Energy for Sustainable Development 37 (2017) 124–132

Contents lists available at ScienceDirect

Energy for Sustainable Development

Dis-adoption of Household Biogas technologies in Central Uganda

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ARTICLE INFO

Article history:
Received 3 January 2017
Revised 23 January 2017
Accepted 25 January 2017

Keywords:
Dis-adoption
Abandonment
biogas technology
anaerobic digesters

ABSTRACT

The study analyses dis-adoption of biogas technologies in Central Uganda. Biogas technology makes use of livestock waste, crop material and food waste to produce a flammable gas that can be used for cooking and lighting. Use of biogas technology has multiple benefits for the households since it reduces the need for fuelwood for cooking and also produces bio-slurry which is a valuable fertilizer. Despite efforts by Government and Non-Governmental Organizations to promote the biogas technology, the rate of its adoption of biogas technology was found to be low, estimated at 25.8% of its potential. A review of literature showed that the households that dis-adopted biogas technology, did so within a period of 4 years after its installation, yet the lifespan of using it is estimated at 25 years. There was need to examine the factors contributing to dis-adoption. Using cross sectional data collected from Luwero and Mpigi districts found in Central Uganda, a probit model was estimated. The findings showed that an increase in the family size, the number of cattle, number of pigs and the age of the household head reduced the likelihood of biogas technology dis-adoption. Other factors that contributed to dis-adoption included the failure to sustain cattle and pig production that are necessary for feedstock supply, reduced availability of family labor the and inability of the households to repair biogas digesters after malfunctioning. Based on the findings, it was concluded that long term use of biogas technology required improved management practices on the farm so as to sustain livestock production. It is also recommended that quality standards and socio-cultural factors be considered in the design of biogas digesters and end use devices.
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Introduction

In order to reduce dependency on wood and fossil fuels, energy sources such as biogas have been used in both rural and urban areas. Biogas is produced through anaerobic digestion of livestock waste, human waste, bio-degradable domestic waste, municipal waste and plant material (Amigun et al., 2012). The digestion process also results in the production of bio-slurry, a bi-product that is used as an organic fertilizer (Parawira, 2009).

In Uganda, biogas technology was introduced in the 1950s and since then, there have been many initiatives by private individuals, Non-Governmental Organizations (NGOs), Government and different development partners to promote the technology (Sengendo et al., 2010). These include pilot demonstrations, capacity building and provision of subsidies to households so as to increase uptake. Farm based biogas digesters with a capacity ranging between 5 and 10 m^3 are the most widely used. Common designs include a floating drum, fixed dome and tubular design (Mulinda et al., 2013).

Despite the concerted efforts made to promote the use of biogas technology in Uganda, the rate of its uptake in the country is low (Amigun et al., 2012; Mulinda et al., 2013). A feasibility study by Renwick et al. (2007) estimated the potential to install biogas plants in Uganda at 20,000 yet by 2013, only 5168 plants had been constructed (MEMD, 2014; Mugerwa, 2012) thus realizing 25% of its potential. Mwirigi et al. (2014), Mulinda et al. (2013) and Walekhwa et al. (2009) investigated factors affecting biogas technology adoption in Sub-Saharan Africa and cited economic barriers to investment as major inhibitors to adoption. However, even when financial burdens are lifted through subsidies, the users do not sustain use of the technology (Mwakaje, 2012). Nabuuma and Okure (2006) conducted a field study in Central Uganda and found out all the tubular biogas digesters that had been adopted were abandoned within four years after installation. In addition, 80% of the households that had abandoned the use of the fixed dome biogas digesters, did so within less than four years after completion of their construction. Kabarole Research Centre (2013) also conducted a field study in Central, Eastern and Western Uganda and found out that some households stopped using the biogas digesters within 6 months after installation. It is estimated that

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http://dx.doi.org/10.1016/j.esd.2017.01.006
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households should be able to use the tubular biogas digesters for at least 5 years and the fixed dome biogas digesters for at least 25 years (Nzila et al., 2012). Therefore, the benefit for investment is not fully realized by the government and NGOs that provide subsidies for investment, and also by the households that invest their resources to take up the technology.

The purpose of this study therefore was to examine the reasons for dis-adoption of biogas technology. Primary data was obtained by conducting household surveys in two selected districts of Mpigi and Luwero. The data was analyzed by using a probit regression model where the dependent variable took on two values; whether a household that previously adopted the biogas technology abandoned it or is still using it. The findings are presented and discussed in the proceeding sections.

