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Are smallholder farmers willing to pay for a flexible balloon biogas digester? Evidence from a case study in Uganda

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ABSTRACT

Biogas technology, as a pro-poor renewable energy source, has been promoted in Uganda through the use of fixed dome and floating drum digester designs. However, these designs have proved to be too expensive for the average Ugandan household to afford. A cheaper flexible balloon digester has been proposed to increase uptake. However, there has been lack of evidence on household's willingness to pay (WTP) for the flexible balloon digester and the factors affecting adoption of this alternative design. Primary data were obtained from survey of experimental households and 144 'non-biogas' households in central Uganda. A logistic regression model was used to estimate household's WTP and determine the factors that influence WTP. Results reveal that the majority of surveyed households showed their WTP, but an average household's maximum WTP (US$52) was ten times less than the actual cost of an imported flexible ballon digester unit (US$512). The results further indicate that household size, education level, gender and age of the household head, number of livestock owned, total land area owned and a household's perception on technology significantly influenced the WTP. Thus, government and NGOs interested in promoting this design should pay due attention on ensuring the availability of affordable flexible balloon digester from local sources. Otherwise, the focus should be on promoting either different biogas designs or alternative affordable renewable energy technologies rather than the flexible balloon digester.

Introduction

It is estimated that 2.4 billion people, representing more than a third of the world's population, rely on biomass (wood, charcoal, crop residue and dung) for cooking and heating (KITE, 2008). Current trends suggest that another 200 million people will be dependent on biomass to meet their thermal energy needs by 2030 (Walekhwa, Mugisha, & Lars, 2009). In Uganda the main source of fuelwood for cooking is obtained by cutting down trees. Okure and Nabuma (2004) observed that over 60% of the total wood produced in Uganda is used as fuelwood. Fuelwood still remains the most accessible source of energy to most rural and urban households in Uganda (KITE, 2008). Incomplete combustion of fuelwood generates smoke that results in indoor air pollution (IAP) and poses significant health risks and causes diseases such as respiratory and eye diseases especially among women and children (Malla, Bruce, Bates, & Rehfuse, 2011; WHO, 2006; Winrock International, 2007).

There are a number of options that can be used to overcome the harmful effects associated with traditional uses of fuelwood (Malla et al., 2011). Such interventions include behavioural change, improved kitchen ventilation, sustainable production of biomass, efficient wood/charcoal stoves and the use of cleaner fuels (Hutton, Rehfuse, & Tediost, 2006). However, the most effective way of dealing with the problems, especially that of IAP, is to switch to cleaner burning fuels, such as liquefied petroleum gas (LPG) and kerosene that produce significantly lower emissions (Malla et al., 2011).

Although switching to cleaner fuels offer the first-best solution, current economic conditions and energy infrastructure in Uganda make cleaner petroleum-based fossil fuels an unlikely option. This is because commercial fuels such as LPG are in most cases deemed too expensive and not always available. Consequently, affordable alternatives that are cleaner and more sustainable, and also reduce households' workload are needed. Such energy interventions include biogas, which is produced from animal dung, human excrement and other organic materials (Ruto & Garrod, 2009). Biogas is also likely to produce lower emissions (Semple, Apsley, Wushishi, & Smith, 2014). A study by Walekhwa et al. (2009) indicated that Uganda has a potential to generate 1740 Mtoe of energy from animal waste at a recoverable rate of 30%. If this energy is fully utilised, Peipert, Severyn, Hovmand, and Yadama (2009) reported

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that households would improve in health, economic and environmental outcomes. In particular, adoption of biogas technology by smallholder farmers in SSA has several advantages. It can be produced from different locally available materials such as animal excreta, domestic wastes, and agricultural residues. It provides cheap and clean energy to the household. For example, a study by Winrock International (2007) reported that a biogas digester in Uganda resulted in savings to households due to reduced purchases of cooking fuel (90% reduction in charcoal consumption and 75% in firewood consumption). In addition, household labour time for fuel wood collection can be saved and this could be used in income generating activities. However, most efforts aimed at promoting biogas in Uganda have mainly focussed on feasibility of biogas production from fixed-dome digester designs (Walekhwa et al., 2009; Winrock International, 2007). These digester designs have proved to be too expensive for the average Ugandan rural household to afford (Winrock International, 2007).

A cheaper flexible balloon digester design was being promoted by a project – 'The Potential of Small-Scale Biogas Digesters to Improve Livelihoods and Long Term Sustainability of Ecosystem Services in Sub-Saharan Africa', supported by the UK Department for International Development (DFID) under the New and Emerging Technologies Research Competition (NET-RC) grant– where flexible balloon digester were provided to a selected number of households in Tiribogo village in Mpigi district, central Uganda. The project aimed at providing information that would help the success of national programmes to establish affordable biogas digesters in Sub-Saharan Africa. It focussed on investigating in cheaper designs of biogas digesters to encourage wider uptake of the technology among the poor members of the community and to provide a long-term energy supply. However, the preferences and willingness to pay (WTP) of smallholder households and the factors influencing their WTP for the flexible balloon digester have not been studied. In addition, the potential of the flexible balloon digester to enhance the livelihood of smallholder farm households has not yet been explored. It is against this background that this study was conducted to assess the willingness to pay for the flexible balloon digester and understand the factors that determine household's WTP using household survey data from central Uganda. The main objectives of the study were to: (i) estimate smallholder household's willingness to pay for the flexible balloon digester, and (ii) determine the key factors that influence the willingness to pay of households for a flexible balloon digester designs.

