

Maramura, Tafadzwa Clementine; Maziriri, Eugene Tafadzwa; Chuchu, Tinashe et al.

Article

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Kontakt/Contact

ZBW – Leibniz-Informationszentrum Wirtschaft/Leibniz Information Centre for Economics
Düsternbrooker Weg 120
24105 Kiel (Germany)
E-Mail: [rights\[at\]zbw.eu](mailto:rights[at]zbw.eu)
<https://www.zbw.eu/>

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Renewable Energy Access Challenge at Household Level for the Poor in Rural Zimbabwe: Is Biogas Energy a Remedy?

Tafadzwa Clementine Maramura^{1*}, Eugene Tafadzwa Maziriri², Tinashe Chuchu³, David Mago⁴, Rumbidzai Mazivisa⁴

¹Department of Public Administration, University of Fort Hare, Faculty of Management and Commerce, South Africa, ²Department of Business Management, University of the Free State, Faculty of Economic and Management Sciences, South Africa, ³Department of Marketing Management, University of Pretoria, Faculty of Economic and Management Sciences, South Africa, ⁴Great Zimbabwe University, Julius Nyerere School of Social Sciences, Zimbabwe. *Email: tmaramura@ufh.ac.za

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ABSTRACT

This study examined Zimbabwe's energy access situation and suggests that Zimbabwe's energy access solution goes beyond providing biogas energy alone but needs addressing the root causes of Zimbabwe's inability to access renewable energy. The paper also challenges biogas fuel prospects and shortcomings. A mixed-method methodology has been used. Next, the qualitative data analysis was carried out using thematic analysis. The themes emerging from the findings include lack of knowledge about biogas power, difficulties in accessing start-up capital, and lack of resources needed. From a quantitative viewpoint, it was discovered that lack of adequate funds, high installation costs, lack of adequate data and negative attitudes to the community are some of the challenges that block biogas to be considered as renewable energy for the poor in rural Domboshava, Zimbabwe at household level. Based on the findings of the article, organizational consequences are explored, and recommendations are made for shortcomings and future directions for analysis. Broadly speaking, this study adds enormously new knowledge to the existing energy economics literature in Africa—a context that some scholars in developing countries still ignore most.

Keywords: Waste Management, Energy Poverty, Firewood, Deforestation, Sustainable Development

JEL Classifications: C30, D12, Q41, Q48

1. INTRODUCTION

Energy today is at the heart of sustainable development (Jigar, 2010). Expanding access to sustainable renewable energy, therefore, is the key to people-centered development as evidenced by Zimbabwe's policies which advocate for expanding access to renewable and sustainable energy namely but not limited to Section 73 of the constitution of Zimbabwe, the environmental management act, the national energy policy of 2012, the renewable energy policy, the rural electrification fund act, the Zimbabwe energy regulatory authority and the electricity act (Stiftung, 2015). Expanding access to sustainable and renewable energy is also a priority of the international agenda as evidenced by being

among the aims of the sustainable development goals (SDGs) the successor of MDGs, which advocates for economic development that leaves no one behind but gives everyone chance to a decent life (UNDP, 2015).

This is so because sustainable development goal number seven acknowledges the importance of “access to affordable, reliable, sustainable and modern energy for all” (Munro, van der Horst and Healy, 2017). Energy access, however, varies widely across countries. About 1.2 billion people have no access to electricity in the world (He and Victor, 2017) and 95 % of the 1.2 billion who have no access to electricity are from Sub Sahara Africa and Asia (World Bank, 2014). Over 65% of the Sub Sahara

African population do not have electricity (UN Statistics, 2016). Zimbabwe is part of Sub Sahara Africa and is not immune to the challenge of energy access. The current rate of progress in access to renewable and sustainable energy falls short of what is required to meet the goal of access to affordable, reliable, sustainable and modern energy for all. Energy access in rural areas goes beyond awareness to rural people about the technology but must take into consideration the income status of the rural people. Some of the people who stay in rural areas struggle to put food on the table. In such a scenario, the use of sustainable energy is a second option. Some people even struggle to access firewood, candles, and kerosene worse biogas technology. Overlooking the root causes of why rural people are not able to access sustainable energy will result in solutions which address symptoms making rural people not to graduate from using non-renewable energy (Han and Wu, 2018).

There is need therefore to come up with sustainable energy supply to meet the growing demand. The global energy consumption has many negative effects on the local, regional and global environment that include global, local and regional air pollution. Most households use solid fuels for cooking and the burning of fossil fuels has contributed to the two million deaths annually (World Health Organization, 2009). In Zimbabwe, the majority of the people in use wood. Use of firewood comes with major negative impacts on human health. Wood smoke contains over 200 toxic chemicals. Components of wood are like cigarette smoke, for example, wood and cigarette smoke contain carbon monoxide, formaldehyde, sulfur dioxide, nitrogen oxides, dioxins, and polycyclic aromatic hydrocarbons. Wood smoke exposure doubles the individuals' risk of getting lung cancer (Arrieta et al., 2012), as well as mouth and throat cancer (Pintos et al., 1998). In addition, wood smoke exposure depresses the immune system (Unosson et al., 2013) and damages the DNA (Danielsen et al., 2011). Exposures to wood smoke in children increase the risk of brain tumors (Greenop et al., 2014) and respiratory infections such as bronchitis and pneumonia. Young children under the age of five and women who spent most of their hours cooking are the worst affected. Furthermore, the use of fuelwood has contributed to the increase in deforestation leading to the depletion of forest, loss of carbon sinks and other ecosystem values and functions that come from trees. In this regard, the major drivers of global warming and climate change are anthropogenic activities from fossil combustion (World Health Organization, 2009). This contradicts with section 73 of the constitution of Zimbabwe which states that everyone has the right to an environment that is not harmful to their health and wellbeing and to have the environment protected for the benefit of present and future generation. There is need in introducing renewable sources of energy to reduce environmental damage and protecting human health. Numerous efforts by the SNV Netherlands development organization, ministry of energy and power development, ministry of agriculture, mechanization and irrigation development and renewable energy fund have initiated the biogas in Domboshava and other parts of Zimbabwe, to counteract the environmental, health problems from wood fuel use.

Against the aforementioned background, the rest of the paper progress as follows: To begin with, the next section focuses on

the study's the research context of the study, research objectives, research questions and literature review. The methodology that guides the study is discussed hereafter and, subsequently, the study results, discussions, recommendations and conclusions are presented.

1.1. Research Context

Zimbabwe is confronted by a severe energy crisis characterized by insistent load shedding and power blackouts which undermine the development of the economy and people's livelihood (Maqhuze et al., 2019). An estimate of the cost of electricity supply outages in Zimbabwe in 2009, was about US\$1.8 billion (Kaseke, 2014). Access to renewable energy in rural Zimbabwe is still rampant as evidenced by 94% of the rural households in Zimbabwe which mainly use firewood for cooking which is non-renewable energy as compared to 73% of urban households who use electricity for cooking (Kunatsa and Mufundirwa, 2013). Although firewood is non-renewable, access to firewood in rural areas in Zimbabwe is a challenge because of deforestation through clearing land for agriculture which results in shortage of firewood. Firewood is mostly collected by women and they walk for long distance to collect firewood. Accessing firewood is a big challenge to the poor as compared to the rich people who can afford to buy firewood and use diesel generators.

