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Practices and Challeges of Domestic Biogas Technology Use: The Case of, Wondogenet District and Hawassa City Administration, Sidama Zone, Southern Ethiopia, Ethiopia

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Abstract
The study assessed the existing practices, identified the factors which influences the usage and the challenges that prohibit the expansion of the technology both at the rural and urban settings. Multi stage sampling procedures were applied to identify households for final interview. 14 kebeles from wondogenet district and Tulas sub-city of Hawassa city administration was selected purposively based on their usage of the technology and years of their experience. Households were stratified as users and non users of the technology then after a total of 178 households (85 from users and 93 non users) were randomly selected and interviewed. Among ten variables which were fitted to logistic regression model and six were significantly influenced the decision making of households to use biogas technology. Age of the household head, family size, access to credit, cattle holding, awareness about the technology and shortage of energy for cooking and lighting were significantly and positively influenced the adoption of the technology. Shortage of space to dispose biogas slurry at urban and pier-urban setting, Absence of appliance like Injera Mitad and inflation of construction materials price which in turn inflate construction cost of the technology and low performance of loan repayment by expecting donation were among major challenges to develop the technology as desired and planed.

1. INTRODUCTION

1.1. . Background

Access to modern energy is a key element in any development activities. However, despite all attentions given to energy issues in Ethiopia in the past, urban and rural communities have been continued to be deprived of basic energy services. Over 88% of all citizens rely on biomass fuel for cooking and lighting. Modern forms of energy are simply not available in rural areas; similarly traditional sources are rapidly being depleted, thereby deepening the rural energy crisis. Among the principal manifestation of the rural energy crisis, depletion of wood fuel resources can be an example. This leads to the decline in household welfare caused by damage on the environment, an increased use of inferior fuels, higher wood fuel prices, and a reduction in quality and frequency of cooked meals. Additionally, it leads to a reduction in agricultural productivity as a result of using dung and crop residue as fuel instead of using these as soil nutrients (Nadew Tadele, 2014, Willem Boers & Getachew Eshete, 2007).

Domestic biogas has multiple socio-economic benefits. Among these benefits improved living conditions through reduced use of fuel wood, and improved soil fertility through the use of bio-slurry. Additionally biogas contributes to the reduction of greenhouse gases and to job creation to local masons, construction enterprises, appliance manufacturers and others.

The use of biogas also helps to reduce time used to collect fuel wood, and other household activities such as cooking and cleaning. The time thus saved can be devoted in other income generating activities, which also increases the income of the users. Since biogas is smokeless and environmentally friendly energy technology, it can create the clean cooking environment and improve the health of family members. Furthermore, the attachments of toilet to the biogas improve the health of the family and environment. Healthy environment and increased income may help to enhance the socio-economic status of the people. Thus, biogas technology can play a vital role not only in providing energy, but also can positively contribute for rural development as a whole by enhancing the well-being of the rural people through protection of environment (Daniel, 2004; Mae Wan Ho, 2005; Valerie, 2006; African Biogas Initiative, 2007).

Global experience shows that biogas technology is a simple and readily usable technology that does not require overtly sophisticated capacity to construct and manage. It has also been recognized as a simple, adaptable and locally acceptable technology for Africa (Akinbami et al, 2001). The use of biogas technology can improve

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human well-being (improved sanitation, reduced indoor smoke, better lighting, reduced drudgery for women, and employment generation) and the environment (improved water quality, conservation of resources – particularly trees, reduced greenhouse gas emissions) and produce wider macroeconomic benefits to the nation. (Africa Biogas Initiative, 2007).

Biogas technology as an alternative to the use of biomass for energy was introduced in Ethiopia as early as 1957. The biogas was constructed by Ambo Agricultural college to supply energy for welding. During the 1970s, two biogas plants were introduced by the Food and Agriculture Organization (FAO) as pilot projects to promote the technology (Linda Manon, 2016). In almost two decade period only 1,000 biogas plants were constructed in various parts of the country and 50% of them were reported not in regular use due to lack of effective management and follow-up, technical problems, loss of interest, reduced animal holdings of household, evacuation of ownership and water problems. Other reasons for the limited success of the technology in Ethiopia include the adoption of a project-based stand-alone approach without follow-up structure in place, variations in design, and the absence of a standardized biogas technology. (EREDPC, 2008)

After the establishment of National biogas program (NBP) a total of 9,825 plants constructed since 2008. Wondogenet district is one of the districts which constructed more than 190 biogas plants Since Hawssa zuria woreda and Hawassa city are not among National biogas woredas there is no reliable information regarding but it is known that there is long practice in the city before. (ABPP, 2014 and regional NBP coordination office report, 2015).

