help to support the environment. According to Smith et al. (2018), trees break the wind, which benefits the microclimate, biogas technology, and reduces atmospheric pollution (smoke from biomass) and global warming by reducing GHGs.

Additionally, biogas technology may be a significant part of waste management at the farm level (IFAD, 2009), helping to reduce methane emissions that would result from residues if they were allowed to decay in an open field. The usage of bio-slurry is also helpful for the dairy farmers as it includes a lot of nutrients therefore reducing the use of artificial fertilisers (Katuwal and Bohara, 2009). Animal waste and urine are converted into energy sources, especially among dairy farmers. The selling of bio-slurry, which brings in money for dairy producers, is another advantage of the biogas technology (IFAD, 2019). Additionally, it appears that communities are becoming more and more interested in biogas fuel. Because of installation.

Since more than half of a nation's population lives in rural areas, biogas energy can serve as a replacement source of energy for them (Amjid et al., 2018). If the local population can learn how to operate and manage biogas systems throughout the seasons, this green energy provision will be improved. (2017) Feng et al. According to other studies, animal and plant waste can be used to produce green energy (FAO, 2019). The biogas technology is crucial in lowering the clearing of forest land and scaling back the use of firewood, both of which have a good influence on the environment (Okello et al., 2018). Additionally, by-products of technology like manure have enhanced soil quality, leading to better agricultural output. Thus, as vegetation cover increases, rainfall patterns and livelihoods also do as well (Angelidaki et al., 2018). The efficiency of the biogas fuel during consumption is well recognised. It is utilised as a substitute for petroleum-based goods such kerosene oil, agricultural solid waste, and wood fuel (Pathak et al., 2009). Forest cover loss could be lessened by replacing biomass with biogas energy. By lowering land erosion, this would benefit ecosystems and the environment (Drabez et al., 2019).

The application of biogas technology has economic, environmental; health and a social benefit which contributes towards sustainable development (Azhar and Baig, 2018; Seadi et al., 2018) and also a source of nutrient rich organic fertilizer from effluent slurry which can be helpful for algae growth, fish production and seed germination.

2.8 Chapter Summary

This chapter was organised into sections that outlined the theoretical framework that underpins the study and the conceptual framework of the study. It explored in detail the various theories related to the study as well as reviewing the literature related to the study. The next chapter provides the methodology of the research.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Materials and methods

The study will be carried in Murewa, originally known as Murewa and alternately rendered Murewa, is a township in Zimbabwe, 75 km northeast from the capital of Harare, at the road to Tete. It is situated almost 1400m above sea level. The total land area is 3556km^2 and the latitude for district is -17.645168 and longitude is 31.782228. The latitude DMS and Longitude DMS are and 17^{0}38'42.6''S and 31^{0}46'56.02''E. Murewa population is 205 442 people.

Murewa has a temperate highland tropical climate with dry winter's climate. The district's yearly temperature is 21.53^{0}C and is -1.2% lower than Zimbabwe's average. Agriculture is the main economic activity in the district… maize, the staple crop occupies the main part of the cultivated land of all households and is the main source of on farm income. Other crops cultivated include groundnuts, sunflowers and a variety of vegetates. The study area is Mabikwa ward 28. Figure 3.1 shows the map of the study area.

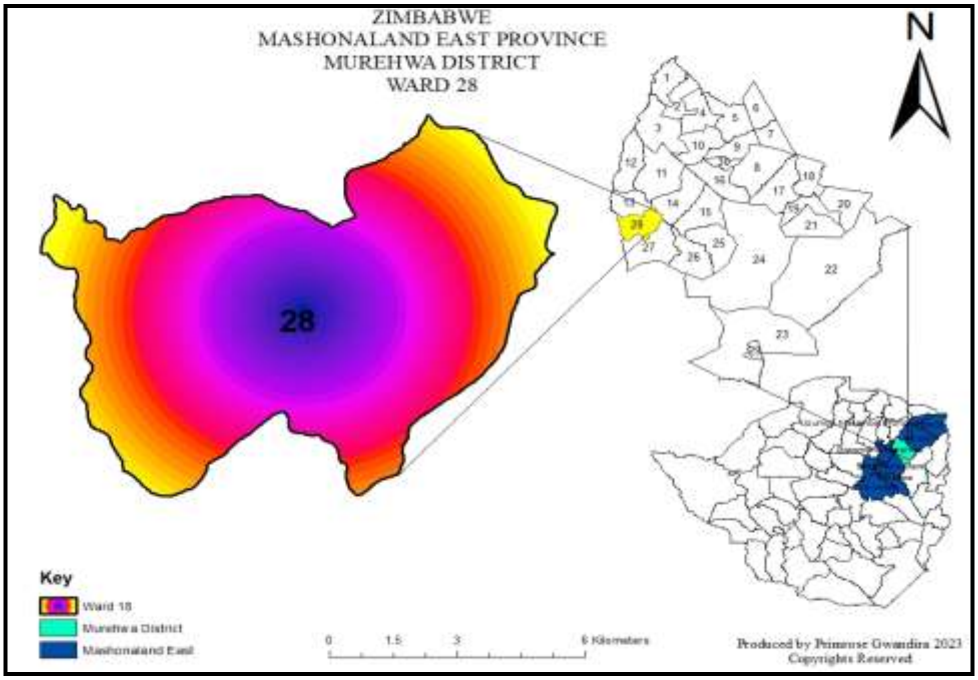

Figure 3. 1: Map of the study area.

3.2 Research design and approach

The research employed mixed methodology (qualitative and quantitative methods). The rational of choosing mixed methodology was that it is suitable to capture quantitative and qualitative issues of this study, (Creswell, 2014). The researcher got the permission from the university and the ward 28 authorities such the chiefs, headman health workers, community leaders, Environmental Health Officers and Community and Development Officers from the ward.

