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ARTICLE

Biogas Technology Adoption as an Alternative Source of Energy in Domboshava Communal Area of Zimbabwe: Benefits and Challenges

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ABSTRACT

The research examines challenges and opportunities of biogas technology adoption to achieve sustainable household energy in Ward 4 of Domboshava communal area, Zimbabwe. The research adopted both qualitative and quantitative research techniques. A total of 65 questionnaires were randomly distributed to households using biogas. Purposive sampling technique was employed to select key informants from the Environmental Management Agency, Netherlands Development Organisation, Zimbabwe Energy Regulatory Authority, Environment Africa and the Ward Councillor. The study revealed that the level of education attained do not influence biogas adoption ($p > 0.05$) whereas funds availability, awareness, promoters and gender of the household head were seen to have a major effect ($p < 0.05$). The benefits of biogas technology noted by households were that it cooks fast, provides clean energy and at the same time reducing the frequency of fire wood collection in the forest. Challenges such as lack of adequate knowledge about the technology and lack of required financial and material resources compromised the adoption of biogas technology by the households in Ward 4. The study recommends that relevant government agencies should provide accessible technical services and set up demonstration centres in every ward with a view of encouraging rural households to adopt biogas technology.

1. Introduction

Scarcity of sustainable energy solutions, accompanied by over dependence on wood energy has remained one of the challenges faced by developing countries [15,19,22]. This has therefore, placed great need for sustainable alternatives of energy such as biogas. Biogas technology is generally defined as the use of biological processes in the absence of oxygen (anaerobic digestion) to degrade and stabilise organic matter and other biodegradable raw materials to create a mixture of methane and carbon dioxide that can be utilised as fuel [13,15,16,17]. Biogas technology has great potential to reduce wood energy consumption since it provides sustainable household energy, thus enabling household members to meet their increasing energy demand [3,15,16]. Unlike wood energy [22], shanchu biogas burns without smoke thereby improving indoor air quality and thus saving household users from respiratory distress and ailments.

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The need for sustainable energy remains a very critical issue in Africa's efforts to meet the increasing energy demands [6,14]. To support this, Scarlet [18] stated that with increasing population densities access to energy is a prerequisite in order to improve the quality of life. This explains why the provision of sustainable, affordable, clean, adequate and efficient energy remains at the core of sustainable development goals (2015 -2030). In spite of the efforts in place so far to provide sustainable energy for all, nearly 1.3 billion people globally do not have access to modern sources of sustainable energy [1,14,17]. The number of people living without access to renewable energy has been increasing in Africa constituting approximately 57% of the World's population [21]. This compounded with other social and economic challenges has left poor people marooned in poverty which frustrates efforts to attain the Sustainable Development Goals (SDG) in Africa.

In sub-Saharan Africa, biomass energy in the form of firewood, charcoal and crop residues accounts for 70 - 90 per cent of primary energy supply [2]. Due to acute energy poverty in sub-Saharan Africa firewood and charcoal have emerged as important sources of energy for lighting and heating [12,17]. In another fascinating development, the US Department of Energy concluded that over 75% of wood harvested in Africa is used for household energy needs [6]. This situation poses a great threat to human and environmental security and also constitutes a major stumbling block to progress towards growing economies as well as realising goals of sustainable development agenda in Africa [12,17,18].

Zimbabwe has a growing understanding of sustainable energy supply as a critical factor for national development [8]. Currently, the country's energy requirements are met through a combination of biomass energy, thermal and hydro-electric power plants as well as imports. ZERA [25], noted that Zimbabwe has a national power generating capacity of 1 400 megawatts (MW) against a national peak demand of 2 400 MW. This situation clearly indicates that there is a mismatch between power supply and demand. The capacity of electric power stations in Zimbabwe has therefore been compromised due to reduced water levels which impact negatively on the power generating capacity. In the same way, the available thermal power stations have passed their lifespan and the equipment is now obsolete resulting in serious inefficiency and frequent breakdowns. For these reasons, prospects of fast connecting rural households with electricity has henceforth remained inconceivable. To this end Zimbabwe's energy consumption has been dominated by wood based energy, agricultural residues and cattle dung thus presenting a disastrous threat to environmental sustainability.