1.2. Significance of the Research (Justification)

Household domestic biogas technology is a renewable clear energy source, which is environmentally friendly and relatively simple to be handled by rural household (African biogas initiative, 2014). National Biogas Program in Ethiopia start implementation before eight years but the achievement is very low compared with target planed and capacity of household who are able to construct and use the technology both in cattle holding and other resource endowments. This is the researcher is initiated to assess the practices and challenges the technology usage at household level by taking cases from Wodogent, Hawassa zuria districts and Hawassa city. The output of the study will provide input for policy directives and further study on the practices of domestic biogas technology usage and program implementing bodies in different decision making level.

1.3. Objective of the study

The main objective of this study was to assess the current practices of domestic biogas technology usage in the study area

Specific objectives:

- To assess the current practices of domestic biogas technology usage in the study area.
- To assess the determinants that influences the use of biogas technology at household level.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

Wondogenet district is located in the southeastern escarpment of the Ethiopian Great Rift Valley (7°06–07′N, 38°37′–42′E), approximately 260 km south of Addis Ababa. The altitude ranges from 1,800 to 2,580 m a.s.l. The average yearly rainfall is 1,210 mm, with a rainy season during March to September, and a relatively dry period from December to February. The average annual temperature is 20°C. (Muluken Mekuyie, 2014). The district is one of the districts in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia. Part of the Sidama Zone located in the Great Rift Valley; Wondo Genet is bordered on the south by Malga, on the west by Awasa Zuria, and on the north and east by the Oromia Region. The administrative center is Wondo Genet. Wondo Genet was part of former Awasa woreda. Based on the 2013 Census conducted by the CSA, this woreda has a total population of 232,899, of whom 119,010 are men and 113,889 women; 41,783 or 17.94% of its population are urban dwellers.

Hawassa city is located in the Southern Nation's Nationalities and Peoples Region on the shores of Lake Hawassa in the Great Rift Valley; 273 km south of Addis Ababa via Debre Zeit and 1125 km north of Nairobi.

Hawassa is served as the Capital of the Southern Nations Nationalities & people's Regional state and the Sidama zone. The City lays on the Trans-African High Way-4 an international road that starched from Cairo (Egypt) to Cape Town (S.Africa). Geographically the City lays between $7^0$3' latitude North and 38^0 28' longitudes east bounded by Lake Hawassa in the West, Oromia Region in the North, Wendogenet woreda in the East and Shebedino woreda in the South and it is divided in to 8 Sub-Cities and 32 Kebeles. These Eight sub Cities are Hayek Dare, Menehariya, and Tabore, Misrak, Bahile Adarash, Addis Ketema, Hawela-Tulla and Mehal Ketema Sub-City.

2.2. Study Subject

The study was undertaken on biogas usage and challenges in Wondogenet district and Tula sub-city of Hawassa. Biogas is a clean and environmentally friendly fuel generated from anaerobic degradation of biomass typically animal dung, agricultural and other biodegradable urban wastes including human feces. The gas consist carbon dioxides (CO_2) and methane (CH4), methane is an attractive renewable carbon source and its exploitation would be advantageous from both a financial and an environmental point of view. The study assessed existing practices and challenges of biogas technology. The detail investigation which mainly focus on the households and the institutions which were promoting the technology were the unit of analysis. The relevant information was collected from both users and non user of the technology.

2.3. Study Design

This study was designed to assess the practice, identify the challenges and analyze the determinants which influence the use of domestic biogas technology in Wondogenet districts and Tula sub-city of Hawassa city administration. Regional Water, Energy and Mines bureau and National Biogas program coordination office, The Netherlands development organization (SNV) and district water, energy and mines offices was consulted for site selection and other necessary information. Both qualitative and quantitative data were employed for the analysis.

2.4. Study Type and Data Source

Cross sectional diagnostic survey was undertaken. Key-informant interview and focus group discussion was held with representatives of major stallholder's. Most quantitative data were collected directly from the users and non users of the technology through interview. Very few information were taken from reports and publications.

