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Demographic Factors that Affect Adoption of Biogas Technology in Kiambu County, Kenya

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Abstract
Biogas is produced through anaerobic digestion of organic feedstock materials. Biogas is an important source of green energy and the growth of its production in Kenya is mainly supported by co-digestion of manure. Economic and institutional factors have been identified to affect the success of the Kenyan biogas sector. This paper reports the demographic factors affecting adoption of biogas technology in Kiambu County. Data was collected by surveying 416 (n=208 households producing biogas and n=208 households not producing biogas). Households were randomly selected using the transect line survey of every fifth household in four sub counties in Kiambu. Equal distribution of sampled households was ensured for each ward sampled (n=13 for households producing biogas and n=13 for households not producing biogas). Biogas technology adoption rate in Kiambu was low (about 40%) and this was even lower in female-headed households (33%). Other demographic factors that significantly influenced biogas production in Kiambu included age of the household head, the main farming activity practiced, land ownership tenure, livestock keeping activity, and household income level (n=416, P≤0.05). However the respondents' education level did not influence the adoption rate. It is recommended that policy on biogas adoption is not only based on the need to decrease environmental pollution but also the need to address the challenges arising from demographic disparities in the communities.

Keywords: *Biogas, Adoption, Demographic, Determinants, Kiambu*

Introduction

Biogas technology is a solution to many adverse health and environmental impacts (Brown, 2006; Yadav, 2014; Inda and Moronge, 2015). Biogas is a mixture of gases produced through anaerobic digestion of biodegradable material like manure and other green waste from plant material and energy crops, particularly corn (Karanja and Kiruiro, 2013; CEF, 2016). These feedstock raw materials are decomposed through anaerobic digestion by the micro-organism to transform into biogas. Biogas is principally composed of methane (CH_4) and carbon dioxide (CO_2) and it is a combustible high grade fuel that burns with a hot blue flame. Biogas is considered clean energy for heating, cooking, and lighting, and for use to power engines. Biogas is considered to be a clean renewable source of energy because during heating it does not produce carbon dioxide (Kangmin and Ho, 2006; Jørgensen, 2009; CEF, 2016; Renewables, 2016). In addition biogas offers benefits such as saving fuel wood and protecting forests as well as reducing expenditure on fuels. It further reduces household labor on time spent on cooking and housekeeping and improves hygienic conditions (Gregory, 2010).

If fully exploited, biogas has the potential of providing up to 6% of global primary energy supply equivalent to a quarter of the current consumption of natural gas (WBA, 2013; German Biogas Association, 2016). This would address challenges posed by use of fossil-based forms of energy, particularly leading to a cleaner environment (International Forum on Globalization, 2004). Today more and more countries are making efforts to adopt the use of renewable energy because it is clean and sustainable. Kenya is advocating, in her Vision 2030 agenda, the use of clean energy such as biogas for environmental, social and economic advantages. Kiambu County hosts many farms that can produce and benefit from biogas production. However, even with all the effort by the various agencies to promote biogas, 80 % of people in Sub-Saharan Africa rely on traditional use of biomass for their cooking (Rogers, 1995; Karekezi and Kithyoma, 2003), with over 90% of rural households in Kenya using fuel wood for cooking (Wamuyu, 2014; Njenga, 2013).

This paper documents the demographic factors affecting the production and use of biogas in Kiambu, which has a high potential area for generation of biogas (Shell Foundation, 2007). Thus, with the prerequisite support mechanisms the current production in Kiambu could be increased for use within and outside the County. This would lead to benefits such as low cost of energy, reduction in environmental degradation and promotion of sustainable development.

Materials and Methods

The research was carried out in Kiambu County in Central Kenya using the conceptual framework shown in Figure 1. The County is divided into 12 Sub-counties and four of them were purposely selected based on geographical location for uniform representation as follows; Githunguri, Lari, Limuru and Ruiru sub-counties. In addition the selected sub-counties met the criterion for high potential for biogas production based on existing secondary data.

Data was collected by administering questionnaires to 208 heads of households producing biogas and also to another 208 from non biogas producing households, who served as the control group. The data was also corroborated through key informant interviews conducted using institutional authorities.

Questionnaires, research diaries, data record sheets, checklists, observational data sets, photographs, focus group discussion recordings, key informant interview reports were used for this research.