3.3 Sample size and sample selection

Ward 28 in Murewa district was chosen because of more villagers seem to be appreciating biogas usage. The researcher visited ward 28 village and ascertained the families who are currently using biogas and those that are not using biogas. Out of 50 populations a sample of was selected. There are a number of sampling techniques available such as Morgan and Krejcie (1970) table and Yamane (1967) formula. In this study the researcher will use Yamane formula which say;

$$n = \frac{N}{1 + N(\varepsilon^2)}$$

Where n = sample size, N = population size and = the margin of error. The method assumes a 95% level of confidence and the margin of error is 5%.

$$n = \frac{50}{1 + 50(0.05^2)}$$

Sample size=44 villagers

20 Environmental Health Officers and Community and Development Officers from the ward were the key informants of this study.

3.4 Research tools

A semi-structured questionnaire was used to gather bio data of the villagers. The questionnaire was administered by the researcher herself. The rational of doing so is premised on the issue of reliability and to be able to take photographic documentation of the biogas digesters currently being used by these villagers. Interviews were also used to collect data from the villager. The questionnaire was written in English and be translated in local language. The questionnaires were completed by the researcher herself. The interview question were in English and were translated to local language. Validity and reliability was ensured using cross loading and Cronbach alpha respectively.

3.5 Data analysis

Data analysis was done using frequencies, percentages and measures of dispersion and central tendency. All the responses were captured in English. Data to be collected was organized into independent and depended variables and analysed using regression analysis and correlations. SPSS will be used to analyse data

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 Introduction

The previous chapter looked at a comprehensive analysis of literature related to knowledge, attitude, and practice (KAP) towards the generation and use of biogas. The main purpose of this study is to present and analyze the results. The chapter also discusses results in relation to the research objectives. The chapter begins by presenting the response rate, followed by the biodata of the respondents, and lastly, the major results. Multiple regression analysis was used to analyze the relationship between KAP and the generation and usage of biogas.

4.1.1 Response Rate

50 questionnaires were self-administered to the villagers. All the questionnaires were collected back, and after effective data coding and cleaning, only a total of 40 were found to be valid. These were subsequently used for data analysis. The response rate was 80%. Figure 4.1 presents a summary of the response rate.

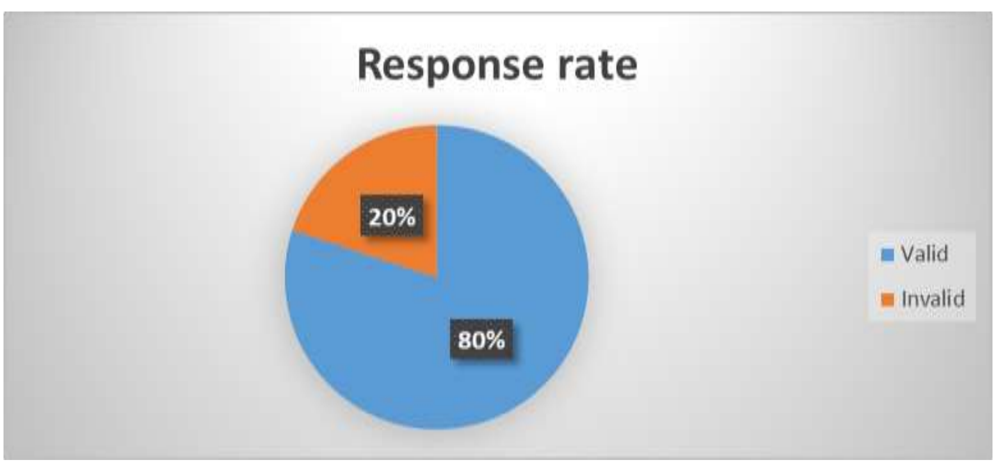

Figure 4. 1: Response rate

4.1.2 Age

The villages were asked to indicate their age. Figure 4.2 shows the age distribution of the respondents.

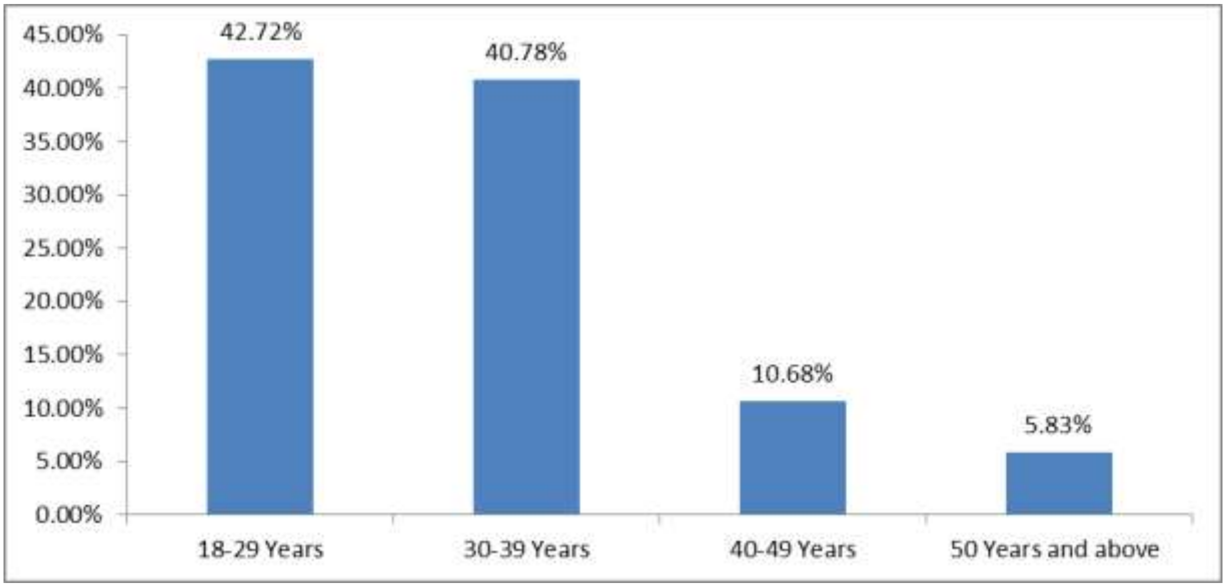

Figure 4. 2: Age of Respondents

Results suggest that most of the villagers in Murehwa Ward 28 are mature individuals. This was important to this study as these mature villagers are able to comprehend the generation and usage of biogas (Figure 4.2).

