

Socio-economic factors affecting smallholder farmers' willingness to adopt biodigester technology in South Africa

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Abstract

Being energy-autonomous has been suggested as a means of having sustainable energy in South Africa, where about 98% of electricity is derived from coal. Research has shown that biogas produced from animal wastes using a biodigester can be used as a source of renewable energy with the added benefits of a by-product called digestate, which can replace inorganic fertiliser. This study analyses the factors that influence smallholder farmers' willingness to adopt a biodigester technology. It uses a structured questionnaire to acquire data from 80 respondents in Ngaka Modiri Molema District in North West Province, South Africa. The respondents were 30 livestock farmers and 29 farmers practising mixed farming. Five extension officers were also interviewed to establish their level of knowledge about the technology. Descriptive statistics and Fisher's exact test were used to analyse the data. Factors such as gender, years of experience and family size were significant to willingness to adopt a biodigester. Farmers who were male and those with more years of experience were open to the idea, while those with larger families were less open to it, due to financial constraint. Overall, respondents practising mixed farming were more willing to adopt a biodigester than livestock farmers.

Keywords: animal waste; biogas; environment; sustainable energy

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1. Introduction

In many developing countries, agriculture is a vital means of livelihood and caters for economic development and poverty alleviation (Botlhoko & Olathele, 2013). Issues concerning sustainable agricultural productions have received more attention recently within the context of food security. However, there are obstacles to realising this goal, such as water scarcity, climate change and its volatility, rising risk of shortfall and land degradation, and stable energy supply (Agbenin & Goladi, 1997). The role of energy in the agricultural sector, which is a major contributor to South Africa's economy, cannot be downplayed (Bekhet & Abdullah, 2010). According to a 2015 survey (DoE, 2015), the sector is primarily reliant on petroleum products (66%) to meet its energy demand, as petrol and diesel are used for the transportation of agricultural raw materials and animal feeds, while electricity generated from coal accounts for 36% (DoE 2018.) Application of inorganic fertilisers, which consumes significant energy during production could also lead to soil and water pollution, including accumulation of salt in the soil, since they are soluble and may easily be eroded during heavy rains (Gebremedhin & Tesfay, 2015).

The constant supply of energy in South Africa has been a debatable issue due to the country's highly energy-intensive economy (Sparks et al., 2014). A series of phases of load shedding have had significant impacts on human survival and on the sustainability of the country's economy (Ololade, 2018). Energy poverty is therefore a priority for the government and has been given attention in several policies (Ismail and Kembo, 2015). About six million households do not have access to essential modern energy services in South Africa, with significant negative impacts on the standard of living and economic growth. Renewable energy is widely considered a viable option to overcome energy poverty, though the country is still heavily reliant on coal-based electricity generation (DEA, 2018; Ololade 2018). Not only is energy generated from coal not sustainable but it also has detrimental effects on the environment. Alternative sources of energy involving new technologies are required to reduce the level of environmental pollution while increasing energy security. The utilisation of biodigesters, especially in rural and peri-urban areas, has been proposed as one possible sustainable technology for electricity generation (Nape et al., 2019).

A viable biodigester can be constructed to alleviate or lessen environmental pollution. It digests organic waste matter to produce biogas and digestate/fertiliser. Biogas is a renewable source of energy with many advantages. Its utilisation can also decrease the demand for electricity, in response to

concerns that the use of fossil fuels could lead to depletion of natural resources (Uwizeyimana, 2016; Nguu, 2014). Fossil fuel is ever-increasing in cost and pollutes the environment during its combustion. Although methane, which is a constituent of biogas, is a potent greenhouse gas, contributing 20% to greenhouse emissions, its effect is, however, much lower than carbon dioxide (60%) produced by human activities through the combustion of fossil fuel (Nguu, 2014). The combustion of biogas helps to decrease the amount of methane in the atmosphere that comes from livestock waste, and leakages during the drilling of fossil fuel (Nguu, 2014). Thus, environmental impact is at a minimum with the utilisation of biogas, since the organic residue (digestate) can be used to benefitiate the growth of crops. Digestate improves nitrogen status and soil structure, thus reducing the need for the application of inorganic fertilisers (Tshikalange et al., 2020).