The household was used as the primary sampling unit to evaluate the demographic factors affecting biogas production and use. The sampled households were 416 (n=208 households producing biogas and n=208 households not producing biogas). All households were randomly selected using the transect line survey of every fifth household for each of the four administrative wards in each sub-county. Equal distribution of sampled households was ensured for each ward sampled (n=13 for households producing biogas and n=13 for households not producing biogas in each ward). This ensured each household had equal chance of being sampled to avoid bias in the selection process as previously described by others (Gravetter and Forzano, 2011).

Both quantitative and qualitative data were collected. Quantitative data was analysed using descriptive statistics and the significance tested using *Student-T test ($P \leq 0.05$)*. Qualitative data was tested using *Chi-square test ($P \leq 0.05$)*

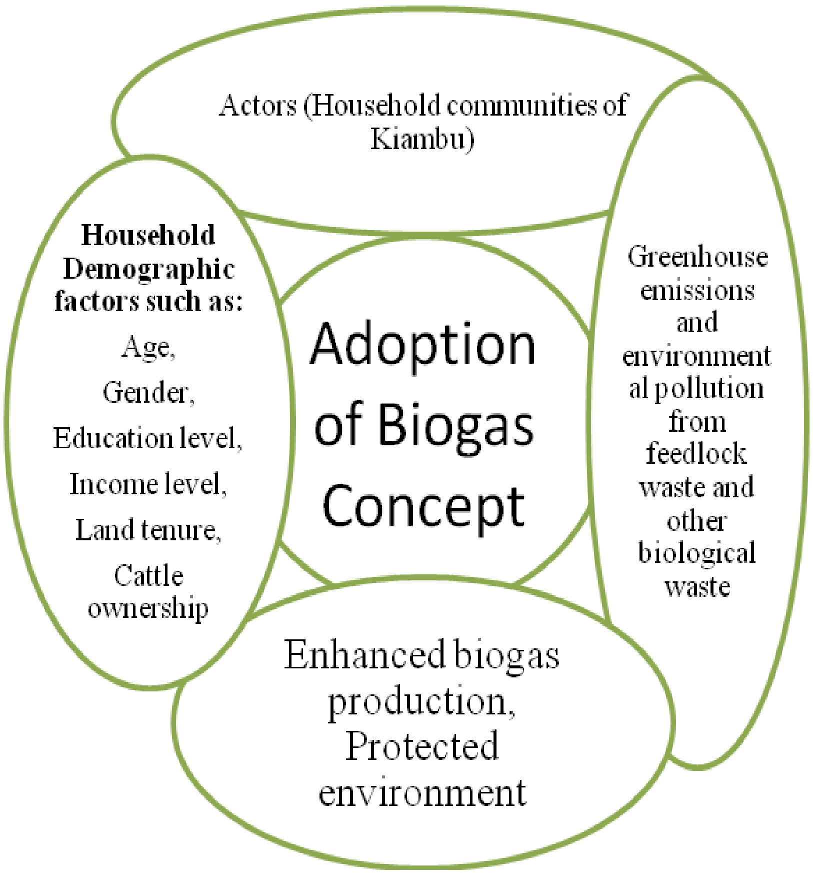

Fig. 1: The conceptual framework for adoption of Biogas for enhanced environmental management.

Results and Discussions

Gender effects on biogas technology adoption

In general there was significantly low adoption rate for biogas technology within both male and female-headed households (39% against a non-adoption rate of 61% in male-headed households and 33% against 67% for female-headed households). Also gender of the household head significantly affected adoption of biogas technology in Kiambu (Table 1). Significantly higher adoption rate for biogas technology was noted in male- headed households (39%, n=300, $P \leq 0.05$ when compared to female-headed households (33%, n=116, $P \leq 0.05$).