According to Hivos [8], wood based energy consumption in Zimbabwe is particularly high and unsustainable accounting for up to 95% of total energy consumption in rural households. Most rural communities are now facing acute shortage of household energy supply mainly because of unsustainable firewood harvesting and land clearance for agriculture [10]. Another worrying development as observed by Mbulayi [10], is that people in rural areas mainly women travel long distances to collect firewood at the expense of engaging in other productive economic activities. Other than this, continued reliance on firewood for energy has been linked to increased respiratory ailments among users due to incomplete combustion and smoke emissions in poorly ventilated houses common in rural areas [5]. In a study on indoor air pollution from biomass combustion and acute respiratory illness in pre-school ages in Zimbabwe, Mishra [11], found out a worrying high incidences of respiratory related deaths. This therefore calls for an urgent shift to other alternative sources of energy which are clean, affordable and sustainable with biogas technology being one of the best option.

Efforts to disseminate biogas technology amongst rural communities in Zimbabwe were reignited in 2012 following a partnership between the government and development agencies. The National Domestic Biogas Programme was thereafter launched with an aim to establish a vibrant biogas sector set to benefit many rural households across the country. Given the inter-related challenges of poverty and energy demand, climate change, indoor air pollution and human health, accelerated and large scale dissemination of biogas technology is now necessary more than ever [8]. Regrettably though, benefits and challenges of adopting and using the technology have never been comprehensively documented from the users' perspective, information that is critical to guide sustainable adoption and implementation of biogas initiatives. This paper therefore seeks to understand the challenges and opportunities of biogas technology adoption in communal areas of Zimbabwe to achieve sustainable development goal seven (SDG7) which seeks to ensure access to affordable, reliable, sustainable and modern energy for all.

2. Study Area

The study was carried out in Ward 4 of Domboshava (31^0E and longitude 17^0S), a peri-urban communal area in Mashonaland East province of Zimbabwe (Figure 1). Administratively Domboshava falls under the local authority of Goromonzi Rural District Council and lies

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approximately 29 km northeast of Zimbabwe's capital city, Harare.

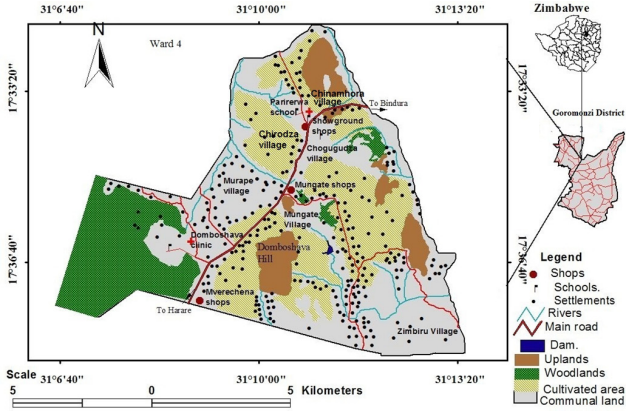

Figure 1. Ward 4 of Domboshava Communal Area in Mashonaland East Province, Zimbabwe

Goromonzi District has a total of 15 wards and a population of about 227 987 people [26]. The district is divided into three political constituencies which are Goromonzi North, South, and East. Domboshava itself is made up of five wards and falls under Goromonzi North constituency which has a total of eight Wards [9]. Ingwani [9], further stated that two of the wards (ward 6 and 7) of Goromonzi North constituency are commercial farms. Ward 4 is found on the boundary of Harare and stretches all the way to Makumbe Mission along the Domboshava road.