Smallholder farmers are identified as a crucial development tool for meeting the United Nations Millennium Development Goals, one of which is to reduce poverty and hunger (Mwangi & Kariuki, 2015). According to DAFF (2012), there is no explicit definition for smallholder farmers; however, literature provides various definitions depending on the context, ecological zone and country. The smallholder sector is very diverse and in South Africa integrates a diversity of contextual factors, such as former homelands, land reform beneficiaries, particular personal circumstances – that is, former farm workers, (renting versus private land), and production scale at a subsistence level. These farmers produce at a small scale due to limited resources, with heavy reliance on family labour and using simple and outdated technology. They need support to become well established or independent, requiring services such as financial, extension and marketing development. They are at a level below taxable personal income and are not VAT registered (DAFF, 2012). This study analysed the factors that influence smallholder farmers willingness to adopt a biodigester technology.

2. Study area

The study was conducted within Ngaka Modiri Molema District, in the north-western part of the North West province, South Africa. Agriculture contributes 4.9% to the gross domestic product of the province (INDP, 2016). It is 31 039 km² in size, with 23% of the surface area sharing a common boundary with Botswana (INDP, 2016). The District comprises five local municipalities, but the study was conducted in only two of these, namely Ramotshere Moiloa and Mahikeng (Figure 1).