4.1.3 Gender

Results in Figure 4.3 suggest that most of the villagers who participated in the study were women. This supports the assertions by Barbie (2018), who said that women have a better appreciation of biogas usage because they are the ones who mostly use it to prepare food for the family. Gender matters most when it comes to knowledge, attitude, and practice towards the usage of biogas. Figure 4.3 below shows the gender distribution of the villagers.

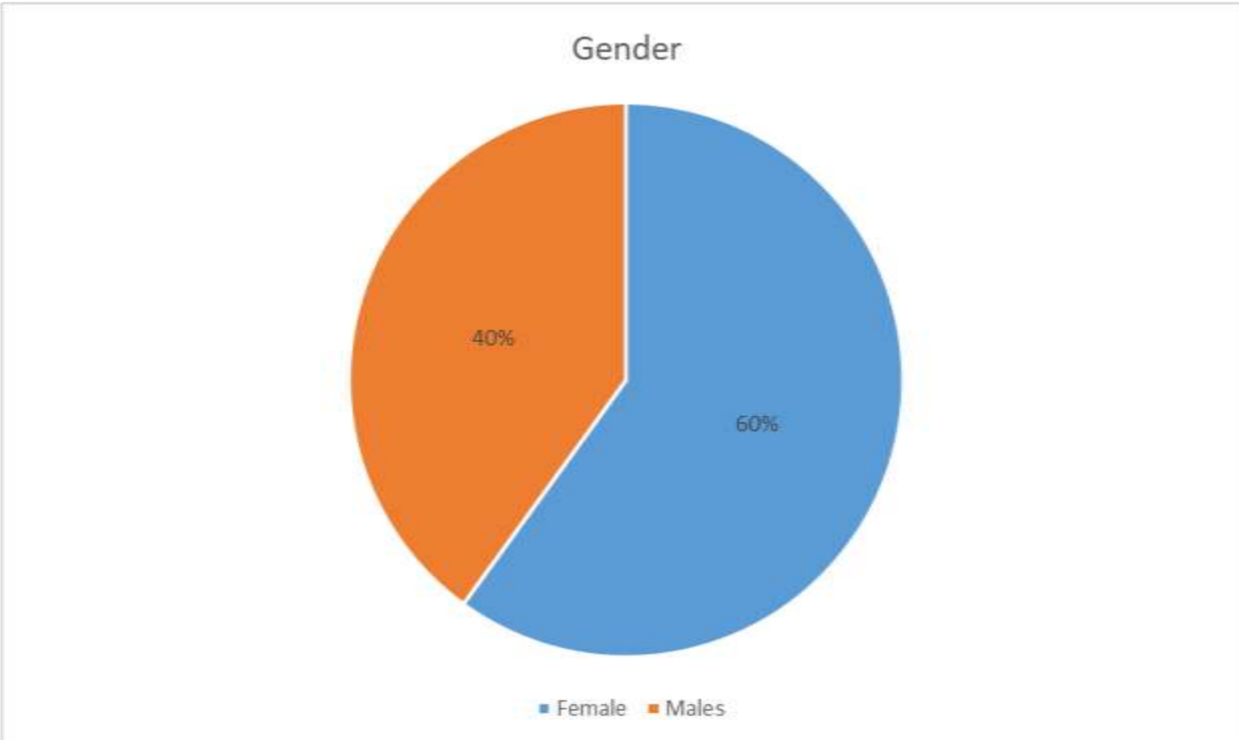

Figure 4. 3: Gender of Respondents

4.1.4 Marital Status

Results in Table 4.1 above suggest that most of the villagers are married. This implies that the burden of searching for firewood or fuel is solely on them. Marital status is important when it comes to KAP and the use and generation of biogas. There, the villagers were asked to indicate their marital status, and a summary of these results is presented in Table 4.1 below.

Table 4. 1: Marital Status of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Married	53	51.5	51.5	51.5
	Divorced	3	2.9	2.9	54.4
	Single	42	40.8	40.8	95.1

	Widowed	5	4.9	4.9	100.0
	Total	103	100.0	100.0	

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4.1.5 Educational Level

Educational level matters most in the relationship between KAP and biogas generation and usage. Table 4.2 shows the level of education of the villagers. According to the results above, most villagers have secondary education, implying that they are fairly educated.

Table 4. 2: Educational qualification of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Certificate	21	20.4	20.4	20.4
	Diploma	30	29.1	29.1	49.5
	Degree	16	15.5	15.5	65.0
	Other	36	35.0	35.0	100.0
	Total	103	100.0	100.0	

4.2 Knowledge of respondents on Biogas

The section presents major results of the study in relation to KAP towards use and generation of bio gas. The objective of the study was to determine the knowledge of people living in rural areas of Murehwa towards the usage and generation of biogas. Table 4.3 above shows the results in relation to this objective.