Since independence, most rural people continue to have no access to renewable energy which makes it questionable if Zimbabwe will be able to meet SDG7 of accessing modern energy for all in a country where even accessing firewood is a challenge. Getting income for energy among unemployed rural people is a challenge. Most rural households depend on agriculture, artisanal mining, and remittances. Due to lack of agriculture support systems such as provision of agricultural inputs, irrigation, support in marketing, drought, and use of traditional tools, agriculture in some rural areas does not bring much on the table, leaving such rural unemployed people with an option of artisanal mining and remittances. From the little income which rural people get, they spent most of their income on energy, for instance, buying firewood, candles, kerosene, and diesel for generators. In the same line, Sovacool (2012) pointed out that the motive of profit maximization over meeting the energy needs of the private sector and competing priorities of government officials are barriers of rural people in access to energy. Not having access to and inability to afford renewable and modern energy and cooking with firewood are signs of poverty.

Using the UNDP multidimensional poverty indicator, inability to cook, read or do other household productive activities with electricity and cooking with traditional renewable energy constitutes poverty. This goes in line with the International Energy Agency which classifies lack of access to electricity and depending on using traditional energy (Sovacool, 2012). This study used the Asian development bank definition which defines energy poverty as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (Masud et al., 2007. p. 47).

This study's demarcation area answers to the name Domboshava. According to Hungwe (2014. p. 8), Domboshava is situated twenty

kilometers northeast of Harare. In addition, Hungwe (2014, p. 8) notes that Domboshava is considered as a rural area and falls under traditional authority and a local authority called Goromonzi rural district council (GRDC). Domboshava communal area is largely populated by people who speak Zezuru, a Shona dialect which is one of the main vernacular languages of Zimbabwe (Ingwani, 2015). The average poverty prevalence in the area ranges between 61% and 72% according to (Sakarombe, 2017). Poverty is more prevalent on the northern peripheral areas of Goromonzi District in wards 01, 02, 03, 04 and 05 which forms the huge part of Domboshava area (Sakarombe, 2017). Major economic activities in the area range from market gardening, grain production, livestock rearing and in general terms it can be said that most people in Domboshava are subsistence farmers who grow groundnuts, maize and other small grains for food security (Sakarombe, 2017). However, Zvigadza et al. (2010) mentioned that for decades' families in Domboshava has been relying on market gardening activities for survival but things seem to be changing as the area is facing serious deterioration of water levels, expanding population, economic stagnation and a flooded market for some of its agricultural products. Figure 1 below depicts the map of Zimbabwe showing the Domboshava rural area.

1.2. Research Objectives

The purpose of this study is to give a comprehensive energy access situation of rural poor people in Zimbabwe and analyze whether biogas energy can be an appropriate remedy.

1.3. Research Questions

This research is guided by the following key questions:

- What are the types of energy sources at the household level in Domboshava?

- What are the social, environmental, health benefits of biogas in Domboshava?
- What challenges do households face in the adoption of biogas in Domboshava?
- How can biogas energy be promoted in Domboshava?

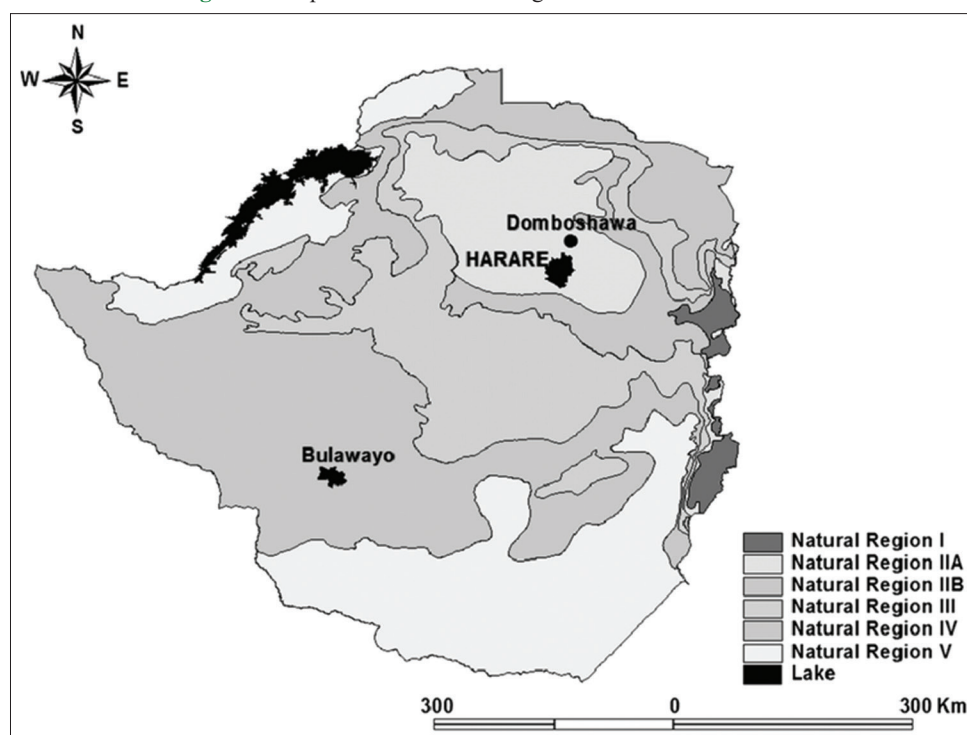
2. LITERATURE REVIEW

Chinomona and Maziriri (2017) posit that literature serves the purposes of sharing findings of other studies related to the study at hand, relating the study to a larger ongoing conversation in literature as well as fillings gaps and extending prior studies. The literature review will comprise: defining biogas technology, the status of biogas technology in Zimbabwe, the advantages and challenges of adopting biogas technology.

2.1. Defining Biogas Technology

Biogas technology is a renewable form of energy that utilizes various organic wastes in the absence of oxygen to produce a combustible mixture of methane and carbon dioxide gases, mineralized water and organic fertilizer (Gautam, Baral and Herat, 2009). In other words, the technology recovers biogas by harnessing anaerobic degradation pathways controlled by microorganisms. The gas is principally a mixture of methane (CH_4) and carbon dioxide (CO_2), and other trace gases such as hydrogen sulfide (H_2S) (Singh and Sooch, 2004; Shin et al., 2005). Biogas which can be produced from municipal solid waste, sewerage, livestock manure, crop and forest residues is one of such renewable energies (Shane et al., 2017). Biogas can be used as fuel to provide energy for cooking, lighting, heating and electricity generation (Igliński et al., 2015). Biogas is biomass based renewable energy;

Figure 1: Map of Zimbabwe showing the Domboshava rural area



Source: Hungwe (2014, p. 8).

by 2009, biomass contributed about 13% towards energy demand globally and by 2012 biomass primary energy supply had reached 55 EJ per annum (Hijazi et al., 2016).