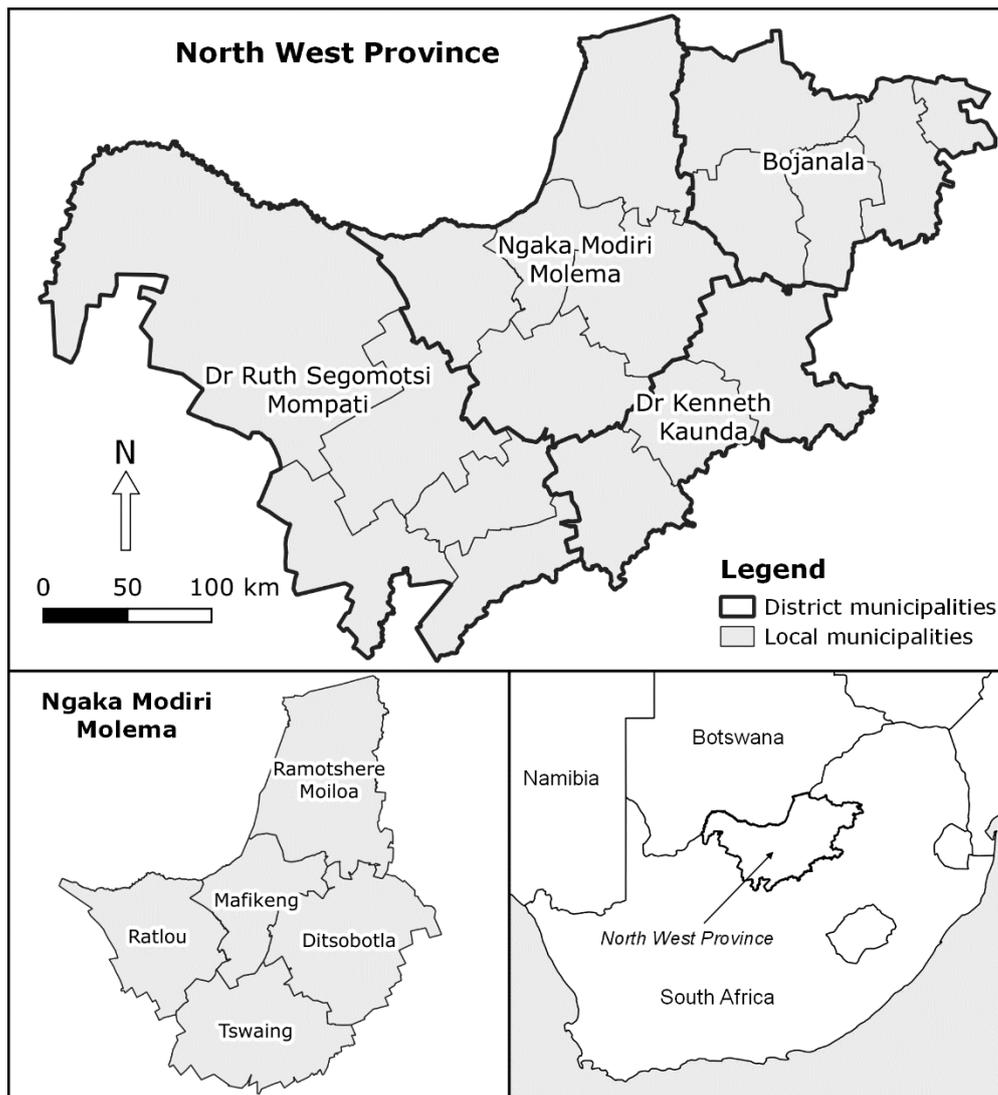


Figure 1: Map showing the location of the study area.

3. Method

Eighty farmers were selected from a list of small-holding farmers from the provincial Department of Rural Environment and Agricultural Development, based on their location within the two chosen municipalities. The sample included 40 livestock farmers and 40 farmers practising mixed farming. The purpose of the study and definition of concepts such as biodigester and inorganic fertiliser were explained to all the selected farmers before they were requested to complete the questionnaire. Extension officers from the Department assisted in gaining access to the farmers, since they are the Department's direct clients. Ethical clearance (UFS-HSD2018/1278) was granted by the University of the Free State. The questionnaire was pilot-tested on five farmers to ascertain whether the questions were well understood, and all of them were able to answer the questions without any difficulty. Of the 80 questionnaires given out for completion in the main survey, 59 were completed, returned and considered

valid for capturing in August 2018, from 30 livestock farmers and 29 mixed farming farmers. Five extension officers were also interviewed in order to ascertain their level of awareness about the workings and benefits of the biodigester.

The data were coded and captured in Microsoft Excel 2010 and then imported into the Statistical Package for the Social Sciences version 25. Descriptive statistics were used to derive frequencies and percentages, while cross tabulation using Fisher's Exact Test (FET) was performed among some of the variables to test whether they had any effect on the farmers' willingness to adopt a biodigester technology. FET was used to analyse the data since it is generally appropriate when dealing with a small sample to test whether there are differences between two groups in a specific study (Freeman and Campbell 2007). FET was used to determine whether there were differences between livestock farmers and those practising mixed farming in terms of their willingness to adopt a biodigester.

4. Result and discussion

4.1 Socio-economic profile of respondents

The age of the majority of respondents (livestock, 50.00% (n = 30) and mixed farming, 55.17% (n = 29) ranged between 36 and 50 years. Some of the respondents were aged 18-35 years (livestock farmers (33.33%, n = 30) and mixed farming operators (17.34%, n = 29). Muturi and Ogubazghi (2014) state that age is one of the factors that could affect farmers' adoption of a new technology, including benefits from government and financial institutions. According to Meyer (2008), the youth are more likely to adopt a technology and may learn faster while the adoption of new technology decreases with an increase in age. Ntshangase et al. (2018) posit that older people adopt a technology because they have acquired resources such as land and gained more experience over time than younger ones. On the other hand, Nyambose and Jumbe (2013) found that older farmers are generally accustomed to the conventional method of farming, thus contributing to a decrease in their likelihood to shift their mind-set in order to adopt new technologies. Considering the fact that most of the respondents in this study were young, there

was an assumption that they would be more likely to adopt a new technology.