Table 1: Gender effects on adoption rate of biogas technology within Kiambu households (n=416)

Gender of Household head	Adopted (positive) (%)	Not adopted (negative) (%)
Male-headed households (n=300)	38.9±2.1[a]	61.1±1.7[c]
Female-headed households (n=116)	33.1±1.6[b]	66.9±1.8[d]

[a-d] Different letters in the same row and column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

In Kiambu, just like in most African communities, men own most household assets in male-headed households. Thus, it was expected they would be the main gender deciding whether to adopt or not adopt biogas technology. A study carried out in Nepal made a similar conclusion (Karki *et al.,* 2015). This could point towards a need by national and county governments to prioritize policies on energy that take into account the concerns of women because of their critical role in the paradigm shift towards use of clean energy based on the fact that they are the gender involved in firewood searching and cooking for families (Obisesan, 2014). Similar results were reported by Wawa (2012), who found out that gender of household influenced decision to adopt biogas technology. Male-headed households were more likely to adopt biogas than female-headed households. The patriarchy system where men own resources and they are the decision makers (Njenga, 2013) gives them an advantage to make decision for or against adoption of biogas.

Effects of age of respondents on biogas adoption

Apart from between age group 20-40 years, there were significant differences (P≤0.05) between the age groups on adoption and/ or non adoption practices for biogas in Kiambu (Table 2).

Table 2: Effect of age of respondents on adoption of biogas technology (n=416)

Respondents' age	Adopted (n=208)	Not Adopted (n=208)
	Percentage %	Percentage %
20 – 30 Years	18.5±1.3[a]	81.5±1.6[e]
30 – 40 Years	19.7±0.8[a]	80.3±0.9[e]
40 – 50 Years	29.1±1.1[b]	70.9±1.4[f]
50 – 60 Years	38.9±2.3[c]	61.1±1.5[g]
Over 60 Years	51.0±0.7[d]	49.0±0.4[h]

[a-h] Different letters in the same column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

The data confirms that young people (age 20-40) had low adoption rate for biogas technology as also reported previously by others (Wawa, 2011; Kinya, 2014). This could be explained by the fact that this age group prefers sources of energy like hydro-electric power and solar which to them are not labour-intensive when compared to biogas production and the fact that the older generation controls the household land and capital for such investments.

Effects of education level of respondents on adoption of biogas

Education level had no significant effect on adoption and/ or non adoption practices for biogas in Kiambu (Table 3, P≤0.05).

Table 3: Effects of respondents' education level on adoption of biogas

Education level	Adopted (n=208)		Not Adopted (n=208)	
	n	Percentage	n	Percentage
No Education	8	38.1±0.2[a]	11	61.9±0.3[b]
Primary Education	52	25.9±.07[a]	58	74.1±0.9[b]
Secondary Education	66	36.5±0.6[a]	65	63.5±0.6[b]
Tertiary Education	71	36.9±0.9[a]	70	63.1±0.8[b]
Postgraduate Education	11	33.3±0.1[a]	4	66.7±0.1[b]

[a, b] Different letters in the same column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

This data is contrary to our expected outcome that level of literacy would have enabled household heads to make decisions for adoption of clean energy such as biogas. A literate population is expected to be more trained and sensitized on environmental issues (Wawa, 2009). May be this could be attributed to the fact that it is not only the level of education that informs decision on adoption but rather other confounding factors like social, economic and personal decisions (Riddell and Song, 2012). This finding agrees with that of Walekhwa et al. (2010) who revealed that level of education was negatively correlated to adoption of biogas technology because people viewed it as the technology for the less educated.

Effects of farming activity on adoption of biogas technology

There was significant effect of the main farming activity on the adoption rate of biogas in Kiambu (Table 4). There is a direct correlation between farming and adoption of biogas technology.

Table 4: Effects of household farming activity on adoption of biogas technology

Household main farming activity	Adopted (n=208)		Not Adopted (n=208)	
	n	Percentage	n	Percentage

Mixed crop and livestock farming	94	42.7±1.3[a]	88	57.3±1.1[d]
Agri-business	63	24.8±1.9[b]	85	75.2±1.6[e]
Formal office employment	51	31.4±0.8[c]	35	68.6±1.2[f]

[a-f] Different letters in the same row and column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

The data agrees with the fact that biogas is expected to mostly come from agricultural manure (Make It Be, 2012). Thus the amount of available bovine, swine and poultry manure available in farms could easily be converted into biogas as long as there is capital for investing on the technology (Reale *et al.,* 2009). This supports the fact that households engaging in agri-business and formal office employment could be engaged in biogas. Thus, the data also support the fact that beyond traditional adoption framework based on farming enterprise, income from other sources becomes a key variable for adoption of biogas technology by providing the capital needed for setting up biogas facilities (Selden and Song, 1994).