The study area is found at an altitude of 1 080 m above sea level. The area is largely a rugged terrain with a drainage dominated by dendritic river patterns, draining to the north-east into Mazowe Catchment. Soils in the area are dominantly sand veld, red clay soils, black turf and sandy soils which are derived from the same parent material but differ in properties as they occupy different topographical positions. The area lies in agro-ecological region 2b of Zimbabwe which receives good rains although subject to frequent droughts, dry summer spells and short rainy seasons [9]. Rainfall averages 650-800 mm per annum with temperatures averaging around 26-29 degrees Celsius in summer [27]. In winter the temperatures drop to as low as 10-15 degrees Celsius. Zvigadza et al. [27], further pointed out that frequent mid-season and unusual rainfall variations are threatening many livelihoods in some parts of the area. Vegetation is sparsely distributed with shrubs and mature trees severely subjected to deforestation. This situation limits the potential use of wood as a source of fuel.

Population has been increasing in ward 4 of Domboshava and is estimated to be around 7 100 households [26]. Increasing population increases demand on energy sources including biogas, thus it is imperative to comprehensively examine the challenges and opportunities of biogas technology adoption. The average poverty prevalence in the area ranges between 61% and 72%. Poverty is more prevalent on the northern peripheral areas of Goromonzi District in wards 1, 2, 3, 4 and 5 which forms the huge part of Domboshava area. This leaves the local communities with no option except to use the available raw materials such as wood and dung for energy.

Major economic activities in the area ranges from market gardening, grain production and livestock rearing. In general terms most people in Domboshava are subsistence farmers who grow groundnuts, maize and other small grains for food security. However, Zvigadza et al., [27], 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. In terms of ethnicity, Domboshava communal area is largely dominated by people who speak Zezuru, a Shona dialect which is one of the main vernacular languages of Zimbabwe [9].

3. Data Collection Methods

A mixed methods research approach combining both quantitative and qualitative research techniques was adopted in this study. Field surveys were carried out between January and March 2017 using questionnaires and semi-structured interviews to gather information on challenges and opportunities of biogas adoption in ward 4 of Domboshava area.

The study targeted individuals and institutions involved in biogas technology implementation such as households, traditional leaders, local political leaders, Domboshava Community Development Association, Netherlands Development Organisation (SNV), Environment Africa, Environmental Management Agency (EMA) and Department of Renewable Energy in Zimbabwe. The households were chosen because they had first-hand information on challenges and opportunities that are arising from biogas technology adoption and use. Sixty-five households using biogas drawn from all villages making up Ward 4 of Domboshava communal area participated in the questionnaire survey. A register of households using biogas was obtained from the ward councillor and verified with the development agency funding adoption of the technology. Household heads or the eldest person who makes decisions in the absence of

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a household were asked to complete the questionnaire. Household heads provided information on socio-economic characteristics of households (e.g. size, age of head and sources of income), level of awareness and attitude towards biogas technology, factors influencing adoption and use of biogas technology.

Key informants were purposefully selected from traditional leaders, local political leaders, Domboshava Community Development Association, Netherlands Development Organisation (SNV), Environment Africa, Environmental Management Agency (EMA) and Department of Renewable Energy in Zimbabwe for semi-structured interviews. With the participants' consent interviews were audio recorded and notes were taken at the same time to capture important cues and relevant points. Field observations aided by a checklist assisted to document how biogas practice was undertaken in the area. Ethical issues were considered before and during the study. Prior to fieldwork ethical clearance were sought from the Department of Geography and Environmental Studies at Midlands State University. Thereafter, permission to enter Ward 4 of Domboshava was granted from the Rural District Authority.