Table 4. 3: Knowledge towards biogas generation and usage

No	statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	Mean score
K1	I have heard about biogas generation before		2.4%	24.4%	43.9%	29.3%	4.0
K2	I know how biogas is generated		7.3%	14.6%	58.55%	19.5%	3.90
K3	I'm currently using biogas in my home	4.9%	2.4%	26.8%	53.7%	12.2%	3.66
K4	I participated in the construction of biogas digester in my community		4.9%	41.5%	39.0%	14.6%	3.63
K5	I encourage other villagers to try biogas		4.9%	41.5%	43.9%	9.8%	3.58
	Grand mean						**3.754**

According to results in the table 4.3 above its shows that a total of 73.2% were agreeing that they have heard about the production or generation of biogas before while a total of 2.4% did not and the remaining total of 24.45 were neutral over the issue under study. A total 65.9% of villagers in Murehwa were currently using biogas in their homes implying that they have a better knowledge about biogas usage and generation, while a total of 7.3% were not using biogas in their homes. A total 53.6% of villagers in Murehwa participated in the construction of the biogas digesters that is currently being used in their areas while only 4.9% did not participate. In addition to that, a total 53.7% were encouraging those not using biogas in their homes while a total of 4.9% were not spreading the word of mouth about biogas generation. The grand mean of 3.8 implies that most villagers were in agreement that they have knowledge about biogas generation and usage in Murehwa. Therefore, according to results in the table 4.3 above the study can conclude that people in Murehwa has knowledge towards generation and usage of biogas.

4.3 Attitude of respondents on biogas production and use

The second objective of the study was to determine the attitude of people living in Murehwa towards the biogas generation and usage. Table 4.4 presents results in relation to this objective.

Table 4. 4: Attitude towards biogas generation and use

Code	**Statement**	**1 Strongly Disagree**	**2 Disagree**	**3 Neutral**	**4 Agree**	**5 Strongly Agree**	**Mean**
A1	I find it interesting using biogas in my home		10.0%	47.5%	30.0%	12.5%	3.45
A2	I'm satisfied by using biogas as source of fuel in my home		2.5%	7.5%	72.5%	17.5%	4.05
A3	Generation and using biogas is relatively simple		2.5%	47.5%	47.5%	2.5%	3.50
A4	I actively involved in biogas generation in my village		2.5%	22.5%	45.0%	30.0%	4.025
A5	Experimental activities involved in biogas generation helped me in understanding the importance of biogas		5.0%	15.0%	60.0%	20.0%	3.95
A6	Using biogas improved the quality of some task in my home		5.0%	10.0%	50.0%	35.0%	4.15
	Grand mean						3.85

A total of 42.5% of villagers in Murehwa find it interesting to use biogas in their homes while a total of 10% were no interested in using biogas in their homes. A total of 90% of people living in rural areas feel satisfied using biogas in their homes and a total of 2.5% were not interested in using biogas. The villagers in Murehwa were found to be actively involved in the biogas generation as noted by the total of 75% who agreed. Quality of life of people living in rural areas was eventually improved due to biogas usage as indicated by a total of 85% villagers who in agreement. The grand mean of 3.85 shows that most villagers were in agreement that they have a positive attitude towards usage and generation of biogas.

4.4 Practices towards biogas generation and use

The third objective of this study was determine the extent to which biogas generation and usage in currently practiced in Murehwa. Results pertaining to this objective are presented in the table 4.7 below.

Table 4. 5: Practice towards biogas generation and use

CODE		**Strongly Disagree 1**	**Disagree 2**	**Neutral 3**	**Agree 4**	**Strongly Agree 5**	**Mean**
P1	I usually make it safe to use biogas as a source fuel in my home		5.0%	12.5%	50.0%	32.5%	4.1
P2	I know how to transfer biogas from the main tanks to tanks which I use at my home	2.5%	2.5%	15.0%	62.5%	17.5%	3.9
P3	I participate in the production of FS-derived products		2.5%	30.0%	47.5%	20.0%	3.85
P4	I observe all the safety protocols during the production/generation of biogas		2.5%	22.5%	55.0%	20.0%	3.925
P5	As a community we practice biogas generation related programs with zeal			37.5%	52.5%	10.0%	3.725
	Grand mean						3.9

A total of 82.5% of villagers living in Murehwa practice the use of biogas safely in their homes while 5.0% confirms that they sometime do practice unsafe ways of using biogas. A total of 80% of villagers in Murehwa were able to transfer biogas from main tanks to smaller tanks while a total 5.0% were seeking help from others to use biogas. A total of 67.5% of villagers in Murehwa participated in the production of FS- derived products while a total of 32.5% were disagreement. The grand mean of 3.9 implies that villagers were in agreement that they are currently practicing biogas generation and usage.

4.5 Impact of KAP on social-economic factors

The last objective of the study was to determine the impact KAP on socio-economic factors of people living in Murehwa. Results in relation to this objective is presented in the table 4.6 below.

Table 4. 6: The impact of knowledge, attitude and practice on socio-economic factors

Code		**Strongly Disagree 1**	**Disagree 2**	**Neutral 3**	**Agree 4**	**Strongly Agree 5**	**Mean**
KAPSEF 1	Knowledge, attitude and practice towards biogas has created jobs to many people in my village			20.0%	60.0 %	20.0%	4.00
KAPSEF2	The installation of biogas digesters in my community has reduced the demand for imported LP gas and other related fuels			35.0%	50.0 %	15.0%	3.80
KAPSEF3	Organic fertilizer have been produced in my community and has resulted in greater yields	2.5%	2.5%	17.5%	62.5 %	15.0%	3.85
KAPSEF4	Successful biogas program brought villages clean fuel	2.5%		32.5%	50.0 %	15.0%	3.75

	and conserved forest						
KAPSEF5	Availability of clean fuel has lessen the burden on children and women in searching for fuel	2.5%	5.0%	20.0%	65.0 %	7.5%	3.7
KAPSEF6	Greenhouse emissions have subsequently been reduced owing to biogas generation		5.0%	17.5%	57.5 %	20%	3.925
KAPSEF7	Children have more time to attend to school work because there are no longer take time in searching for firewood		10.0%	37.5%	32.5 %	20.0%	3.625
	Grand mean						3.84

A total of 80% of villagers in Murehwa were in agreement that KAP has brought benefits to their current community and these are in the form of jobs. Importation of LP gas has subsequently been reduced due to usage and generation of biogas as indicated by a total 77.5% who were in agreement. A total of 72.5% of villagers in Murehwa were in agreement that the availability of clean fuel has lessen the burden on children and women in searching for fuel. Overall, a total 78.5% of villagers agreed that greenhouse emissions have subsequently been reduced owing to biogas generation and usage. The grand mean of 3.84 shows that people in Murehwa are in agreement that biogas generation and usage has brought benefits to their community.