2.2. The Status of Biogas Technology in Zimbabwe

Biogas production and use are not new in Zimbabwe (Sakarombe, 2017). According to a journal published by the then Department of Energy and Water Resources, the government-assisted towards the construction of more than a hundred biogas units in rural areas and tertiary institutions in the 1980s. According to Chimombe (1988), these were set to be demonstration centers where people could be taught and replicate the new technology. However, it has been concluded that the technology has never taken off as initially envisaged and it is in the recent years that the government has sought to revive the dissemination of biogas technology in a desperate need to quench the growing need of renewable energy sources in rural areas (Sakarombe, 2017). In another development, SNV in partnership with the ministry of agriculture, mechanisation and irrigation development and the renewable energy fund is actively promoting biogas to provide access to clean energy for cooking, lighting and other productive use in Insiza, Chegutu, Goromonzi, and Mvuma. Furthermore, more than 70 biogas masons, as well as 18 fabricators, have been trained to take up the installation of biogas plants. Despite the efforts, potential and advantages of biogas technology in Zimbabwe, (Sakarombe, 2017) stated that low uptake of the technology and further reported partial adoption in households with biogas units. The reasons for this have never been adequately known and are yet to be documented.

2.3. Biogas Technology is an Alternative for Healthy Cooking which Reduces Pollution

Biogas energy is a suitable alternative for cooking and heating energy (Subedi et al., 2014). Biogas technology uses animal waste therefore, it reduces pollution of air and water through animal waste (Roy, 2018). Using biogas for cooking instead of firewood reduces the exposure to smoke during cooking thereby reducing respiratory diseases and lowering of the immune system. About 4.3 million people die prematurely due to household air pollution and use of non-renewable sources of energy.

2.4. Biogas Technology is Affordable and Renewable

The technology for biogas such as small-scale biodigesters is affordable, simple and easy to maintain. Small scale biogas is affordable in the sense that material for biogas such as kitchen and animal and plant waste can be free. Biogas energy can be used for cooking, lighting charging batteries and the waste can be used as manure for crops. Biogas energy is clean as compared to firewood which produces a lot of indoor air pollution (Muvhiiwa et al., 2017). Using household waste for biogas keeps the environment clean and improves water quality because household waste will not flow in rivers. Biogas energy could be a suitable alternative for cooking and heating energy and therefore is proposed as one of the approaches to reduce deforestation, particularly deforestation resulting from wood fuel consumption (Subedi et al., 2014). According to Yasmin and Grundmann (2019) biogas may reduce the burden upon women of collecting wood and is acknowledged to have a positive impact on rural livelihood as it reduces the number of flies and controls waste odor.

By providing an alternative energy source that would otherwise be obtained from fuelwood or charcoal, it is widely assumed that biogas digesters could help to reduce the rate of deforestation in SSA (Lohan et al., 2012; Garfi et al., 2012; Sovacool and Drupady 2011; Felix and Gheewala, 2011). Against this background, it is imperative to note that, as compared to firewood, biogas technology saves time especially to women and children who are the main people who collect firewood in rural areas. Instead of spending much time walking for long distances looking for firewood, using biogas technology which uses readily available household waste. This relieves women and children from a daunting task of collecting firewood and gives children especially the girl child more time to focus on their studies rather than missing classes whilst looking for firewood (Muvhiiwa et al., 2017).

2.5. Biogas Energy is Sustainable

Biogas produced from organic matter is increasingly becoming a renewable energy solution in relation to growing energy and organic waste concerns to mitigate the environmental and public health concerns of organic waste (Govender et al., 2019; Garcia and You, 2018). Compared to other renewables such as wind, solar and hydroelectric, Biogas offers end-user multifaceted benefits (Hakawati et al., 2017). Biogas can produce fertilizer, heat, carbon dioxide (food and beverage industries) and methane that can be used in various industrial applications (solvents, plastics and insecticide industries), including electricity production (Cheng et al., 2014), besides having a distinct advantage in controlling organic waste. In addition to the above, for renewable energy systems, biogas has the second smallest life cycle emissions (LCE), with wind energy having the smallest LCE. Compared to conventional energy systems such as coal, gas, and oil, Biogas LCE is also more than 3 times smaller (Govender et al., 2019). Deducing from the aforementioned elucidation, it can be also noted that the inputs for biogas such as manure, crop residues, and food scraps are freely available and will always be available which makes it be a sustainable energy alternative at household level in rural areas.

2.6. Challenges of Adopting Biogas Technology

According to Chinomona and Maziriri (2015) a challenge is a situation that tests someone's abilities and points out that a challenge is a thing, action or situation that causes an obstruction; it blocks or hinders progress. In addition, Chinomona and Maziriri (2015) are also of the view that a challenge is something needing great mental or physical effort in order to be done successfully. Challenges could be analogous to barriers. In line with this thought, Horn et al. (2009) define barriers as obstacles that prevent movement or access. For the purpose of this paper, challenges will refer to those hurdles that hinder the community of Domboshava from successfully adopting and utilizing biogas technology. These challenges are discussing in the next sections. Although biogas technology can be an alternative source of energy for rural people, some rural people are poor to such an extent that they do not own any animal to produce manure neither do they afford to buy biogas technology. In such a situation, introducing biogas technology, without providing jobs or energy grants will not solve the challenge of energy poverty but will leave the rural people with an option of using firewood which contributes to deforestation and global

warming. Just like other energy sources such as solar, biogas has a disadvantage of being affected by weather, when it is cold biogas digesters require heat energy to maintain constant biogas supply. Therefore, during cold weather, biogas energy will be affected yet people will need to use energy all the times irrespective of weather. Biogas technology is less suitable for use in rural un-electrified clinics, schools, and townships because people who live in such areas do not have animals. In schools, it is not easy for teachers to keep cattle in school cottages neither nurses to keep cattle at the clinic. Using biogas technology in such a situation is limited and becomes more expensive and time-consuming because of the nurses and teachers, specifically those who will be originally coming from other provinces if they want to use biogas technology they will have to buy or ask for cow dung and crop residue from neighboring villages.

3. METHODOLOGICAL ASPECTS

This present investigation pursued a pragmatism paradigm, as it socially constructed, based on the lived realities of research objects. According to Feilzer (2010), pragmatism as a research paradigm emerges as accepting both singular and multiple realities in the world, setting itself towards solving practical problems in the real world. Wahyuni (2012) is of the view that the pragmatic paradigm is grounded on the notion that the nature of reality is multi-faceted and externally generated and that the best research approach is the one that answers the research questions of the study. Pragmatism is outcome-oriented and interested in determining the meaning of things or focusing on the product of the research (Johnson and Onwuegbuzie, 2006). Moreover, Sefotho (2015) succinctly explains that central to pragmatism is the practical nature of being, reality or phenomenon and through pragmatism, researchers become aware and are receptive of the ideas of others.