The majority of the respondents were male (livestock farmers – 18 males, (60.00%, n = 30) and 20 males involved in mixed farming, (68.97%, n = 29). Tanellari et al. (2014) state that women and men engage in different farming activities. For example, men usually prepare the soil and handle chemicals, while women perform roles such as weeding and processing. Men are, therefore, more likely to adopt farming technologies compared to women (Tanellari et al. 2014; Ngoc Chi & Yamanda, 2002). This is because women are usually responsible for household chores and looking after children, hence they hardly have enough time to attend training related to the use of a new technology (Ngoc Chi & Yamanda, 2002).

Of farmers practising mixed farming, 37.93 % (n = 29) had tertiary education, 30.00% (n = 30) of livestock farmers had secondary education with matriculation, while 6.67% (n = 30) of livestock farmers did not have any education (Table 1). The majority of respondents were literate, an indication that most respondents will want to acquire information to improve their farming practices. This is in

Table 1: Distribution according to level of education and size of households of respondents.

	<i>Livestock farming n = 30</i>	<i>Mixed farming n = 29</i>	<i>Total N = 59</i>
Education level of respondents			
No formal education	2 (6.67%)	0 (0.00%)	2
Primary education	4 (13.33%)	5 (17.24%)	9
Secondary education without the National Senior Certificate	7 (23.33%)	8 (27.59%)	15
Secondary education with the National Senior Certificate	9 (30.00%)	5 (17.24%)	14
Tertiary education	8 (26.67%)	11 (37.93%)	19
Total	30 (100%)	29 (100%)	59
Size of households of participants			
1-5 members	20 (66.67%)	19 (65.52%)	39
6-10 members	8 (26.67%)	7 (24.14%)	15
>10 members	2 (6.67%)	3 (10.34%)	5
Total	30 (100%)	29 (100%)	59
No of dependents in each respondent household			
None	0 (0.0%)	2 (6.90%)	2
1-2 members	6 (20.00%)	9 (31.03%)	15
3-5 members	18 (60.00%)	13 (44.83%)	31
5-7 members	2 (6.67%)	3 (10.34%)	5
>7 members	4 (13.33%)	2 (6.90%)	6
Total	30 (100%)	29 (100%)	59

line with Ntshangase et al. (2018), who found that a higher literacy level increases chances of adopting a new technology, as it makes it easier to understand and be receptive towards a new technology.

As to households size, 66.67% (n = 30) of livestock farmers had 1–5 members in their households, while 65.52%, n = 29 of farmers involved in mixed farming had 1–5 members (Table 1). The majority (60.00%, n = 30) of livestock farmers had 3–5 dependants while 44.83% (n = 29) of farmers involved in mixed farming had 3–5 dependents. 13.33% (n = 30) of livestock farmers had the highest number of dependents (more than seven), in contrast to 6.90% (n = 29) of farmers practising mixed farming. Most farmers are able to afford the installation of a biodigester since there were fewer members in the household, an indication of fewer financial constraints in running the household. Hence, biodigesters become financially feasible for households with fewer members (Berhe et al., 2017). It is, however, assumed that a biodigester might become feasible for households with a bigger size considering the fact that there will be more labour available to operate such technology. Ntshangase et al. (2018) state that it is expected that big households will be more likely to adopt no-till conservation technology due to the assumption that they have more labour available for its operation. On the other hand, Ntshangase et al. (2018) state that this is not always true, since availability of labour depends not only on the size of the family but also on the age and type of people in the household. Despite the fact that most livestock farmers were single, they had more dependents than farmers involved in mixed farming. Hence most of the livestock farmers may not be able to afford the instal-

lation of a biodigester as most of their income may be used to cover the needs of their dependents.