4.4.1 Chi-square test on the relationship between knowledge toward generation and usage of biogas

Chi-square test was employed in this study to test whether knowledge towards biogas is associated with biogas usage and generation. The test is performed based on the following hypothesis;

H_0: knowledge towards biogas is not associated with biogas usage and generation

H_1: knowledge towards biogas is associated with biogas usage and generation

Table 4.10 below shows the chi-square test between knowledge towards biogas is associated with biogas usage and generation

Table 4. 7: Chi-square test between knowledge and biogas use and generation

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	103.364[a]	70	.006
Likelihood Ratio	64.616	70	.659
Linear-by-Linear Association	6.095	1	.014
N of Valid Cases	40		

a. 88 cells (100.0%) have expected count less than 5. The minimum expected count is .03.

According to results in the table 4.7 the Pearson chi-square statistic 103.364 and the p-value is below 0.05 this implies that H_0 is rejected and H_1 is accepted to be true and we conclude that knowledge about biogas is associated with biogas usage and generation. To put it simply, the result is significant and suggest that when villagers have knowledge about biogas it encourages them to adopt the use of biogas in their homes.

4.4.2 Chi-square test on the relationship between attitude towards generation and usage of biogas

Chi-square test was employed in this study to test whether attitude towards biogas is associated with biogas usage and generation. The test is performed based on the following hypothesis;

H_0: attitude towards biogas is not associated with biogas usage and generation

H_1: attitude towards biogas is associated with biogas usage and generation

Table 4.8 below shows the chi-square test between attitude towards biogas is associated with biogas usage and generation.

Table 4. 8: Chi-square test between attitude and biogas use and generation

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	67.851[a]	70	.551
Likelihood Ratio	57.322	70	.861
Linear-by-Linear Association	4.363	1	.037
N of Valid Cases	40		

a. 88 cells (100.0%) have expected count less than 5. The minimum expected count is .03.

Results in the table shows the Pearson Chi-Square test statistic 67.851 with p value above 0.05 this suggest that null hypothesis is accepted and alternative hypothesis is rejected and conclude that attitude towards generation and usage of biogas are independent. In other words, the results imply that people in Murehwa even if they develop some attitude towards biogas this does not necessary translate into them adopting and use biogas.

4.4.3 Chi-square test on the relationship between practice towards generation and usage of biogas

Chi-square test was employed in this study to test whether practice towards biogas is associated with biogas usage and generation. The test is performed based on the following hypothesis;

H_0: practice towards biogas is not associated with biogas usage and generation

H_1: practice towards biogas is associated with biogas usage and generation

Table 4.13 above shows the summary of the cases that was processed when the crosstabs analysis was ran. It is clear that 40 valid cases were included there was no missing cases within the data set. Table 4.14 below shows the chi-square test between practices towards biogas is associated with biogas usage and generation.

Table 4. 9: Chi-square test between practice and biogas use and generation

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	47.283[a]	35	.080
Likelihood Ratio	44.245	35	.136
Linear-by-Linear Association	16.923	1	.000
N of Valid Cases	40		

a. 48 cells (100.0%) have expected count less than 5. The minimum expected count is .03.

The Pearson Chi-square statistic of 47.283 which is associated with probability value of 0.08 which is above 0.05 suggest that alternative hypothesis is rejected and null hypothesis is accepted and conclude that practices towards biogas generation is not associated with usage.

4.4.4 Chi-square test on the relationship between KAP towards generation and socio-economic factors

Chi-square test was employed in this study to test whether KAP towards biogas is associated with socio-economic factor. The test is performed based on the following hypothesis;

H_0: KAP towards generation and usage of biogas is not associated with socio-economic factors

H_1: KAP towards generation and usage of biogas is associated with socio-economic factors

Table 4.10 below shows the chi-square test between KAP towards generation and usage of biogas is not associated with socio-economic factors.

Table 4. 10: Chi-square test of KAP and generation and socio-economic factors

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	47.381[a]	55	.758
Likelihood Ratio	42.768	55	.885
Linear-by-Linear Association	2.635	1	.105
N of Valid Cases	40		

a. 72 cells (100.0%) have expected count less than 5. The minimum expected count is .03.

Results in the table 4.10 shows the Pearson chi-square statistic of 47.381 which is associated with p-value greater than 0.05. Therefore, based on these results it implies that alternative hypothesis is accepted and null hypothesis is rejected and conclude that KAP is not associated with socio-economic factors.

These quantitative results were backed by qualitative information which was obtained from interviews. Some of the key informant who were interviewed had this to say;

> *As one of the NGO's operating in and around Murewa, we have been conducting massive trainings for villagers in order for them to have knowledge pertaining to the generation and usage of biogas. And I can confirm that on our last training, it was packed with villagers from different wards who attended the training, and I'm happy to say that almost every villager has knowledge of how biogas is generated and used. However, the challenge we noted was that fewer villagers have a positive perception of the usage and generation of biogas, perhaps because it's a new thing to them. However, as the providers of relief services in the area, we have partnered with a Chinese company to construct other biogas digesters and try to inculcate knowledge among the villagers; perhaps their negative attitude and practice towards the generation and usage of biogas might change for the better.*

One of the villagers who participated in the study had this to say;

> *I am very grateful for the knowledge I have gained from the NGO's organized training sessions, but its property is the issue. We still have a negative perception of biogas because it's new to us and we are used to firewood. However, the other reason why some of us have negative perception about biogas is because of its highly inflammable properties. However, we expect that to change since we are currently being taught how to safely use biogas.*

Another villager who was interviewed confirmed that by saying;