Against the aforementioned elucidations, the current study employed both qualitative and quantitative methods of data collection to complement each other. According to Bryman (2008), the strength of one method helps to overcome the weakness of another thereby achieving a cost-benefit analyst balance. The main idea behind quantitative research is also to separate issues easily so that they can be counted and modeled statistically, to remove factors that may distract from the intent of the research. Quantitative methods are important because they set the research problem in very specific and set term clearly and precisely. The qualitative approach enabled the researchers to make an in-depth investigation of the variables related to adoption and non-adoption of biogas technology. The instruments used include questionnaire, key informant interviews, focus group discussions, observation and desk study.

3.1. Target Population and Sampling Procedures

Selection of respondent households was done through purposive stratified sampling method. Quantitative methods were also used in collecting data. Stratified random sampling was done to select the households that were interviewed in the village. Purposive sampling was employed for selecting 20 households that had adopted biogas technology and 80 households that had not adopted the technology. Interviews were conducted with Domboshava community members for the purpose of data collection.

3.2. Qualitative Data Analysis

All interviews were documented and transcribed for analysis. The study employed a qualitative research design using a thematic analysis. The grounded theory technique is a systematic approach encompassing the discovery of theory through the analysis of data. After verbatim transcription of the focus group interviews, the researchers analysed all the records of the focus group interviews by using the process suggested by Corbin and Strauss (1990). The researchers recommended the utilization of the following procedures in the data analysis:

- Open coding: According to Corbin and Strauss (1990, p. 4) “open coding is the process of breaking down, examining, comparing, conceptualizing and categorizing data.” The researchers began data analysis by interpreting the recorded notes and paying attention to the interviews documented on tape to familiarize themselves with the data. This stage was important to ensure that the researchers capture all the important points raised by respondents in the focus group interviews and to establish the depth of the data
- Axial coding: According to Muposhi and Dhurup (2016), axial coding involves reading the transcribed notes again to identify the connections between the themes that emerged from open coding. The researchers reviewed the themes to analyses the relationship between themes and sub-themes. Themes that were related were further collapsed to come up with one dominant theme
- Selecting coding: “Selective coding is the procedure of selecting the core category, systematically relating it to other categories, validating those relationships, and filling in categories that need further refinement and development” (Corbin and Strauss, 1990, p. 5). This procedure was undertaken to identify the main themes that were related to the study (Cresswell, 2014) and draw conclusions grounded on the emerged themes.

4. FINDINGS

The discussion in this research paper is presented in line with the themes that arose from the focus group and interview transcripts. Thematic analysis is defined as a meticulous process of identifying, analysing and reporting themes that emerge from a qualitative study (Maziriri et al., 2017). Thematic analysis is regarded as the “foundational method for qualitative analysis” and was the chosen to formally commence the analytical process given its suitability to the exploratory nature of the research (Apolloni, 2010, p. 88). The major advantage of thematic analysis is that it is a logical process that allows the researcher to scrutinize interview transcripts comprehensively and glean all possible themes (Maziriri et al., 2017; Muposhi, 2015, p. 168; Muposhi et al., 2015, p. 230). The following framework indicates the main themes identified in the data sources. Each theme will be discussed individually, followed by substantiating quotes.

4.1. Theme 1: Lack of Knowledge about Biogas Energy

The first theme that emerged from the interviews was that of lack of knowledge about biogas energy. Data from the study also revealed that participants were not aware of the advantages that emanate from biogas. Only a few indicated that they had once received

support from the government and went further to high light that the government support, they received was not enough to sustain them in running biogas energy generation projects. This view is aptly encapsulated in the following comments:

"I am not even aware of what bio-gas energy is and the available support that may assist me depending on biogas energy." (Male, 45)

"With the current energy crisis that is here in Zimbabwe, I wish I knew long back that there is an option to depend on biogas energy." (Male, 43)

"Although the government tried to support us with the generation of biogas, I feel that the support was not adequate to sustain us in running biogas energy generation projects." (Male, 37)

4.2. Theme 2: Hardships in Obtaining Start-up Capital

Another theme that emerged from interviews was hardships in obtaining start-up capital to buy cattle and to establish biogas plants. The majority of the participants attested that they experience some hardships in obtaining start-up capital, mostly when they seek help from financial institutions for loans. It has also been learned that individuals may be prepared to embrace biogas technology, but they believe otherwise because of high installation costs. Research findings have revealed that many households are failing to diversify the use of biogas due to financial constraints regarding the challenges of using biogas technology. This reflected in the following statement:

"Commercial banks do not want to offer loans to individuals living with rural areas, for the reason that they are not confident in our competences to run projects such as this one-off biogas energy generation." (Female, 31)

"The high installation costs are a major barrier for us to make use of biogas technology." (Female, 23)

4.3. Theme 3: Lack of Required Resources

Lack of required resources emerged as one of the most important themes during interviews. Lack of required resources was one of the major constraints inhibiting adoption and use of biogas. The researcher noted that many households with biogas digesters lack efficient appliances such as cooking stoves, lighting and storage of gas hence resorting to firewood and other energy types as a supplement to biogas. Therefore, community members would need proper equipment and machinery to support them in biogas implementation projects. Here are some of the comments they made:

"It is worthless for us to pursue with the implementation of biogas technology when we do not even have the basic resources such as cooking stoves, lighting, and storage of gas." (Female, 41)

4.4. Quantitative Data Analysis

For the quantitative approach, the researchers used research instruments (questionnaires) and the data was presented using SPSS software version 26. Precisely, by means of descriptive

statistics. Wells et al. (2008) illustrate that descriptive statistics may be presented graphically by means of histograms, bar diagrams and pie charts. According to Shao (2002), charts can take several graphic forms such as line charts, pie charts, bar charts and histograms, which are utilised to display research findings. Hence, for the purpose of this study results are presented in the form of frequency tables, pie charts and bar graphs.

4.4.1. Demographics of respondents

Out of 100 sampled population questioned, 68% of them were from male-headed while 32% were from female-headed families (Table 1 and Figure 2). These findings indicate the patriarchal nature of society whereby men are considered to be the decision-makers. In this regard, a male-headed family decides whether the household adopts biogas technology or not. The presence of female-headed households is a result of the late husbands, divorced women and unmarried women who decide to stay on their own. The results in Table 1 and Figure 2 further indicate that women are the users of domestic energy and they are likely to adopt alternative technologies such as biogas, though their male counterparts are the energy decision-makers and they are less affected by energy problems.