4.2 Farming characterisation

The majority of farmers involved in mixed and livestock farming had more than 10 years of farming experience, with 41.38% (n = 29) of farmers practising mixed farming having above 10 years' experience (Table 2). Ainembabazi and Mugisha (2014) found that as farmers gain experience over time they steadily change from traditional methods of farming to more improved ways by observing performance and learning-by-doing. However, learning-by-doing is dependent on the release of new technologies, which could lead to progressive adoption only when researchers develop technologies that are superior (Ainembabazi and Mugisha, 2014). On the contrary, Stacy et al. (1994) state that it is very difficult to predict people's reaction towards adoption of a new technology. This implies that some farmers might consider a biodigester as a superior technology based on its benefits.

37.93% (n = 29) of farmers practising mixed farming had more than 46 hectares of land compared to livestock farmers operating on smaller land size as indicated in Table 2. In order to avoid unnecessary installation costs, the amount of by-products from a biodigester that is required to run the farm operations should be in line with the size of the biodigester required (Bishop et al., 2010). Hence the size of the land required for the installation of a biodigester may not affect its users if the appropriate size is installed to meet the expected needs of farmers. This indicates that the farm size does not influence the choice to install or not install a biodigester.

Table 2: Farming experience of respondents in years and farm size in hectares.

	<i>Livestock farming</i> <i>n = 29</i>	<i>Mixed farming</i> <i>n = 29</i>	<i>Total</i> <i>N = 58</i>
Farming experience in years			
<1 year	1 (3.45%)	0 (0.0%)	1
1-5 years	9 (31.03%)	7 (24.14%)	16
6-10 years	8 (27.59%)	10 (34.48%)	18
> 10 years	9 (31.03%)	12 (41.38%)	21
I do not know	2 (6.90%)	0 (0.0%)	2
Total	29 (100%)	29 (100%)	58
Farm size in hectares			
5 ha	6 (26.09%)	7 (24.14%)	13
6-15 ha	10 (43.48%)	7 (24.14%)	17
16-30 ha	3 (13.04%)	2 (6.90%)	5
31-45 ha	0 (0.0%)	2 (6.90%)	2
>46 ha	4 (17.39%)	11 (37.93%)	15

Table 3: Role of extension agents in improving farming practices.

	<i>Livestock farmers</i> <i>n = 30</i>	<i>Mixed farming</i> <i>n = 29</i>	<i>Total</i> <i>n = 59</i>
Information transfer	24 (80.00%)	24 (82.76%)	48
Skills transfer	6 (20.00%)	2 (6.90%)	8
Advice	0 (0.0%)	3 (10.34%)	3
Total	30 (100%)	29 (100%)	59

4.3 Importance of extension services to the farming practices of respondents.

All the farmers practising mixed farming agreed that extension service is important to their farming practices. Most livestock farmers (96.67%, n = 30) responded positively to this question, as shown in Table 3. This shows that both groups of farmers clearly understood the role of extension officers in improving their farming practices. However, some livestock farmers (3.33%, n = 30) reported that the role of extension officers is not important, since they do not visit farms very often. These farmers felt that they could still operate their farms efficiently despite the few or no visits from extension officers, thus making their role less important as per to this viewpoint. According to the National Policy on Extension and Advisory Services (2012), the role of extension services is to assist farmers to increase their production and to promote sustainable development and productions through the provision of advice, trainings and farm visits. They could also help in the transfer of information, which involves providing information to farmers and training to improve their farming operations' performance, social and environmental sustainability (European Network for Rural Development, 2013).

Most farmers (82.76%, n = 29) practising mixed farming and 80% (n = 30) of livestock farmers said that extension officers are important in the transfer of information. However, very few (20.00%, n = 30) livestock farmers understood extension as an agent of change through skills transfer. This could be due to lack of information and awareness of the services provided by extension officers. The majority (67.86%, n = 28) of farmers involved in mixed farming and 66.67% (n = 30) of livestock farmers were not aware of the existence of a biodigester. This is an indication that extension officers have not passed on this information to farmers, probably because they have little or no idea about the technology. This was confirmed during the interview with the extension officers, with one of them stating that, although there is awareness of the technology, there was no in-depth knowledge about its operations or benefits. Ntshangase et al. (2018) reported that visits by extension officers are one of the important factors that can promote the adoption of a technology by farmers, provided they give information