4. Data Analysis and Presentation

Quantitative data obtained from closed-ended questionnaires was cleaned to check for errors and completeness. This data was coded in Microsoft Excel spreadsheet before exported to the Statistical Package for Social Scientists (SPSS) Version 25.0. Descriptive statistics and inferential statistics were generated to show patterns in biogas adoption and associated challenges. Chi-square tests were carried out at 95% confidence interval to determine the association between households' characteristics and level of biogas adoption as well as households' awareness and attitude to use of biogas. Qualitative data obtained from semi-structured interviews, field observations and open-ended questions in the questionnaire were analysed using content analysis method. Content analysis involves coding and categorising of verbal or behavioural data in a manner that differences and similarities can be recognised.

5. Results and Discussion

5.1 Level of Awareness on Biogas Technology

The study results show that a few of the adopters' neighbours, friends and relatives in the Domboshava community are well appraised of biogas technology. The majority of the household respondents, that is, 56.6% were in disagreement with the fact that people in Domboshava are well aware of the biogas, a situation that has potential to compromise adoption of the technology in the communal area despite having several benefits (Table 1). In addition, while 22.2% of the questionnaire respondents are not sure (undecided) of the level of biogas technology awareness, only 13% maintained that people in the communal area were fully aware of the technology. However, it is not clear whether the knowledge encompasses both existence, operation, maintenance and efficiency of the technology since awareness of the existence of the technology does not point to the technical awareness of the technology itself. Therefore, knowledge and awareness towards a certain technology may have an influence on its adoption, a situation also observed by Adeola *et al.* [2].

Table 1. Responses on the level of awareness on biogas technology

Level of agreement	Frequency	Percentage
Strongly Agree	4	8.9
Agree	6	13
Undecided	10	22.2
Disagree	25	55.6
Strongly Disagree	0	0

Wawa [24] proposed that awareness of biogas technology should encompass people getting to know finer details of the technology, that is; what it is, how it functions, its services and financial aspects for it to be able to influence people's decision on adoption. Findings from the study indicated that only 37.8% of the respondents had received training on biogas technology while 62.2% indicated that they have never received some form of training or attended a meeting on biogas technology. This relates with the discovery that a substantial number of the respondents have learned about biogas technology from their neighbours and friends. However, the implication of the result is that biogas adopters who have never attended meetings or receive some form of training on biogas technology may fall short of the adequate knowledge on the benefits, operation, maintenance and services offered by the technology hence low awareness.

Chi-square test results show that employment status and level of education attained do not influence biogas adoption ($p > 0.05$). Thus regardless of the level of education attained households can implement the technology depending on local skills acquired either through community meetings.

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5.2 Source of Information about Biogas Technology

As indicated in Figure 2, NGOs (33.3%) and existing biogas adopters (friends/neighbours) 40% served as the main sources of information about biogas technology. Only 13% of the biogas users have heard about the technology from government while less than 12% mentioned media publications. The results relate to the findings of Wawa [24], who observed that in Tanzania NGOs are more active than the government in the promotion and awareness raising of biogas technology. In addition, it was observed that existing biogas users with the largest representation stands to be tools for biogas technology promotion and use in Domboshava. The explanation to this, is that both friends and neighbours often relay information to each other as they meet more frequently during domestic chores such as fetching water and through community based food security projects. The role of media (12%) is not much visible given location of the study area in the outskirts of urban areas which hence inhibits access to information and media publications. To support this, results from interviews also revealed that media plays a minimal role in raising awareness given the rural set up of the area. In fact, most people are engaged in agricultural activities during the day and pledges no time to radio, reading newspapers or watching television. The prime effect of this situation is that there is limited awareness yet the technology presents numerous opportunities as local communities often do not spare their time but rather seek to improve their livelihood status.