About 50 % of the respondents were over 40 years of age (Table 2 and Figure 3). Other age groups were of young respondents aged 0-17 years at 5% while 18-25 years at 10% and 26-40 at 35%. Most young people had migrated to town in search of better education and better jobs. The findings of the study also indicate that respondents who are over 40 years adopted the biogas technology because households' own cattle which is one of the most required feed stocks for biogas plants. A study by Wawa (2012) also highlighted that in Tanzania the probability of

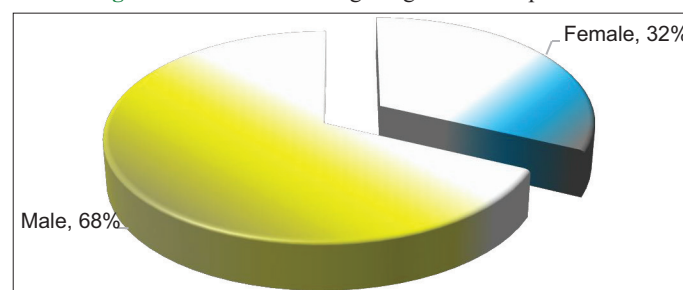
Table 1: Gender of respondents

Gender	Number of respondents	Percentage
Male	68	68
Female	32	32
Total (n=100)	100	100

Table 2: Age of respondents

Age	Number of respondents	Percentage
0-17	5	5
18-25	10	10
26-40	35	35
Over 40	50	50
Total (n=100)	100	100

Figure 2: Pie chart showing the gender of respondents



people adopting biogas energy was over years of age which is in line with this study.

Table 3 shows that 5% of the sampled population had attained pre-primary education 20% had gone through primary education. About 40% of the sampled population had also attained secondary education and lastly, 35% are post-secondary.

Table 4 and Figure 4 present distance travelled by respondents to fetch firewood. The respondents had to walk more than 4 km in search of firewood. The respondents feel that school children especially girls would encounter school dropouts thereby affecting their education. They also encounter wild animals during the travel and cases of rape cases are regarded to be normal. Having back pains problems due to carrying heavy loads of firewood is also another challenge experienced. The respondents further had

to say biogas would reduce the burden of carrying heavy loads of firewood and time saved will be used for other income-generating activities.

Table 5 shows money spent per month on households' sources of energy and it is clear that out of 60 respondents who use firewood 16.66% and 83.33% of the respondents spent \$15 and \$20 per month. About 10 of the respondents use \$10 (50%) and \$15 (50%) per month on charcoal. The findings further show that out of 10 of the respondents, who use paraffin, 50% spend \$10, 30% spend \$15 and 10% spend \$20 per month. Lastly, 2 of the respondents use electricity and they spend 50% of the respondents spent \$15 while the other 50% used \$20 per month. They commended that these fuels are expensive for them and suggest that if they had biogas digesters, the savings will be used for other households needs. Hence, alternatives sources of energy that are cheap are needed.

Table 6 and Figure 5 show several obstacles that hinder the adoption of biogas technology in the area. The main factors were high installation costs (50%), negative attitude towards biogas energy (6%), lack of adequate information (19%) and lack of adequate funds (25%). Majority of the farmers were of the view that the high upfront cost of installing biogas units was one of the major barriers that have hindered adoption among potential biogas users in the study area. This clearly indicates that some of the potential biogas users may not have the cash to pay for biogas plants upfront, thus they cannot benefit from biogas.

Microfinance institutions in the study area provided low-interest loans for biogas procurement which makes difficult for many households to adopt the technology. Respondents who have not accessed biogas technology had the perception that biogas is a dirty technology as it used animal waste to cook. They were also not aware of the potential benefits of the technology hence, there is need of biogas-oriented training through demonstrations and dissemination of information on how biogas digesters work; the importance and viability of biogas energy in improving livelihoods and environmental management.'

4.5. Challenges Faced by Biogas Facilitators in Promoting the Technology

The biogas facilitators that were interviewed in the study area were from both the private and public sector. The public actors were from the government ministries that are the: Ministry of agriculture, mechanization and irrigation development and ministry of energy and power development. Private actors were from non-governmental organizations (NGOs) and individual households' owners. The extension officers from the ministry of agriculture were based on the provision of extension services and the private actors provided subsidies and incentives to attract potential users to install biogas.

The challenges faced by the agents in the private sector in promoting biogas technology in the study area were; negative publicity, limited government support, lack of trained installers and high installation cost. Agents from the private sector pointed out that some biogas users in the study area could not feed their plants correctly and this resulted to poor functioning of the plants,

Figure 3: Bar graph showing age of respondents (n=100)

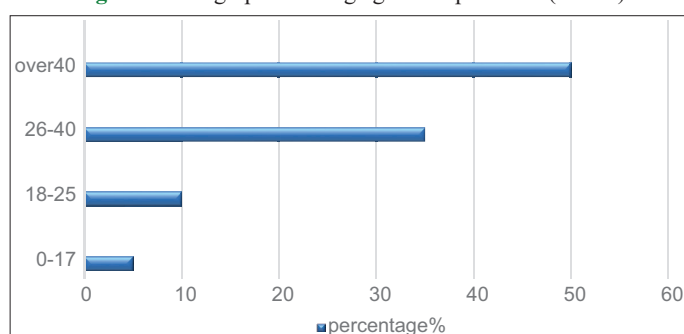


Figure 4: Distance traveled per day to fetch firewood (n = 60)

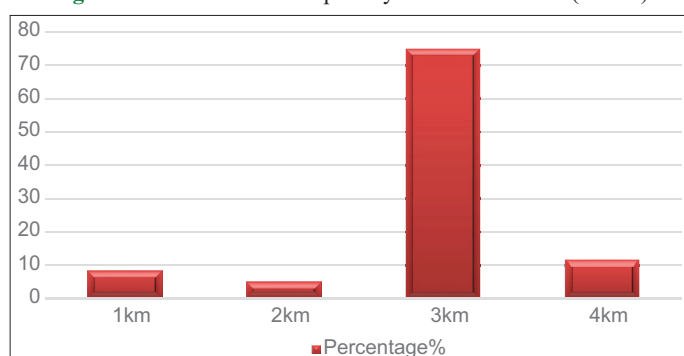


Table 3: Education level of respondents

Education	Number of respondents	Percentage
Pre-primary	5	5
Primary	20	20
Secondary	40	40
Post-secondary	35	35
Total (n=100)	100	100

Table 4: Distances traveled per day to fetch firewood

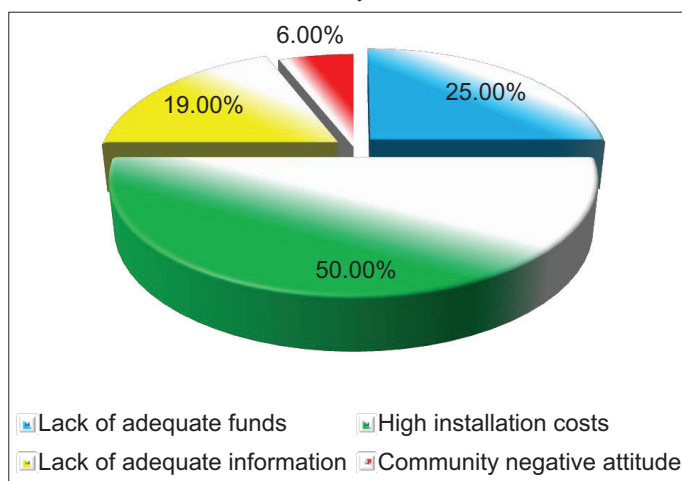
Distance (km)	Respondents	Percentage
1	5	8.33
2	3	5
3	45	75
4	7	11.66
Total (n=100)	60	100