Household income effects on adoption of biogas technology

There was significant relationship between the respondent's income and adoption of biogas technology (Table 5). However differences were noted that existed between various categories of income levels and the role this played in an individual's decision to adopt biogas technology.

Table 5: Effect of household income on adoption of biogas technology

Household Monthly income level in Thousands Ksh	Adopted (n= 208)		Not Adopted (n=208)	
	n	Percentage	n	Percentage
Below 10	26	12.3±1.7[a]	64	87.7±2.0[e]
10-20	70	41.7±2.0[b]	70	58.3±1.6[f]
20-30	57	49.3±0.8[b]	38	50.7±0.8[f]
30-40	25	69.0±0.4[c]	9	31.0±0.2[g]
40-50	11	24.0±0.1[d]	14	76.0±0.4[e]
Over 50	9	40.9±0.3[b]	13	59.1±0.1[f]

[a-f] Different letters in the same row and column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

This data seems to support that issue of energy consumption mainly focuses on the relationship between energy and income (Kalyoncu *et al.,* 2013). Also, the data agrees with recently reviewed energy-growth nexus, which identified prevailing viewpoints on adoption and consumption of energy. These views state that energy is an input of production, and thus correlates energy consumption to economic growth (Stern and Cleveland, 2004). Therefore it is also agreeable that economic growth influences energy consumption (Aziz, 2011; Toman and Jemelkova, 2003) and that economic development affects energy consumption, and by extension the type of energy adopted (Aziz, 2011). This also agrees with Sufdar *et al.,* (2013) who indicated that households with high income are more likely to adopt biogas technology as compared to households with low income.

Effects of Land ownership on adoption of biogas technology

Land ownership significantly influenced adoption of biogas technology (Table 6).

Table 6: Effect of land ownership on adoption of biogas technology (n=416)

Household land tenure system	Adopted %	Not Adopted %
Household head owns land (n=208)?	63.2±1.8[a]	36.8±2.3[c]
Household head didn't own land (n=208)?	0±0[b]	100±0.1[d]

[a-d] Different letters in the same column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

This data supports that individuals have their own visions about which renewable energy sources are acceptable but a vision of production of biogas in non-owned land would entail responsibility of many actors posing a challenge towards the desire to adopt the technology (Natuur and Milieu, 2011). Access to farms has certain structural advantages regarding bio-energy production, such as land ownership, appropriate machinery and storage facilities (Ruppert *et al.,* 2013).

Effects of cattle ownership on adoption of biogas technology

Cattle ownership significantly influenced adoption of biogas technology in Kiambu County (P≤0.05). However there were a few instances of adopters who did not own cattle but bought manure for biogas production.

Table 7: Effect of cattle ownership on adoption of biogas technology (n=416)

Cattle ownership	Producing biogas %	Not producing biogas %
Household owned cattle (n=208)	50.5±1.3[a]	36.8±2.3[c]
Household didn't own cattle (n=208)?	2.3±0.2[b]	97.7±1.8[d]

[a-d] Different letters in the same column differ statistically by Chi-square, P<0.01; Adopted: respondents who had adopted biogas; Not adopted: respondents of the contrary practice

This data supports the fact that households owning cattle had certain structural advantages regarding bioenergy production from anaerobic digestion of the manure for biogas production (Iqbal *et al.,* 2013). This was expected because most of the adopters in Kiambu kept cows on zero-grazing making it easier for them to collect feedstock for the digesters. Kiambu practices dairying as a means for household income generation (KNBS, 2009). The results are supported by Kabir *et al.,* (2013), who suggested that cattle ownership is an important step in owning biogas since it provides the substrate required for anaerobic digestion.

Conclusion and Recommendations

The data points towards demographic factor dependent adoption of Biogas technology in Kiambu. This conclusion ties well with the Resource Dependence Theory (RDT) as explained by Nienhüser (2008). The theory states that the success of a venture like biogas production in our case depends on the level of dependence on critical resources, in this case as influenced by the above listed demographic factors. Thus, based on the environmental Kuznets curve (EKC) hypothesis, in which the relationship between income and environmental deterioration exists, it is recommended that policy on biogas adoption is not only based on the need to decrease environmental pollution but also the need to address the challenges associated with demographic factors in the communities.

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