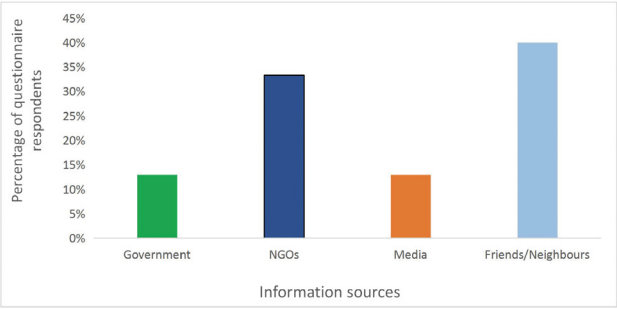

Figure 2. Sources of information on biogas technology in Domboshava Communal Area

5.3 Attitude towards Biogas Technology

The results from the survey revealed that, the majority that is 56% agreed to the fact that biogas technology reduces the rate of deforestation a situation that creates a positive attitude towards adoption of the technology. Households are also intensifying biogas technology activities in Domboshava in a bid to relieve women work load and reduce time spent in collection of firewood. This was confirmed by 44% of households using biogas technology in Domboshava communal area (Table 2). Households in Domboshava either recommended as the best alternative energy source which pointed out that the technology benefits completely outweigh its weaknesses. Scores for strongly agree and agree are higher than those of disagree, undecided and strongly disagree combined together. This is a clear indication that overall respondents have a positive attitude towards biogas technology. However, further enquiries indicate that many people were not very sure (undecided) if the technology can help reduce smoke inhalation given higher frequency (38%) of neutral responses.

Table 2. Respondents attitude towards biogas technology

Statement	SA	A	UD	D
Biogas will reduce the rate of deforestation	15 (33)	25 (56)	4 (10)	1 (2)
Biogas will relieve women workload	7 (15)	16 (36)	15 (33)	5 (11)
Biogas will save time spend on fire wood collection	12 (27)	20 (44)	8 (18)	4 (10)
Biogas will reduce inhalation smoke	9 (20)	11 (25)	17 (38)	9 (20)
Biogas technology will help improve soil fertility	13 (29)	31 (69)	4 (10)	0 (0)
Biogas is recommended as the best alternative energy source	33 (73)	9 (20)	2 (4)	1 (2)
Benefits of biogas overweighs its weaknesses	5 (12)	18 (40)	13 (29)	9 (20)

(Bolded figures indicates frequency and those in brackets is the percentage frequency)
***Key: SA** Strongly agree; **A** Agree; **UD** Undecided; **D** Disagree*

Also, high frequency of neutral responses was noticeable on the ability of biogas to relieve women workload (33%) and outweighing its weaknesses (29%). This is attributed to the fact that most of the biogas adopters have not yet fully utilized all the benefits offered by biogas technology. However, on a general note, neutral responses could not dilute the general trend of a clear positive attitude towards biogas technology expressed by the household respondents.

5.4 Factors Influencing Adoption and Use of Biogas Technology for Household Energy

Results from the study revealed that motivation from promoters and other users in the area, environmental, economic and health considerations contributed towards the adoption of the bio gas technology in Domboshava. This was confirmed by 91% of the households who revealed that biogas is the main contributor for household technology which they have adopted as a result of motivation from various promoters. This result concurs

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with findings by Wawa [24], who observed that various promoters are key in adoption of biogas technology adoption since they provide funds and any related material towards the adoption of the technology so as to ensure sustainable and clean energy for all. Additionally, it was revealed that various promoters such as Netherlands Development Organisation (SNV) contribute towards the adoption of the technology through sponsored cooking stoves.

Table 3. Respondents' motivation for biogas technology adoption

Factor	Frequency %
Motivation from promoters	91
Motivation from other biogas users	69
It cooks quickly	60
Produce less smoke	51
Health benefits	28
Non availability of cheap fuel sources	9

Results from the survey also revealed that biogas adopters (69%) motivated the adoption of biogas technology. This relates to the findings that friends and neighbours were also crucial sources of information in terms of awareness in Domboshava communal area. Ability of the technology to cook quickly was mentioned by 60% a gesture that promoted the adoption of biogas technology in Domboshava communal area. About 51%, confirmed that biogas produces less smoke as compared to other sources of fuel such as wood. This makes it clear that biogas is a clean source of fuel a factor that motivated households to adopt the technology. Households in Domboshava communal area adopted biogas because of the associated health benefits received as confirmed by 28% of the respondents. To support this, during an interview, it was highlighted that most people are lured into biogas technology because of the need to have an alternative source of energy which is sustainable, environmentally friendly and cost effective in nature. This therefore makes it clear that adoption of the technology is critical since it ensures access to affordable, reliable, sustainable and modern energy for all thus attainment of SDG goal 7. The results of the study are in agreement with studies carried out in Kenya where people's involvement in biogas technology was mainly due to the need to enjoy multiple services that it provides a situation observed by Bonnke [4].