Table 5: Money spent per month on sources of energy

Sources of energy	\$5	\$10	\$15	\$20
Fuelwood				
Respondents (60)			10	50
Percentage			16.66	83.33
Charcoal				
Respondents (8)	4	4		
Percentage	50	50		
Paraffin				
Respondents (10)	5	3		1
Percentage	50	30		10
Electricity				
Respondents (2)			1	1
Percentage			50	50

Table 6: Challenges faced by households in adopting biogas plants in the study area

Non-adopters of biogas technology		Percentage
Obstacles	Number of respondents	
Lack of adequate funds	20	25,00
Community negative attitude towards biogas	40	50,00
Lack of adequate information	15	19,00
High installation cost	15	6.00
Total (n=80)	80	100

Figure 5: Challenges faced by households in adopting biogas plants in the study area

creating a negative image of the technology to no- adopters. A study by Marchaim (1992), showed that wrong operation and poor maintenance by the users in developing countries creating negative publicity. Hence, there is need for awareness in promoting adoption of new technology.

Fixed dome digesters are expensive to install so this is another setback that private actors are still facing in promoting biogas. This problem is further worsened by the lack of micro-finance institutions in the study area. This scenario is similar to a study conducted by Pandey et al. (2007), which also revealed that the most important constraint hindering the dissemination of biogas technology has been the high initial cost of installation. Lack of trained biogas installers in the study area is another challenge in the

dissemination of biogas technology. The private biogas agents said that complained that they were no trained biogas installers locally and this situation increases the cost of biogas installation. The other constraint faced by the private extension agents in promoting biogas technology is limited government support. The private biogas agents said that government support on biogas energy is still at its primary and that there is need in the promotion of local manufacture of biogas plants and equipment's in the country.

The findings of the study further revealed that poor promotion strategies, high installation costs, lack of credit facilities and lack of awareness are some of the challenges that the public sectors are still facing. One of the public biogas agents said that the promotion of the technology is still low hence, there is a need for marketing strategies that would provide information required to increase and promote the use of biogas. Lack of awareness due to limited information on the benefits and use of biogas technology is still a barrier.

High installation costs and lack of credit facilitators are other challenges in promoting biogas energy. The public agents said that fixed dome digesters are expensive to install, and it is also difficult for them to promote the technology due to lack of microfinance institutions that promote biogas in the study area. A study by Karekezi (2002) indicates that the investment cost of even the smallest biogas unit is prohibitive for most poor African rural households and Pandey et al. (2007), revealed that the most important constraint hindering the dissemination of biogas technology has been the high initial cost of installation. This concurs with the results of this study.

4.6. Measures that Can Increase the Uptake of Biogas Technology

The public and private actors cited measures that can increase the uptake of biogas in the study area. They felt that the provision of micro-finance, increased government support, increased training programs and increase awareness programs can increase the adoption of biogas. The provision of micro-finance services can increase adoption due to the availability of microfinance institutions and banks that provide loans for biogas installation. Mugo and Gatheha (2010) recommended that there is need for financial credit system for interested consumers, especially in the dairy farming areas; could see many households adopting the technology. This concurs with the results of this study.

Increased government support is also needed as far as the promotion of biogas technology is concerned. Sustainability could therefore be achieved through efficient and governance (Mashele and Chuchu, 2018; Tideman et al., 2013). The respondents said that there is need of local manufacture of biogas and the government should increase training of artisans who can construct and provide quality services for any interested clients and training programs that can benefit members of the local community. For people to embrace technology, awareness is needed. Respondents said that increased awareness was another measure that was viewed as appropriate. For potential biogas users to appreciate and embrace the technology there is need for them to understand the benefits accrued. Awareness of the technology involves people getting

detailed information about the technology: what it is, how it functions, its advantages and its financial aspects, for it to be able to influence people's decisions on its adoption. As such, there is need for community sensitization on the social, economic and environmental gains that would arise if they adopted biogas plants at the household level. Awareness creation activities such as workshops, training, meetings, campaigns, and demonstrations on biogas matters can further increase the uptake of the technology. After becoming aware people accumulate more knowledge through training, then test the new technology and when satisfied with the result, people take up the innovation (Rogers, 1995).

5. RECOMMENDATIONS

Shane et al. (2017) recommend that to further improve biogas technology adoption, females and female-headed households should be empowered. Education levels of household heads must be improved, increase the number of livestock per household, raise income levels, increase credit access and encourage land ownership (Shane et al., 2017). This is so because these factors have been found to significantly affect the adoption rate of biogas technology in sub Saharan Africa and other developing countries elsewhere (Mengistu et al., 2016). Energy subsidy for the poor could be a way to address energy poverty in rural areas. However, even though more often subsidies are intended for the poor, the political economy of most developing countries, Zimbabwe included tends benefit the better-off segments of the country who are powerful and better connected (Koplow, 2004). This further entrenches the energy poverty issue because subsidies distort the relative prices of energy options, resulting in over-exploitation of fossil fuels and exacerbating associated environmental costs Half et al. (2014). p. 316).

Energy poverty is usually a symptom of a much larger challenge such as income and asset poverty. Consequently, an incremental approach that only tackles energy poverty alone will not be sustainable in addressing the root cause of poverty for rural people. Thus, the best avenue for addressing energy poverty would be a bottom-up approach that touches on issues on employment and wealth creation. Biogas technology is seasonal in nature. During winter season bio digesters require heat energy to maintain constant biogas supply. This presents a double challenge in that winter season energy demand increases yet at the same time biogas digesters require an alternative energy source to function effectively. It is crucial for poor people to have additional sources of energy that works well throughout all the seasons. Apart from this, there are socio-cultural issues such as disharmony with prevailing social values and ideology may also be a hindrance associated with the use of biogas technology in rural areas. In other cultures, food cooked with cow dung might be accepted as culturally viable. In such circumstances, awareness campaigns of the advantages of biogas technology are thus indispensable.

6. CONCLUSION

The study revealed that firewood, paraffin, and charcoal were the main sources of cooking energy at household level, despite the

potential of biogas in the area. The use of biogas has benefited the community through the provision of organic fertilizer, creation of employment, reduction in deforestation, reduction in workload and reliable means of cooking energy at household level.

The findings of the study revealed that there were challenges that were faced in adopting the biogas technology and these include community negative attitude towards the technology, lack of adequate funds, lack of adequate information and high installation costs. Public and private agents are still promoting the technology though they are faced with setbacks in their promotional activities and these include high installation costs, lack of credit facility, ignorance among users and lack of awareness.