and advice on the use of the new technology. Many people have a biodigester feedstock readily available; however, the challenge is that they do not know about such technology. Thus, it is important to educate them on the technology, which will assist them in realising its benefits (Muvhiwa et al. 2017). When farmers receive training about the importance of a biodigester, they are likely to adopt it in their farm operations. Most farmers (66.66%, n = 9) practising mixed farming indicated that they were aware of the benefits, while the majority (54.55%, n = 11) of livestock farmers were not. Lack of awareness of such benefits could be an impediment to adopting such technology.

With regard to awareness of the existence of a biodigester, farmers practising livestock farming provided the highest number of responses (n = 11) about the benefits, as follows: production of biogas (54.55%) and cost-effectiveness (45.45%), while reduction of environmental pollution had the least response, with 21.43%. Farmers practising mixed farming provided the following responses (n = 9): cost-effectiveness (55.56%) and production of biogas (22.22%); only one (11.11%) respondent indicated that it contributes to pollution reduction in the environment (Table 4). The trend observed from the responses revealed that incentives related to cost savings are more attractive for participant farmers to adopt the technology than its environmental benefits. Farmers practising mixed farming who were willing to adopt the technology believed it is cost-effective because they will spend less money on fertilisers and energy. The results also show that most farmers practising livestock farming (61.52%, n = 13) believed a biodigester could increase their farm revenue. Sahu and Das (2016) found that smallholder farmers tend to adopt technologies that are less risky and cost-effective. The biodigester is one of the technologies that have proved to be cost-effective, considering the fact that the cost of electricity and fertilisers could be minimised or avoided. Sahu and Das also stated that the adoption of a particular form of technology with a function that is compatible with farming operations might contribute to alleviating poverty by means of increasing farm profit, increasing production for home consumption and reducing the risk of lower yields. This is an indication that adoption of a bio-

digester by farmers would eventually contribute to raising the welfare of many poor families since its by-products could decrease expenditure on fertiliser and electricity. Thus, money that is normally

used to purchase these products could be used to take care of high-priority family needs such as paying school fees of children, especially those from disadvantaged families.

Table 4: Potential benefits of using biodigester technology.

	<i>Livestock farming</i> <i>n = 11</i>	<i>Mixed farming</i> <i>n = 9</i>
Cost-effective	5 (45.45%)	5 (55.56%)
Produces biogas	6 (54.55%)	2 (22.22%)
Reduces environmental pollution	3 (27.27%)	1 (11.11%)

Table 5: Reasons for the willingness to adopt a biodigester

	<i>Livestock farming</i> <i>n = 13</i>	<i>Mixed farming</i> <i>n = 20</i>
Cost-effective	2 (15.38%)	10 (50.00%)
No electricity on the farm	3 (23.08%)	2 (10.00%)
Available animal waste that is not used	2 (15.38%)	1 (05.00%)
The potential to produce biogas as a backup source of energy	1 (7.69%)	5 (25.00%)
To increase farm revenue	8 (61.52%)	3 (15.00%)

4.3 Farmers' awareness of the impact of inorganic fertiliser on the environment

The majority of respondents were not aware of the negative environmental impacts of the application of inorganic fertiliser, including soil and water resource pollution such as soil acidity and eutrophication of surface water, which have an alarming dimension due to the effects on global food security, water quality and hygiene, as well as sustainable development (Akinbile et al., 2016). Most farmers practising mixed farming (64.29%, n = 28) indicated that they were not aware, while 57.14% (n = 28) of farmers involved in livestock farming gave the same response. It is expected that farmers practising mixed farming, with more experience, should be more aware than livestock farmers, since they apply inorganic fertilisers for better yields. However, more livestock farmers (41.67%, n = 12) were aware of the negative effects of the application of inorganic fertiliser in terms of polluting the environment than those practising mixed farming (20.00%, n = 10). This is an indication that farmers practising mixed farming are mostly focused on high crop yields linked with the application of inorganic fertiliser. Mohammadi et al. (2017) stated that farmers who depend only on agriculture for their livelihoods tend to apply excessive inorganic fertilisers in order to increase their income. Research has shown that digestate, a by-product of a biodigester can replace inorganic fertiliser with little to no impact on the environment while producing the same quality product (Tshikalange et al., 2020).