Approaches to willingness to pay

The willingness to pay (WTP) approach of valuation was based on well-known standard consumer behaviour theory (Bishop & Heberlein, 1979; Hoehn & Randall, 1987). Most valuation methods measure the demand for a good or service in monetary terms for a particular benefit (Hanneman, 1991; Shogren & Hayes, 1997). Contingent valuation (CV) and choice experiment approaches are the most widely used economic valuation methods to elicit consumer's WTP for a good or service. In contingent valuation, respondents are directly asked for their WTP for a specified good or service. The CV method elicits values for specified goods by presenting respondents with a description of a proposed hypothetical scenario and asks the respondents to express their maximum WTP to enjoy a positive change (Balana, Catacutan, & Mäkelä, 2012). Because the elicited WTP values are contingent upon the market described to the respondents, this approach came to be called the "contingent valuation" method (Venkatachalam, 2003). In choice experiments, however, respondents are asked to consider combinations of attributes and associated levels to choose their preferred option from a set of alternatives with particular attributes (Sabah, 2009). In reference to this study, we used the CV method to determine the value of the flexible balloon digester.

Contingent valuation method has been employed for the estimation of willingness to pay for renewable energy and factors that affect it (Sabah & Jeanty, 2011). In addition, CV method has been used for evaluation of choice among various alternatives renewable energy choices such as wind, hydropower and biomass (Angeliki, Nick, & Konstantinos, 2007). Most of the studies have explored willingness to pay for renewable energy by households using the binary or multinomial logit models. Garson (2008) investigated the willingness to pay for solar photovoltaic energy lighting using a multinomial logit and the results indicate that socioeconomic, demographic and environmental conditions influence willingness to pay. Multinomial Logit has limitations such as failure to account for varying levels of substitution between choice alternatives, taste homogeneity ignores the fact that preferences are unobservable and violates consumer axioms of transitivity and stability of choices by imposing independence of unobserved factors over time or across time (Foster, Ghosa, Carrillo, Molina, & Panico, 1998). Riccardo and Ken (2010) explored the willingness to pay for renewable energy in United Kingdom. This study compared the results from conditional and mixed logit models, which estimated the distribution of utility coefficients. This then derived willingness to pay values as a ratio of the attribute coefficient to the price coefficient. With such a model, the willingness to pay distribution is estimated directly from utility in the money space.

Mixed logit overcomes the limitations imposed by multinomial logit such as accounting for taste differences by allowing model coefficients of observed variables to vary randomly over individuals (Train, 1998). In addition, individual preferences are assumed to be heterogeneous and continuously distributed random variables for the whole population (Train, 1998). Sabah and Jeanty (2011) examined the households' willingness to pay for electricity connection in Kenya and found out that households were willing to pay more for geothermal energy services than Photovoltaic using a binary logit. In addition, households favoured monthly connection payments over a lump sum amount. However, Daniel (2009) explored the willingness to pay and attitudes regarding biogas digester and linear regression were used in determining the factors that influence willingness to pay for anaerobic digestion on dairy farms. The parameter estimates from the linear regression are unbiased, but inefficient and inconsistent (Mugisha, Ajar, & Elepu, 2011).

Our present study adopted the logistic regression model to the conventional linear probability regression model in analysing the factors that influence willingness to pay for a flexible balloon digester. The reason is that parameter estimates from the former are asymptotically consistent and efficient Greene (1997). The estimation procedure employed also resolves the problem of heteroscedasticity and constrains the conditional probability of making the decision to pay for the flexible balloon digester lie between zero and one. Other studies that have used logit model include (Foster et al., 1998; Sabah & Jeanty, 2011) among others. The study therefore used a binary Logit because of the nature of the dependent variable.

Methods and materials

Study area description

The study was conducted in Mpigi district, Muduuma Sub-county in Tiribogo village (Fig. 1). Muduuma Sub-count is located on 0°21′5″ N and 32°17′56″ E and the average minimum and maximum temperature recorded is 15 °C and 28 °C respectively. The areas experience a bimodal rainfall pattern, with the first season starting in March–April and ending in May. The second rains start in July and go up to November and are usually more reliable. The annual rainfall ranges from 800 mm and 1200 mm. Tiribogo village is bordered by Muduuma forest reserve with dominant vegetation consisting of savannah woodland. The village has a total population of 4800 whose livelihood is based on mixed crop-livestock agricultural system with livestock is kept mainly to supplement household cash incomes.