REFERENCES

- Apolloni, L. (2010), Bringing About Behaviour Change: Nursing Practice and Cardiac Rehabilitation. Doctor of Public Health Thesis, University of Wollongong. Wollongong, New South Wales: School of Health Sciences, University of Wollongong.
- Arrieta, O., Cardona, A.F., Bramuglia, G., Cruz-Rico, G., Corrales, L., Martín, C., Casas, G. (2019), Molecular epidemiology of ALK rearrangements in advanced lung adenocarcinoma in Latin America. *Oncology*, 96(4), 207-216.
- Bryman, A. (2008), *Social Research Methods*. 3rd ed. Oxford, United Kingdom: Oxford University Press.
- Cheng, S., Li, Z., Mang, H.P., Neupane, K., Wauthelet, M., Huba, E.M. (2014), Application of fault tree approach for technical assessment of small-sized biogas systems in Nepal. *Applied Energy*, 113, 1372-1381.
- Chimombe, C.E. (1988), Biogas development in Zimbabwe. *MIRCEN Journal of Applied Microbiology and Biotechnology*, 4(1), 91-94.
- Chinomona, E., Maziriri, E.T. (2015), Women in action: Challenges facing women entrepreneurs in the Gauteng province of South Africa. *The International Business and Economics Research Journal*, 14(6), 835-850.
- Chinomona, R., Maziriri, E.T. (2017), The influence of brand awareness, brand association and product quality on brand loyalty and repurchase intention: A case of male consumers for cosmetic brands in South Africa. *Journal of Business and Retail Management Research*, 12(1), 143-154.
- Corbin, J.M., Strauss, A. (1990), Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, 13(1), 3-21.
- Danielsen, P.H., Møller, P., Jensen, K.A., Sharma, A.K., Wallin, H., Bossi, R., Autrup, H., Mølhave, L., Ravanat, J., Jan Bried, J., Martinus, T., de Kok, T.M., Loft, S. (2011), Oxidative stress, DNA damage, and inflammation induced by ambient air and wood smoke particulate matter in human A549 and THP-1 cell lines. *Chemical Research in Toxicology*, 24(2), 168-184.
- Feilzer, M.Y. (2010), Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research*, 4(1), 6-16.
- Felix, M., Gheewala, S.H. (2011), A review of biomass energy dependency in Tanzania. *Energy Procedia*, 9, 338-343.
- Garcia, D.J., You, F. (2018), Addressing global environmental impacts including land use change in life cycle optimization: Studies on biofuels. *Journal of Cleaner Production*, 182, 313-330.
- Garfi, M., Ferrer-Martí, L., Velo, E., Ferrer, I. (2012), Evaluating the benefits of low-cost household digesters for rural Andean communities. *Renewable and Sustainable Energy Reviews*, 16(1), 575-581.
- Gautam, R., Baral, S., Herat, S. (2009), Biogas as a sustainable energy

- source in Nepal: Present status and future challenges. *Renewable and Sustainable Energy Reviews*, 13(1), 248-252.
- Govender, I., Thopil, G.A., Inglesi-Lotz, R. (2019), Financial and economic appraisal of biogas to electricity project. *Journal of Cleaner Production*, 214, 154-165.
- Greenop, K.R., Hinwood, A.L., Fritschi, L., Scott, R.J., Attia, J., Ashton, L.J., Milne, E. (2015), Vehicle refuelling, use of domestic wood heaters and the risk of childhood brain tumours: Results from an Australian case-control study. *Pediatric Blood and Cancer*, 62(2), 229-234.
- Han, H., Wu, S. (2018), Rural residential energy transition and energy consumption intensity in China. *Energy Economics*, 74, 523-534.
- Hakawati, R., Smyth, B.M., McCullough, G., De Rosa, F., Rooney, D. (2017), What is the most energy efficient route for biogas utilization: Heat, electricity or transport? *Applied Energy*, 206, 1076-1087.
- Half, A., Sovacool, B.K., Rozhon, J. (2014), *Energy Poverty: Global Challenges and Local Solutions*. Oxford, United Kingdom: Oxford University Press.
- He, G., Victor, D.G. (2017), Experiences and lessons from China's success in providing electricity for all. *Resources Conservation and Recycling*, 122, 335-338.
- Hijazi, O., Munro, S., Zerhusen, B., Effenberger, M. (2016), Review of life cycle assessment for biogas production in Europe. *Renewable and Sustainable Energy Reviews*, 54, 1291-1300.
- Horn, N., Huygen, P., Woodward, S., Smith, K. (2009), *Human and Social Development National Qualification Framework Level 3: Student's Book*. Northlands: Macmillan.
- Hungwe, E. (2014), *Land Transactions and Rural Development Policy in the Domboshava Peri-urban Communal Area, Zimbabwe* (Doctoral Dissertation). Stellenbosch, South Africa: Stellenbosch University.
- Igliński, B., Buczkowski, R., Cichosz, M. (2015), Biogas production in Poland-current state, potential, and perspectives. *Renewable and Sustainable Energy Reviews*, 50, 686-695.
- Ingwani, E. (2015), *Land Transactions and Rezoning Strategies in the Peri-urban Communal Area of Domboshava*, Reviewed Paper. Zimbabwe: Challenges and Pitfalls. p379-389.
- Jigar, E. (2010), *Study on Renewable Biogas Energy Production from Cladodes of Opuntia Ficus-indica* (Doctoral Dissertation). Addis Ababa: Addis Ababa University.
- Johnson, R.B., Onwuegbuzie, A. (2006), Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14-26.
- Karekezi, S. (2002), Renewables in Africa-meeting the energy needs of the poor. *Energy policy*, 30(11-12), 1059-1069.
- Kaseke, N. (2014), A comparative cost assessment of electricity outages and generation expansion in Zimbabwe. *International Journal of Advanced Research in Management and Social Sciences*, 3(4), 1-20.
- Koplow, D. (2004), Subsidies to energy industries. *Encyclopedia of Energy*, 5(1), 749-764.
- Kunatsa, T., Mufundirwa, A. (2013), Biogas production from water hyacinth case of lake Chivero-Zimbabwe a review. *International Journal of Recent Technology and Engineering*, 2(2), 138-142.
- Lohan, S.K., Dixit, J., Modasir, S., Ishaq, M. (2012), Resource potential and scope of utilization of renewable energy in Jammu and Kashmir, India. *Renewable Energy*, 39(1), 24-29.
- Maqhuzu, A.B., Yoshikawa, K., Takahashi, F. (2019), The effect of coal alternative fuel from municipal solid wastes employing hydrothermal carbonization on atmospheric pollutant emissions in Zimbabwe. *Science of the Total Environment*, 668, 743-759.
- Marchaim, U. (1992), *Biogas Processes for Sustainable Development*. Food and Agriculture Organisation. Agricultural Service Bulletin, No. 95-96. Rome, Italy: Food and Agricultural Organization.
- Mashele, F., Chuchu, T. (2018), An empirical investigation into the relationship between sustainability and supply chain compliance within the South African public and the private sector. *Journal of Business and Retail Management Research*, 12(2), 121-132.
- Masud, J., Sharan, D., Lohani, B.N. (2007), *Energy for All: Addressing the Energy, Environment, and Poverty Nexus in Asia*. Manila: Asian Development Bank.
- Maziriri, E.T., Madinga, W., Lose, T. (2017), Entrepreneurial barriers that are confronted by entrepreneurs living with physical disabilities: A thematic analysis. *Journal of Economics and Behavioural Studies*, 9(1), 27-45.
- Mengistu, M.G., Simane, B., Eshete, G., Workneh, T.S. (2016), Factors affecting households' decisions in biogas technology adoption, the case of Ofla and Mecha districts, Northern Ethiopia. *Renewable Energy*, 93, 215-227.
- Mugo, F., Gathe, T. (2010), *Biomass Energy use in Kenya. A Background Paper Prepared for the International Institute for Environment and Development (IIED) for an International ESPA Workshop on Biomass Energy*. Edinburgh, Nairobi, Kenya: Parliament House Hotel Practical Action.
- Munro, P., van der Horst, G., Healy, S. (2017), Energy justice for all? Rethinking sustainable development goal 7 through struggles over traditional energy practices in Sierra Leone. *Energy Policy*, 105, 635-641.
- Muposhi, A. (2015), *Green Consumer Buying Behaviour: Antecedents, Selection Attributes of Generation y Consumers and the Relationship with Future Behavioural Intentions*. Doctor of Technology Thesis. Vanderbijlpark, South Africa: Vaal University of Technology.
- Muposhi, A., Dhurup, M., Surujlal, J. (2015), The green dilemma: Reflections of a generation y consumer cohort on green purchase behaviour. *The Journal for Transdisciplinary Research in Southern Africa*, 11(3), 225-240.
- Muvhiwa, R., Hildebrandt, D., Chimwani, N., Ngubevana, L., Matambo, T. (2017), The impact and challenges of sustainable biogas implementation: Moving towards a bio-based economy. *Energy Sustainability and Society*, 7(1), 1-11.
- Pandey, B., Subedi, P., Sengendo, M., Monroe, I. (2007) Report on the Feasibility of a National Household Biogas Commercialization Program in Uganda. Morrilton: Winrock.
- Pintos, J., Franco, E.L., Kowalski, L.P., Oliveira, B.V., Curado, M.P. (1998), Use of wood stoves and risk of cancers of the upper aero-digestive tract: A case-control study. *International Journal of Epidemiology*, 27(6), 936-940.
- Production in Zimbabwe. Available from: <http://www.library.fes.de/pdf-files/bueros/simbabwe/13717.pdf>. [Last accessed on 2020 Apr 4].
- Rogers, E. (1995), *Diffusion of Innovations*. 4th ed. New York: The Free Press.
- Roy, A.D., Prakash, O., Kumar, A., Kaviti, A.K., Pandey, A. (2018), Design and selection criteria of biogas digester. In: *Low Carbon Energy Supply*. Singapore: Springer. p91-112.
- Sakarombe, S. (2017), Challenges and opportunities of biogas technology adoption for sustainable household energy inward 4 of Domboshava communal area. In: *Bachelor of Science Honours Degree in Geography and Environmental Studies*. Gweru, Zimbabwe: Midlands State University.
- Sefotho, M.M. (2015), A Researcher's Dilemma: Philosophy in Crafting Dissertations and Theses. *Journal of Social Sciences*, 42(1), 23-36.
- Shane, A., Gheewala, S.H., Phiri, S. (2017), Rural domestic biogas supply model for Zambia. *Renewable and Sustainable Energy Reviews*, 78, 683-697.
- Shao, A.T. (2002), *Marketing Research: An Aid to Decision Making*. Cincinnati: South Western Thompson Learning.