5.4.1 Cost of Biogas Digester Installation

From the results obtained in the field, a small number of respondents (4.5%) highlighted that the installation process is reasonably affordable. The estimated cost of installing a domestic biogas digester and its appliances ranges from US$600.00 to US$ 1 500 depending with the size of the plant. About 93.5% of the household heads expressed that the cost of acquisition and installation of the technology was high and they find it very difficult to raise the required funds in time. This implies that cost of biogas technology is an important influencing factor with high initial cost of installing the technology being a limiting factor in Domboshava as revealed during field observations. This finding concurs with Bonnke [4], who observed that in most developing countries high initial costs of access to modern energy sources are often exorbitant and inhibitive for poor rural populations. The results therefore indicate that while biogas technology maybe expensive as expressed by the biogas adopters, people are motivated by other factors superior than the expensive nature of the technology.

Chi-square test results revealed that there is a relationship between employment status and affordability of installing a biogas plant (p=0.000). This indicates that people who are employed are better positioned to adopt biogas technology in Domboshava than those who are unemployed. Employed household heads can afford initial installation costs of biogas technology and have better access to information when they migrate to various urban centres in pursuit of their occupations.

5.4.2 Adequacy of Biogas for Daily Energy Needs

Few adopters (32.2%) stated that biogas produced from their digesters was enough for their daily energy needs, whereas the majority (67.8%) pointed on its inadequacy. Most households mentioned that they still need to supplement their biogas plants with other energy types as the majority showed that they are still using firewood to supplement biogas. As a result, it was reported that fast cooking with biogas is only possible for simple meals like porridge, vegetables and tea using stoves in figure 3. For heavy meals and especially for larger families, most biogas technology adopters are reportedly resorting to firewood (Figure 4). During interviews it was revealed that most people in the area are surely energy stressed. This was further augmented by sparse vegetation and distances travelled to the nearest forest observed during field work. Results from the survey also revealed that several government efforts have been launched so as to connect rural households to the national grid through rural electrification programs. However, it emerged that not all segments of the population benefited from this initiative with majority still languishing in energy stress. One of

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the elderly biogas adopter in the community revealed that when he first heard of biogas technology, it was said the technology will provide energy for cooking, heating, lighting, ironing as well as refrigeration. However, this has never been the case as most households, if not all rarely use biogas for other uses except cooking.

Figure 3a. Self purchased biogas cooking stove

Figure 3b. SNV sponsored cooking stove

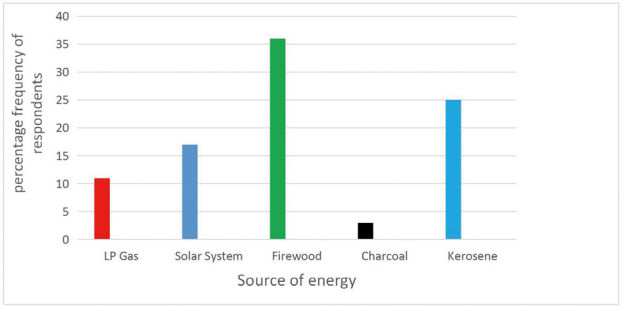

Figure 4. Energy types being used together with biogas by adopters

Although there are a number of energy sources being used, firewood scored highest frequency (36), followed by kerosene (25) definitely used for lighting. Other households have since secured and installed solar systems as observed during field work although it registered a low frequency due to its expensive nature and hence cannot be afforded by low income households. Due to the proximity of Domboshava to Harare, it emerged that some households are using liquefied petroleum gas (LPG) to meet increasing household energy. The proportion is however limited owing to issues of affordability as confirmed by 22.7%. This finding concurs with Bonnke [4], who in a separate study observed that the cost of household energy sources determines the number of people who are likely to adopt the technology.