> *Biogas digesters seem to be difficult to build, and some of us did not go to school, so it is becoming difficult to understand. However, we are grateful to the NGO, which has partnered with a Chinese firm that is currently training each of us, and now I have an appreciation for how it is built. Oops, there is more to learn.*

Results from the interviews confirms that villagers are aware of the socio economic benefits that their area is currently realizing from biogas generation and usage and had this say;

> *The majority of us engaged in and gained experience with the building of the Eosin (urine diversion) toilets, which were built by a local NGO called CCI. CCI also taught the community members and handled financial loans to families. Since faeces comes out of our body, we've been taught that we can't utilize it. My religion forbids me from handling or eating human garbage. I would only eat faeces-derived products if the source was concealed or unknown. If it's human faeces or pee, it's filthy. Regardless of that I think as community we are benefiting from biogas as villagers are no longer cutting down trees which conserve our environment.*

In addition of the villagers had this to say

> *Forest cover loss might be lessened by replacing biomass with biogas energy. By lowering land erosion, this would benefit ecosystems and the environment. The use of biogas technology benefits the economy, the environment, human health, and society. It also provides a source of nutrient-rich organic fertilizer from effluent slurry that can be beneficial for algae growth, fish production, and seed germination.*

4.6 Chapter summary

The chapter gave a detailed presentation and discussion of results. The study results showed that there is low adoption of biogas in Murewa. In addition, the study established that villagers in Murewa are aware of the socio-economic benefits associated with biogas as indicated by positive correlation found between KAP and socio-economic factors. The next builds on this and present summary, conclusion and recommendations.

CHAPTER FIVE

DISCUSSION OF THE RESULTS

5.0 Introduction

The preceding chapters sought to lay a basis upon which the researcher could come up with findings. This chapter therefore seeks to summarize these research findings attaching meaning to data in the previous chapter. The discussion of these findings is based on the study objectives.

5.1 Discussion of findings

5.1.1 To assess rural people's knowledge towards generation and use of biogas

The first objective of the study was to assess rural people's knowledge towards generation and use of biogas. According to the results in the table 4.5 and 4.10 an association between knowledge and biogas generation and usage was discovered, implying that villagers in ward 28 have knowledge about biogas. In another words, increase in knowledge leads to increase in usage and generation of biogas. These results are in tandem with several studies that well documented.

These findings support Wrapai's (2019) hypothesis that sewage treatment plant biogas fuel might be used to generate electricity for cooking, heating sewage treatment facilities, and water heating. This fuel is readily accessible in raw form and is safe for the environment. Slurry, another by-product of biogas systems, is rich in nutrients and outperforms artificial fertilizers in terms of performance. The residue that is created as a byproduct in the digester may potentially be used as animal and poultry feed due to the nutrients it contains. For the management of the slurry, skilled work is not required (Mwakaje, 2018).

5.1.2 To assess rural people's attitude towards generation and use of biogas.

The study's second goal was to evaluate rural residents' opinions toward the production and usage of biogas. A Chi-square value above 0.05 indicates that there was no association between views regarding biogas generation and utilization and the findings in tables 4.6 and 4.12. This finding suggests that even if residents of Murewa in Ward 28 adopt a positive attitude toward biogas, this does not necessarily transfer into their adoption and use of the fuel. The findings also imply that although the communities in Ward 28 are not even involved in its production or use, they have a negative opinion of biogas. The findings are at odds with research that have been done on biogas.

For instance, Raskovic et al.'s 2019 study found that biogas fuel is a useful tool for boosting local populations' quality of life. It is an advanced biomass energy source that calls for more resources and technology than what can be provided by straightforward bio-digesters (Jury et al., 2018). This technology has significant benefits for the welfare of people and ecosystems while being a very efficient approach to meet local energy demands. The technology is additionally thought to help with rural development (Raskovic et al., 2019). More people than ever before are using biogas.

Biogas plants come with a number of unexpected benefits in addition to offering solutions to present environmental problems (Drabez et al., 2019). According to other studies, building human and financial capacity through the provision of power that is affordable and dependable is a vital component of rural communities' ability to adapt to the effects of climate change (Casillas and Kammen, 2018).

The benefits of biogas include time and money savings, a reduction in burden, and improvements to health and quality of life. Women are the main beneficiaries in families, according to various research (Amjid et al., 2017; Ghimire, 2018; Justus K. Laichena & Wafula, 2017; Rajendran et al., 2018; Sankarlal, 2018; Sovacool et al., 2018). In rural areas, 90% of the energy used is for cooking. Women predominately perform the task of cooking (Rajendran et al., 2018; Rowse, 2018). In rural homes using biogas, the average use of firewood declines by 53% (Rowse, 2018). Sovacool et al. (2018) used emotional responses that were produced by showing photographs of the most well-liked products made from excrement and hearing about their uses to rural communities in their study.

5.1.3 To assess rural people’s practices towards generation and use of biogas

Third objective of the study was to assess rural people’s practices towards generation and use of biogas. Results found in this study suggest that villagers in Murewa are not practicing the production and usage of biogas as the results established that there is no association between practice and usage and generation of biogas. The p value of the Chi-square obtained was $p > 0.05$, implying that there is no association between the usage of biogas usage and generation. These results are contradicting several authors who found that a positive relationship between practicing biogas generation and usage and adoption of biogas.

The Norwegian Institute of Bioeconomy Research, NIBIO (formerly Bioforsk), undertook a study in China in 2022 to ascertain whether more sophisticated and useful biogas digesters exist in comparison to the traditional fixed dome and floating dome digesters made of brick and concrete. The study's conclusions suggested that fibreglass digesters would be effective in tropical countries like Africa, where they are already used.