- Shin, H., Kim, H., Shin, E. (2005), Environmental and economic assessment of landfill gas electricity generation in Korea using the LEAP model. *Energy Policy*, 33, 1261-1270.
- Singh, K.J., Sooch, S.S. (2004), Comparative study of economies of different models of family size biogas plants for state of Punjab, India. *Energy Conservation and Management*, 45, 1329-1341.
- Sovacool, B.K. (2012), The political economy of energy poverty: A review of key challenges. *Energy for Sustainable Development*, 16(3), 272-282.
- Sovacool, B.K., Drupady, I.M. (2011), Summoning earth and fire: The energy development implications of Grameen Shakti (GS) in Bangladesh. *Energy*, 36(7), 4445-4459.
- Stiftung (2015), The State of the Policy and Legal Framework on Clean Renewable Energy
- Subedi, M., Matthews, R.B., Pogson, M., Abegaz, A., Balana, B.B., Oyesiku-Blakemore, J., Smith, J. (2014), Can biogas digesters help to reduce deforestation in Africa? *Biomass and Bioenergy*, 70, 87-98.
- Tideman, S.G., Arts, M.C., Zandee, D.P. (2014), Sustainable leadership towards a workable definition. *Journal of Corporate Citizenship*, 49, 17-33.
- Unosson, J., Blomberg, A., Sandström, T., Muala, A., Boman, C., Nyström, R., Bosson, J.A. (2013), Exposure to wood smoke increases arterial stiffness and decreases heart rate variability in humans. *Particle and Fibre Toxicology*, 10(1), 20.
- UNDP. (2015), Background of the Sustainable Development Goals. Available from: <https://www.undp.org/content/undp/en/home/sustainable-development-goals/background.html>. [Last accessed on 2020 Apr 4].
- UN Statistics. (2016), Goal 7: Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for all. Available from: <https://www.unstats.un.org/sdgs/report/2016/Goal-07>. [Last accessed on 2020 Apr 4].
- Wahyuni, D. (2012), The research design maze: Understanding paradigms, cases, methods, and methodologies. *Journal of Applied Management Accounting Research*, 10(1), 69-80.
- Wawa, A.I. (2012), The Challenges of Promoting and Adopting Biogas Technology as Alternative Energy Source in Semi-arid Areas of Tanzania: The Case of Kongwa and Bahi Districts of Dodoma Region (Doctoral Dissertation). Tanzania: The Open University of Tanzania.
- Wells, W., Burnett, J., Moriarty, S. (2008), Advertising Principles and Practice. 5th ed. Upper Saddle River: Prentice-Hall.
- World Bank. (2014), Energy Overview. Available from: <https://www.worldbank.org/en/topic/energy/overview>. [Last accessed on 2019 Oct 04].
- World Health Organization. (2009), Climate Change, Air Pollution and Noncommunicable Diseases. Available from: <https://www.who.int/bulletin/volumes/97/2/18-224295/en>. [Last accessed on 2020 Apr 4].
- Yasmin, N., Grundmann, P. (2019), Adoption and diffusion of renewable energy-the case of biogas as an alternative fuel for cooking in Pakistan. *Renewable and Sustainable Energy Reviews*, 101, 255-264.
- Zvigadza, S., Mharadze, G., Ngena, S. (2010), Communities and Climate Change: Building Local Capacity for Adaptation in Goromonzi District, Munyawiri Ward, Zimbabwe. Available from: https://www.eepsea.org/en/ev-156352-201-1-do_topic.html. [Last accessed on 2019 Oct 04].