5.4.3 Benefits of Using Biogas Technology

From the survey the majority of the households (60%), highlighted that biogas is an efficient and fast technology with limited smoke. To support this, during an interview it was emphasized that biogas technology is an effective source of energy as it offers multiple services at household level. Besides provision of gas for energy, field observations conducted revealed that biogas technology provides well rotten organic manure that is free from pests and diseases. Maize and beans grow very well from this organic fertilizer a situation that has increased crop production for biogas adopters in Domboshava communal area. Questionnaire survey results also show that the time spend collecting firewood has been reduced significantly as shown in Table 4. This implies a reduction in deforestation levels in the area, reduced indoor air pollution and of course subsequent reduction in emission of carbon dioxide into the atmosphere.

Table 4. Comparison of time spend collecting firewood before and after biogas technology adoption

Variables	Frequency	Percentage%
Less time	39	86.6
More time	0	0.0
Same time	7	15.6

The study findings revealed that a minority (15.6%) are still using same time after installing a biogas plant. This is despite the majority (86.6%) conforming that they have observed a difference between times spend collecting firewood before and after adopting biogas technology. During interviews it was highlighted that: "*...the adoption of biogas has reduced the rate of firewood collection in*

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Domboshava communal area since the majority have now resorted to this new technology over other sources of energy. As a result, firewood is now used for cooking heavy meals like beans"

About 32.2% of the biogas adopters highlighted that despite reduced frequency of firewood collection there is need to supplement biogas especially in winter when temperatures are low therefore causing low biogas production. The proportion of those not seeing difference in terms of frequency of firewood collection before and after adopting biogas technology may be explained in terms of different household sizes and an engraved culture of being used to firewood as a parent source of firewood. During field observations, the researchers observed quantities of firewood piles per each household. The general observation is that firewood quantities seems to correlate with household size. Less quantities of ashes pointed to reduced use of firewood as observed during field work.

5.5 Challenges and Constraints to Biogas Use and Adoption

Construction of large digesters was limited by lack of resources as the majority could not afford construction of large digesters as confirmed by 33% of the households. Those with large digesters are at liberty to use gas for different purposes given the amount produced. To support this, during interviews it was highlighted that if all things are held at constant, a $4m^3$ plant digester should be able to support a family of about 6-10 people. The challenge therefore as revealed by the interviewee is that of failing to feed the plant as persistently and constantly as required. This hence points to lack of understanding on the operation and maintenance of the plant by adopters. This finding concurred with Collins et al. [6], who also observed the similar challenge in a separate study conducted in Uganda. Constant need to ensure sufficient supply of cow dung for the digester was also raised by other respondents as labour intensive although the proportion is low (22.2%) in comparison with the issue of appliances. This is despite many households acknowledging that the task is easy when compared to firewood collection.

Chi-square test results revealed that there is an association between biogas plant size and adequacy of biogas for daily energy needs ($p=0.02$). This means that the bigger the plant size the higher the chances of getting adequate biogas sufficient to meet daily energy needs.

Table 5. Constraints to biogas technology adoption in Domboshava

Constraints to biogas technology adoption	% Frequency
Ignorance	95.5
Lack of required resources	91.2
Additional labour	17
No cattle	77.8
Lack of technical personnel	46.7
Lack of post installation support	21

The majority of the households that is (95%), revealed that lack of adequate information (95.5%) complicated the adoption of biogas technology in Domboshava. About 91.2% pointed lack of required resources as another set back towards the adoption of biogas technology in Domboshava communal area. This was not surprising as results with key informants revealed that biogas technology is associated with high initial costs of installation a situation that has potential to compromise adoption of the technology among rural populations. To support this, field observations conducted by the researchers revealed that households with biogas digesters are richer in comparison with other households in the area. The findings are similar to those of Waqah et al. [23], who proposed that households that are relatively rich have higher likelihood of adopting biogas than low income earners households.