4.4 Perception of respondents about the willingness to adopt a biodigester

All the respondents indicated that they did not have enough information about a biodigester, which seems to have a huge impact on its adoption. However, the majority of the farmers were willing to adopt it: 71.43% (n = 30) of farmers practising mixed farming and 43.44% (n = 28) of livestock farmers. Farmers practising mixed farming were willing to adopt a biodigester on their farm because it is cost-effective in terms of spending less money on fertilisers and energy. Most livestock farmers (61.52%; n = 13) believed a biodigester could increase their farm revenue (Table 5). Sahu and Dahu (2016) found that smallholder farmers tend to adopt technologies that are less risky and more cost-effective. The biodigester is a technology proven to be cost-effective, given that the costs of electricity and fertilisers could be reduced or avoided (Tshikalange et al., 2020). Of the farmers involved in livestock farming, 15.38% (n=13) revealed they had a lot of unutilised animal waste on their farms. 7.69% (n = 13) of livestock farmers believed a biodigester could provide biogas as a backup source of energy.

Of all the respondents, 21 farmers gave reasons for their unwillingness to adopt a biodigester in their farms (livestock farmers (n = 14) and mixed farming farmers (n = 7)), as indicated in Table 6. Some gave more than one reason, including: lack of information regarding the technology, lack of skills and training, lack of money for the installation of a

biodigester and satisfaction with current energy use. Some livestock farmers maintained they did not plant crops and thus did not know what to do with the digestate. According to livestock farmers, the major constraints are lack of information, capital for installation and, skills and training. However, it should be noted that only two farmers were happy with their current source of energy. Dissemination of information regarding a biodigester is important towards enhancing the adoption of the technology in the study area. This will help address the gap with regard to lack of knowledge about the use of a biodigester. Gibbons et al. (1998) state that, in order for people to change their minds, they need to be convinced that there is a need to change from their traditional way of going about an activity.

When the farming groups were cross-tabulated separately, in terms of their farming experience, and the willingness to adopt a biodigester, livestock farmers were statistically significant at $Pr \leq P$ 0.0280. Hence, livestock farmers with more farming

experience were more likely to adopt a biodigester. There was also a significant relationship for farmers practising mixed farming at $Pr \leq P$ 0.0399. The association between farming experience and the willingness to adopt a biodigester technology by all participants was statistically significant at $Pr \leq P$ 0.0036 (Table 7). According to Ainembabazi and Mugisha (2014), farmers with more experience in farming are more likely to adopt new technologies by observing the performance of their traditional technologies and their practical suitability in farming operations. Thus, farmers with more experience could realise the need to adopt a biodigester based on their experience about traditional technologies they are using.

The association between age and willingness to adopt a biodigester by all respondents in both groups was statistically significant at $Pr \leq P$ 0.0376 (Table 8). Notably, increasing age was associated with more willingness to adopt a biodigester, probably because older farmers have more experience

Table 6: Reasons for unwillingness to adopt a biodigester.

	<i>Livestock farming</i> <i>n = 14</i>	<i>Mixed farming</i> <i>n = 7</i>
Lack of information about the biodigester	5 (35.71%)	3 (42.86%)
Lack of skills and training	5 (35.71%)	2 (28.57%)
Lack of capital for the installation of a biodigester	2 (14.29%)	3 (42.86%)
Happy with the current energy used within the farming operations	2 (14.29%)	0 (0.00%)
Do not have crops	2 (14.29%)	0 (0.00%)

Table 7: Association between farming experience and willingness to adopt the use of a biodigester by all respondents.