2.5. Sample Size and Sampling Procedures

Three stage sampling technique were used to select the households. At The first stage the study woredas and Kebeles were selected purposively based on the number of biogas technology constructed, households were stratified as biogas users and non users and finally Systematic random sampling procedure was employed to identify 85 user households from the list collected from regional biogas coordination office and district offices. Proportionally equivalent non user households were selected from the same kebeles from the lists provided by each kebele administration. As indicated in the following formulas and table. There were 160 and 31 biogas users in Wondogenet districts and Tula sub-city of Hawassa administrative region. A total of 191 user households were found in both study areas. Proportionately equal number of non-user households was taken and a total sampling frame was 382 households and lastly 178 households were selected randomly for the interview from both biogas technology users and non-users. The size of Sample was determined by using the formulas provided by Cochran (1967) and adjusted for finite population proportion as indicated by Glenn (2013) as shown below.

$$n_0 = \frac{Z^2pq}{e^2}$$

---equ.1(Cochran, 1963)

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

------------------------equ.2(Glenn,2013)

Where n_0 is the sample size,
Z is the score of the normal curve at 95% confidence level (1.96),
p is the estimated proportion of an attribute that is present in the population in relation to biogas use (70%), and q is 1-p.(30%)
n is the adjusted sample size for finite population correction and
N is the population size

The higher population variability were taken (70%) and the sample size n_0 was calculated to 323 household ($N_0=(1.96)^2(0.70x0.30)/(0.05)^2=323$) accordingly 178 adjusted sample size was estimated by applying finite population correction (n=323/1+ (323-1)/382=178)

Table 1. sample frame and sample size for biogas users and non-users

Woreda	Sample frame for users	Sample size		
		user	non-user	Total
Wondogenet	320 (160&160)	74	74	148
Tula sub-city	62(31&31)	11	19	30
Total	382	85	93	178

Source: own manipulation

2.6. Study management and Data Analysis

Field survey was handled by enumerators recruited from each study areas and the collected data was coded and administered in to SPSS 20 and strata 14 software. Descriptive statistics was employed the determination of means, percentages, standard deviations; the independent sample t-test was used to compare mean values of the continuous explanatory variables between biogas users and nonusers. Furthermore, logistic regression was employed to identify the underlying factors determining households' decisions on adoption of biogas technology.

3. RESULT AND DISCUSION

This chapter was structured under the three specific objectives of the study, specifically existing practices of domestic biogas technology in the study area, description and analysis of factors influencing the usage of the technology and at last the challenges of the practice was presented.

3.1. Demographic and Socio-Economic Characteristics of Households

The descriptive statistics of the explanatory variables that were expected to influence usage of biogas technology were computed and displayed in Table 3 and 4. Of the total 178 sample households, 165 (92.7%) were headed by males and the remaining 13 (7.3%) by females. And 169 (95.48%) were married while the rest 8(4.52) was single divorced and widowed. Biogas-users and non-users were found to have statistically in-significant in both cases. The result implicates the sex of household head and marital status has no effect on the use of biogas technology.

Table 2. Sex and Marital status of household head

Sex of household head	Use of biogas technology			Pearson chi2(1)
	Non user N(%)	User N(%)	Total N(%)	
Female	5(5.43)	8(9.41)	13(7.34)	1.0268 (p=0.311)
Male	87 (94.57)	77(90.59)	164(92.66)	
Total	92(100)	85(100)	177(100)	
Married	89 (96.74)	80(94.12)	169 (95.48)	5.01(Pr =0.171)
Single	2(2.17)	0(0.00)	2 (1.13)	
Divorced	1(1.09)	4(4.71)	5(2.82)	
Widowed	0(0.00)	1(1.18)	1(0.56)	
Total	92(100)	85(100)	177(100)	

Source; own manipulation

Descriptive statistics result indicates that average age of the household was 43.35 and 42.65 years for biogas users and non users respectively the mean differences were 0.9 which was statistically not significant at less than 5% probability level but logistic regression indicated that it is significant less than 10% critical showing slight influence of the variable. Educational level completed in average years of study were 6.30 and 5.61 for users and non users the difference was not statistically significant, where as average family size was 7.42 and 6.69, annual income was 23944. 32 and 31908.64 birr and heads of cattle were 5.68 and 3.18 respectively and the mean differences were statistically significant and larger for biogas users implicating the influences of the variables.