5.1.4 To relate KAP to socio-economic factors

Last objective of the study was to relate KAP to socio-economic factors. According to results obtained in the study no association was found between KAP and socio economic factors. This implies that an increase in KAP would not lead to substantial increase in socio-economic factors of villagers in ward 28. The reason could be that some people in ward 28 have no positive attitude and are not fully currently practicing generation and usage of biogas. A positive change on socio-economic factors is sometimes realized once they start to fully exploit biogas. The research by Rajendran et al. (2017) and Roubk et al. (2017), which found that biogas has economic benefits in the areas of a cleaner environment, forest preservation, increased food production, decreased carbon emissions/global warming, improved health, economic growth, poverty alleviation, increased employment opportunities, more free time for women, and increased happiness due to a better lifestyle and food security, is not in line with these findings.

Incorporating biogas technology among dairy producers could also help reduce indoor air pollution and the prevalence of respiratory illnesses, according to Katuwal and Bohata (2019). According to Mwakaje's (2018) citation of study, the deployment of biogas technology at the home level promotes women's empowerment by reducing their burdensome chore of harvesting wood fuel. Additionally, this technology helps women and promotes gender equity. Mwakaje's research indicates that families in Tanzania using biogas energy were able to save more time every day by eliminating the need to harvest biomass. Tasks that would generate income would be completed during this period, improving community livelihoods. In addition, the trees that are still surviving because the farms are using less wood fuel. Trees block wind, which enhances the microclimate, biogas technology, and lowers air pollution (smoke from biomass) and global warming by lowering GHGs, according to Smith et al. (2018).

Additionally, biogas technology may play a key role in waste management on farms (IFAD, 2009), assisting in lowering methane emissions that would be produced by residues if they were left to decompose in an open field. Dairy farmers can benefit from using bio-slurry since it contains a lot of nutrients and lessens the requirement for artificial fertilisers (Katuwal and Bohara, 2009). Particularly among dairy producers, animal faeces and urine are turned into energy sources. Another benefit of using biogas is that it may be sold to generate revenue for dairy farmers.v

5.2 Chapter Summary

This chapter gave a detailed interpretation of findings from the preceding chapter. Meaning was given to data presented in figures and tables in the previous chapter. The next chapter will give a conclusion to the study, recommendations to the people in Murewa ward 28 among others and highlight the grey areas that need to be further tackled.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Chapter Introduction

This chapter concludes the research work and provides recommendations based on the responses obtained during the research and data analysis.

6.1 Summary

The project titled "KAP on Biogas Use and Generation in Murehwa District" aimed to assess the knowledge, attitude, and practices (KAP) of rural communities regarding the use and generation of biogas. The main objective was to evaluate the level of KAP towards biogas among rural communities, with secondary objectives focused on assessing knowledge, attitude, and practices individually and examining their relation to socio-economic factors. A mixed methodology approach was employed, combining qualitative and quantitative methods. Data was collected from a sample of 50 individuals using semi-structured questionnaires and interviews, administered in both English and the local language. Data analysis involved descriptive statistics, regression analysis, and correlations using SPSS.

The findings indicated that a significant percentage (73.2%) of the villagers had prior knowledge of biogas, demonstrating a promising level of awareness. Additionally, 65.9% of the participants were currently using biogas in their homes, indicating a positive correlation between knowledge and usage. Interestingly, 42.5% found biogas usage interesting, while 10% expressed no interest. Furthermore, the results revealed that the majority (82.5%) of villagers practiced safe usage of biogas, with only a small percentage (5.0%) occasionally engaging in unsafe practices. It was found that 80% of the participants were capable of transferring biogas from main tanks to smaller ones, indicating a level of proficiency in handling the technology. Moreover, a significant proportion (67.5%) of the villagers actively participated in the production of FS-derived products.

Overall, the findings suggested that the community perceived biogas generation and usage positively, as indicated by the high agreement percentages (e.g., 80% agreed that KAP brought benefits to their community). Additionally, the results indicated a reduction in greenhouse emissions (78.5%) and a decrease in the importation of LP gas (77.5%) due to the utilization of biogas. Regarding the objectives, the study revealed a significant association between knowledge and biogas usage and generation, suggesting that increased knowledge leads to higher adoption rates. However, no significant association was found between attitude and biogas usage, indicating that attitude alone does not necessarily result in adoption. Moreover, no association was found between practices and biogas generation, suggesting that current practices may not directly contribute to biogas usage. In terms of socio-economic factors, the study found no significant association between KAP and such factors. This implies that increasing KAP alone may not lead to substantial improvements in socio-economic conditions within the community.

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6.2 Conclusion

The first objective of the study was to assess rural people's knowledge towards generation and use of biogas. According to the results in the table 4.5 and 4.10 an association between knowledge and biogas generation and usage was discovered, implying that villagers in ward 28 have knowledge about biogas. In another words, increase in knowledge leads to increase in usage and generation of biogas.

Second objective of the study was to assess rural people's attitude towards generation and use of biogas. According to the results in the table 4.6 and 4.12 no association was found between attitude towards biogas generation and usage as noted by a Chi-square value statistic above 0.05. This results implied that that people in Murewa in ward 28 even if they develop some attitude towards biogas this does not necessary translate into them adopting and use biogas. The results also suggested that villages in ward 28 have negative attitude towards biogas but there are not even participating in the production latter its usage

Third objective of the study was to assess rural people's practices towards generation and use of biogas. Results found in this study suggest that villagers in Murewa are not practicing the production and usage of biogas as the results established that there is no association between practice and usage and generation of biogas.

Last objective of the study was to relate KAP to socio-economic factors. According to results obtained in the study no association was found between KAP and socio economic factors. This implies that an increase in KAP would not lead to substantial increase in socio-economic factors of villagers in ward 28. The reason could be that some people in ward 28 have no positive attitude and are not fully currently practicing generation and usage of biogas.