Furthermore, interviews conducted revealed that available information to the people is insufficient to convince them to adopt biogas. Lack of information by the public was also attributed to failure by the biogas adopters to understand the technology. In addition to this, one of the biogas technology adopters mentioned that there are no trained experts, fabricators and building masons in their proximity to assist with information to both biogas users and potential adopters. In the face of this challenge, key informants pressed for more training of some individuals who stay within Domboshava. Questionnaire survey results revealed that almost all the household respondents (95.5%) are of the view that ignorance is one of the major constraining factor to biogas technology adoption.

About 77.8% of the respondents were of the view that adoption of biogas technology is being hindered by lack of cattle for the supply of cow dung. It was highlighted that many households were left without cattle in the past two years following an outbreak of a deadly disease that forced many households in Domboshava to close their pens. Lack of technical personnel for the construction of the digesters presented challenges to the adoption of biogas technology. Lack of technical personnel registered

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a substantial frequency of 37.8% indicating that a sizeable number of biogas technology adopters could have faced this challenge in the process of biogas installation. About 21% of the respondents highlighted lack of post installation support as a challenge faced and threatening sustainability of the technology in the area. This relates to the findings of Parawira et al., [17], where they mentioned that most biogas units installed in the early 1980s in Zimbabwe were left dormant following the withdrawal of the promoting donors. This was mainly because the biogas units were left in the hands of people with no proved technical competence in the face of a challenge a situation that resulted in malfunctioning of the plants.

6. Conclusion

The research examined challenges and opportunities of biogas technology adoption for sustainable household energy in Domboshava. The research findings revealed that adoption of biogas technology has been largely influenced by motivation from promoters, adequacy of biogas for daily needs as well as employment status. Biogas technology presents several benefits which include ability to cook fast, save firewood and health benefits. In addition, the study revealed that biogas is effective in terms of saving firewood, cost effective and reduced time spend collecting firewood. Notably, the research findings revealed multiple services provided by biogas technology which are critical for the conservation of the environment as well as the provision of sustainable household energy. In this case, the study revealed significant reduction of frequency of firewood collection by many households with biogas digesters. This points to reduced cases of deforestation, expenses on other fuel sources and amounts of emitted gases from burning wood. Above all biogas technology adopters appreciated effectiveness of organic manure, an end product of the technology which is said to increase agricultural yields. Ignorance and lack of required resources were the major constraints compromising the adoption and use of biogas. The challenge of meeting initial costs of biogas plant installation as linked to lack of required resources was widely pronounced by the respondents. Chi-square test results revealed that there is a relationship between employment status and affordability of installing a biogas plant (p=0.000). Therefore, many households are failing to diversify the use of biogas due to financial constraints.

Recommendations

In light of the study findings there is need for a coordinated approach to conduct massive awareness campaigns so as to raise awareness on the technical aspects with regards to the use and adoption of biogas technology. This should be spearheaded by the Ministry of Energy and Power Development (MoEPD) together with other currently involved stakeholders particularly NGOs. This will go a long way in improving adoption of the technology by local communal people. In order to increase the number of biogas plants the government through the Ministry of Energy and Power Development together with NGOs must install at least five demonstration biogas plants in each Ward for rural households to replicate and learn from. MoEPD in partnership with the Ministry of Higher and Tertiary Institutions, Science and Technology Development should provide funds for more research on biogas technology to generate more innovative ideas on efficiency so that clean, sustainable and safe energy is made available to all thus attainment of Sustainable Development Goal number seven.

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