	<i>Yes</i>	<i>No</i>	<i>Total</i>
< 1 year	1 (3.13%)	0 (0.00%)	1
1-5 years	3 (9.38%)	12 (52.17%)	15
6-10 years	13 (40.63%)	5 (21.74%)	18
>10 years	15 (46.89%)	6 (26.06%)	21
Total	32 (100%)	23 (100)	55

$Pr \leq P$ 0.0036

Table 8: Association between age and willingness to adopt the use of a biodigester by all respondents.

	<i>Yes</i>	<i>No</i>	<i>Total</i>
18-35 years	6 (18.18%)	9 (36.00%)	15
36-50 years	17 (51.52%)	13 (52.00%)	30
51-65 years	6 (18.18%)	2 (8.00%)	8
>66 years	4 (12.12%)	1 (4.00%)	5
Total	33 (100%)	25 (100%)	58

$Pr \leq P$ 0.0376

and might see the need to adopt new technologies (Ntshangase et al., 2018), especially if it will be more cost-effective in their farming operations. This is in contrast to our earlier assumption that younger farmers will likely adopt the technology because youth more easily adapts to innovations. The association between gender and the disadvantages related with the use of biodigester by all participants was statistically significant at $P \leq 0.0185$. More men 14 (73.68%), $n=19$ indicated that there were no disadvantages associated with a biodigester, thus they were more likely to adopt its use than their female counterparts 5 (26.32%), $n=16$. Research has shown that men have more spare time that could be allocated for training since women spend much of their time on home chores (Tanellari et al. 2014; Ngoc Chi & Yamanda, 2002).

The association between awareness of the potential impacts of the application of inorganic fertiliser on the environment and the size of households was statistically significant at $P \leq 0.0902$. Households with more members were more likely to be unaware of the impacts on the environment associated with the application of inorganic fertilisers than smaller households. This might be because households with larger families are more likely to experience financial constraints, thus making them less concerned about the environmental impacts and focus more on increasing yields to feed their families and increase profit. According to Fillion and Le Dinh (2008), the adoption of technology in households is dependent on many factors such as demographic characteristics, control beliefs and social outcome, among others.

5. Conclusion

This study aimed at identifying the socio-economic factors that influence the willingness of smallholder farmers to adopt the use of a biodigester technology that can convert animal waste to biogas. The trend observed from the responses revealed that incentives related to cost savings are more attractive for participant farmers to adopt the technology than its environmental benefits, with production of biogas and cost-effectiveness being the top two incentives. The role of extension services was also highlighted,

because most participants believed that they ought to learn more about new technologies from them. However, the downsides were that most of these service providers themselves are not sufficiently aware, or lack the necessary training, to be able to transfer the knowledge to farmers. Hence details about biogas digester operations should be included in the training of extension officers, as it will likely constitute a significant part of renewable energy sources in the future, especially among farmers. Factors such as gender, years of experience and family size had a significant relationship with the willingness to adopt a biodigester. Farmers who were male and those with more years of experience were more open to the idea, while those with a family size of ≥ 3 were not, due to financial constraint. Overall respondents practising mixed farming were more willing to adopt a biodigester than livestock farmers, probably because it is possible to use one of its by-products (digestate), apart from the biogas, as a replacement for inorganic fertiliser on their farms. However, the idea that the digestate can be sold at a cheaper price than inorganic fertiliser to mixed farmers and excess biogas can also be sold to the national grid to generate revenue could encourage livestock farmers to adopt this technology. The study has found that the training of extension officers is needed, in order to encourage farmers to adopt this technology, which has the potential to reduce energy poverty in rural areas through off-grid renewable energy while increasing food security and environmental protection at the same time. The inclusion of specific policy that supports the use of a biodigester will unlock doors for potential implementation of this technology in many areas.

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Author roles

L.P. Bonokwane collected the data and wrote the first draft of the manuscript. O.O. Ololade conceptualised the idea for the research and edited the final draft. Both authors analysed the data.

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