6.3 Recommendations

The study's recommendations are based solely on the findings of the investigation. The researcher comes to the conclusion that stakeholders should collaborate in an integrated manner in order to prioritise and raise awareness of the advantages of FS-RRR for communities in Murewa and other areas in order to advance the FS-RRR concept and sustainable FSM. To concentrate his efforts, the researcher identified three crucial areas. First, it is important to educate local people, particularly women, about what FS-RRR implies, including any existing prohibitions on utilising items made from human waste. In order to give consumers the opportunity to see how items are made and utilised, demonstration units should emphasise presenting finished goods that are already well-liked by the public. Third, sanitation management organisations should organise stakeholder gatherings to promote the creation of inclusive policies and rules that will enhance FSM and ensure the secure supply of raw materials for FS-RRR. In conclusion, the study demonstrates that scaling up FS-RRR acceptance in Murewa and elsewhere will require more than simply functional technology. In fact, if we want it to be successful, understanding what people need to know, how they feel, and what it takes for them to use it is just as important.

6.4 Areas for future studies

The study looked at KAP only in Murewa the researcher encourages more similar studies conducted in other areas in Zimbabwe. The study relied on Chi-square to analyse data and to establish association therefore further manipulation of data can be done in other research such regression analysis so that the magnitude of association can be established.

6.5 Chapter Summary

This chapter has summarized the findings, provided the conclusions as well as the recommendations. The researcher also suggested areas for future research.

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APPENDICES

Annex 1: Questionnaire and Interview Guide

BINDURA UNIVERSITY OF SCIENCE EDUCATION
FACULTY OF AGRICULTURE AND ENVIRONMENT SCIENCE

Preamble

I am a student at Bindura University, Department of environment science studying towards a degree in Natural Resource Management. In partial fulfilment of my studies I am supposed to conduct a research project. In compliance with this requirement I have chosen to do a research titled. Knowlegde Attitudes and Practices of biogas use and generation in Murehwa District. I kindly ask you to help me by filling in this questionnaire so that I complete my dissertation. The study is purely for research purposes and any information provided will be treated with strict confidentiality. For further information please feel free to contact my supervisor ………………………………..).

Yours faithfully

Your name. Reg n#

INSTRUCTIONS

1. Please do not write your name on the questionnaire

2. Please respond by ticking (✓) the appropriate box where applicable.

SECTION A: DEMOGRAPHIC DATA

This section focuses on the respondent's demographic data.

1. Age

a). 18-29 years ☐ b). 30- 39 years ☐ c). 40 – 49years ☐

d) 50 and above ☐

2. Sex

a). Male ☐ b). Female ☐

3. Marital Status

a). Married ☐ b). Divorced ☐ c). Single ☐ d).Widowed ☐

4. Highest Level of Education

a). Certificate ☐ b). Diploma ☐ ☐). Degree

d). Others (Specify)…………………

Using the scale given below, please tick or circle the statement that best represents the extent to which you agree with the given statements.

1 - Strongly disagree 2 - Disagree 3 -Neutral 4 -Agree 5-Strongly agree

SECTION B: Knowledge

Indicate your level of agreement with the following statements measuring Knowledge towards biogas generation and usage

No	statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree

1	I have heard about biogas generation before					
2	I know how biogas is generated					
3	I'm currently using biogas in my home					
4	I participated in the construction of biogas digester in my community					
5	I encourage other villagers to try biogas					

SECTION C: Attitude

Indicate your level of agreement with the following statements on attitude towards biogas generation and use

No	**Statement**	**1 Strongly Disagree**	**2 Disagree**	**3 Neutral**	**4 Agree**	**5 Strongly Agree**
1.	I find it interesting using biogas in my home					
2.	I'm satisfied by using biogas as source of fuel in my home					
3.	Generation and using biogas is relatively simple					
4.	I actively involved in biogas generation in my village					
5.	Experimental activities involved in biogas generation helped me in understanding the importance of biogas					
6.	Using biogas improved the quality of some task in my home					

SECTION D: Practice

Indicate your level of agreement with the following statements

		Strongly	**Disagree**	**Neutral**	**Agree**	**Strongly**

		Disagree 1	2	3	4	Agree 5
1.	I usually make it safe to use biogas as a source fuel in my home					
2.	I know how to transfer biogas from the main tanks to tanks which I use at my home					
3.	I participate in the production of FS-derived products					
4.	I observe all the safety protocols during the production/generation of biogas					
5.	As a community we practice biogas generation related programs with zeal					

SECTION E: The impact of knowledge, attitude and practice on socio-economic factors

Indicate your level of agreement with the following statements measuring the impact of knowledge, attitude and practice on socio-economic factors

No		Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
1.	Knowledge, attitude and practice towards biogas has created jobs to many people in my village					
2.	The installation of biogas digesters in my community has reduced the demand for imported LP gas and other related fuels					
3.	Organic fertilizer have been produced in my community and					

	has resulted in greater yields					
4.	Successful biogas program brought villages clean fuel and conserved forest					
5.	Availability of clean fuel has lessen the burden on children and women in searching for fuel					
6.	Greenhouse emissions have subsequently been reduced owing to biogas generation					
7.	Children have more time to attend to school work because there are no longer take time in searching for firewood					

Thank you for your co-operation.

Interview guide

1. Do you use biogas fuel at home?
2. If yes, how do you compare it with other type of fuels in terms of cost?
3. What do you understand about biogas generation?
4. What is your knowledge towards biogas generation?
5. What is your attitude towards generation and use of biogas?
6. What were some of the challenges in the use of biogas fuel?
7. Does biogas fuel use affect the environment negatively?
8. What is your future plan concerning biogas fuel use as a clean energy?
9. What are the current practices in relation to biogas generation?

Annex 2: Pictures taken from ward 28 during research

The following pictures were taken from Murehwa ward 28. These pictures show how the villagers are currently practicing biogas production using cow dung.

Picture 1

The picture 1 shows villagers mixing cow dung with water for the preparation of biogas.

Picture 2

Picture 2 shows fresh dung in a wheelbarrow.

Picture 3: Shows biogas digester made of brick and concrete underground.

Picture 4 shows biogas digester buried underground.

Picture 5 shows an ordinary LP gas cylinder modified to store the harvested biogas.

Picture 7: A water trapping tool made from a bottle