Review of literature

There are numerous studies that assess the factors that affect adoption of new farm technologies. However, few studies have examined the rate and determinants of technology dis-adoption. In regards to biogas technology, studies by Kabir et al. (2013), Mwirigi et al. (2009) and Walekhwa et al. (2009) show that variables such as the education level of the household head, farm income, land size and number of cattle have been found to positively influence adoption, whereas the variables such as gender and age of the household head have been found to negatively influence adoption, where by the older farmers and the male headed households were less likely to adopt the technology. Mwirigi et al. (2014) also showed that the household's socioeconomic status influences adoption but it did not significantly influence the long term utilization of a biogas digester. However, Mulinda et al. (2013) and Kabir et al. (2013) show that many of the households that adopted biogas technology abandoned it including the households that were in the high income status. Puzzolo et al. (2016) reviewed the barriers to sustained use of renewable energies, such as biogas, and concluded that the ability to meet cooking needs, being able to pay for a clean stove and fuel, having access to a reliable and affordable fuel supply and ensuring safe operation are the major conditions for adoption and sustained use of the technologies. Rogers (1995) cited replacement of an old technology by a new one and disenchantment with a technology as reasons for dis-adoption. A common feature of these studies is that their findings and conclusions were based on qualitative analyses. There is therefore a paucity of quantitative empirical research on dis-adoption of biogas technology.

Empirical research has, however, been conducted on related technologies by applying the expected utility theory that treats dis-adoption as a dichotomous choice; whether to continue using a technology or abandon it. Neill and Lee (2001) examined the adoption and dis-adoption of maize-mucuna farming systems in Honduras while Rahim et al. (2005) studied the adoption and dis-adoption of gum Arabic production in Sudan. The models for these two studies were based on two discrete decisions; whether to adopt and, for those who adopted, whether to abandon. They employed bivariate probit models so as to account for the dichotomous nature of the decisions and the potential correlation between the decisions. Moser and Barrett (2006) employed a simple probit model when studying the dis-adoption of rice production. The findings from the studies that have been reviewed show that dis-adoption of biogas technology can be studied using both qualitative and quantitative approaches and that a number of social, economic and technological factors influence its dis-adoption.

Materials and methods

Study area

The study was undertaken in two districts of Central Uganda; Mpigi and Luwero. Mpigi district is located to the West of Kampala, the capital city and along the shores of Lake Victoria whereas Luwero district located North West of Kampala. Mpigi District covers an area of 3714 km^2 which is about 0.16% of the country size. In 2014, the population of Mpigi District was estimated at approximately 250,548 and comprised of 60,511 households (UBOS, 2015). The total area of Luwero district is approximately 2577.49 km^2 and the population of the district was estimated at 456,958 in 2014, and comprising of 105,346 households (UBOS, 2015). In the two districts, farming is dominated by smallholder farmers engaged in food and cash crops, horticulture, fishing and livestock farming. The major fuels used for cooking in rural areas are firewood and charcoal whereas for lighting, kerosene and solar energy are predominantly used.

Mpigi and Luwero districts were selected because they were some of the districts where the Uganda Domestic Biogas Program (UDBP) has been implemented. UDBP is a component of the Africa Biogas Partnership Program that brings together Non-Governmental Organizations, biogas construction companies, financial institutions and government agencies so as to develop and disseminate domestic biogas plants for use in rural and semi-urban areas. UDBP works in collaboration with the Ministry of Energy & Mineral Development, Ministry of Agriculture, Animal Industry and Fisheries, and the Ministry of Water and Environment that are responsible for formulating policies that govern the use of renewable energies (MEMD, 2014). Between 2009 and 2013, 5168 biogas digesters had been installed under the UDBP but this was less than the targeted number of 12,000 installations country wide (MEMD, 2014).

Data collection

Within the study areas, a total of 174 households were interviewed and these comprised three categories as summarized in Table 1.

The households that were considered as dis-adopters are those had not used the technology for at least 8 months by the time the survey was conducted. Given that there are few households that have biogas technology in the two districts, the households that were using the technology and those that had dis-adopted were purposively selected. The households that have never adopted were randomly selected.

Prior to the administration of the questionnaires, pretesting was done with 10 households so as to check the appropriateness of the questionnaires. The pretesting was carried out in September 2015 and the survey conducted for four weeks between October and November 2015. Questions were asked in Luganda which is the local language and the responses were recorded in English.

In-depth interviews were also conducted with 10 households that were using biogas technology and 10 households that had dis-adopted biogas technology in order to find out the challenges faced in the use of biogas technology and reasons for dis-adoption. Interview schedules that comprised both open ended and closed ended questions were used so to guide the discussions.

Data analysis

Conceptual framework and empirical model

According to the random utility theory, a consumer makes a choice that maximizes his or her utility (Walker and Ben-Akiva, 2002). A household adopts biogas technology if the expected utility from using it is greater than the utility of not using it. Similarly, a household decides to dis-adopt a technology when the expected utility from continuing to use a technology is lower than the expected utility from discontinuing it. Assuming that households maximize utility, the decision by a farm household i in year t to dis-adopt biogas technology ($BT_{it} = 1$) or to continue using it ($BT_{it} = 0$) is based on a comparison of expected utilities of both situations. Using the difference in expected utilities gives the

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