Table 3. Characteristics of household head age, family size, education level and annual income over the usage of biogas technology.

Variable	biogas usage	Mean	Std. Err.	Mean difference	t-value
Age HH				0.907	0.58
	No	42.65	1.17		
	Yes	43.35	1.09		
Family size HH				0.75	2.37**
	No	6.69	0.203		
	Yes	7.42	0.24		
Education HH				0.69	1.06
	No	5.61	0.5		
	Yes	6.30	0.45		
Annual IHH				7964.32	2.46**
	No	23944.32	2543.76		
	Yes	31908.64	1992.47		
Livestock OHH				2.55	3.49***
	No	3.18	0.24		
	Yes	5.68	0.73		

Source; own computation, ***, **, and * significant at $p < 0.01$, $.01 < p <0.05$, and at $.05 < p < 0.1$, respectfully.

3.2. Current practices and status of domestic biogas technology.

This section was discussed under two small sub topics of institutional setup and implementation policy and strategy and performance of biogas sector as whole at household level in the study area.

3.2.1. Institutional Arrangement

Biogas was first introduced in Ethiopia by Ambo Agricultural College around 1957 to supply the energy for welding agricultural tools. During the 1970s, two biogas plants were introduced by the Food and Agriculture Organization (FAO) as pilot projects to promote the technology (Linda Manon, 2016). During the last two decades, around 1000 biogas plants were deployed in Ethiopia with sizes ranging between 2.5 and 200 m for households, communities and institutions. The early years of implementation of biogas in Ethiopia were not solely focused on small-scale domestic biogas and experiments were conducted on an isolated manner without proper means to up-scale the technology. In a year 2007 Ethiopian Government initiated National Biogas program (NBP) and commenced its implementation in 2008 (SNV, 2008)

At a regional level National biogas program is led by coordination office under close supervision of bureau of mines and energy. As an apex the organization, Ethiopia Rural Energy Development and Promotion Centre (EREDPC) is responsible for monitoring and evaluation of the overall programme activities. It is also responsible for the approval of annual plans and reports.

For the day-to-day coordination of the programme, EREDPC will delegate responsibilities to a semi-autonomous National Biogas Programme Coordination Office (NBPCO). This office will initiate, coordinate, and monitor the activities within the biogas sector, and responsible for accounting, financial procedures, and staff management. Reporting to EREDPC, the NBPCO will work with both the private and public sectors of the programme stakeholders/partners like research centers, Universities, NGOs and private suppliers etc. Representatives of the main national level programme actors will form a Biogas Sector Steering Committee for advising on policy and programme matters that relate to programme implementation.

3.2.2. Performance of biogas sector at household level.

Report of South Regional National biogas program coordination office (SRNBPCO) indicates in the past nine years (from 2008-2016) 3,112 biogas plants in 34 woredas of the regions including Wondogenet and Tula sub-city. At the time of survey there were 160 and 31 biogas plants in Wondogenet district and Tula sub-city respectively (Appendix 2). Survey result of Table shows average years of biogas usage was estimated to 3 years. Digester type constructed by national Biogas program is fixed dome "*Sinidu*" model with $6m^3$, $8m^3$, $10m^3$ digester size while $6m^3$ digester plant is favored and supported by NBP because of lesser costs. 84% of biogas digesters constructed in the study area were connected to human toilet Almost 90% of the 178 households interviewed heard about the technology either from extension workers, friends or media and mesons (table 6). This shows how much the sector made effort to create awareness about the technology specially the contribution of extension workers were great.

Table 4. Your household members know / heard about biogas

Description of variables		Frequency	Percent
Heard about biogas	No	18	10.3
	Yes	157	89.7
	Total	175	100.0
Source of information	Media	14	8.70
	Extension Workers	99	61.49
	Friends	40	24.84
	Mesons	8	4.97

Source; own survey data.

According to National biogas program implementation document and annual report of regional biogas coordination office, initial investment cost of 6m[3] digester plant was estimated to 14,000 Ethiopian birr. National biogas program subsidize 60% (8,400birr) in item (construction materials and appliance) and cash for as a payment for masons and the other 40% (5,600 birr) covered by the households interns of material and labor. Credit facilities estimated to 8,000 birr per head was arranged through Omo micro finance institution. The households perceived as if the investment cost was moderately fair, given the subsidy and loan is available see fig1 below.

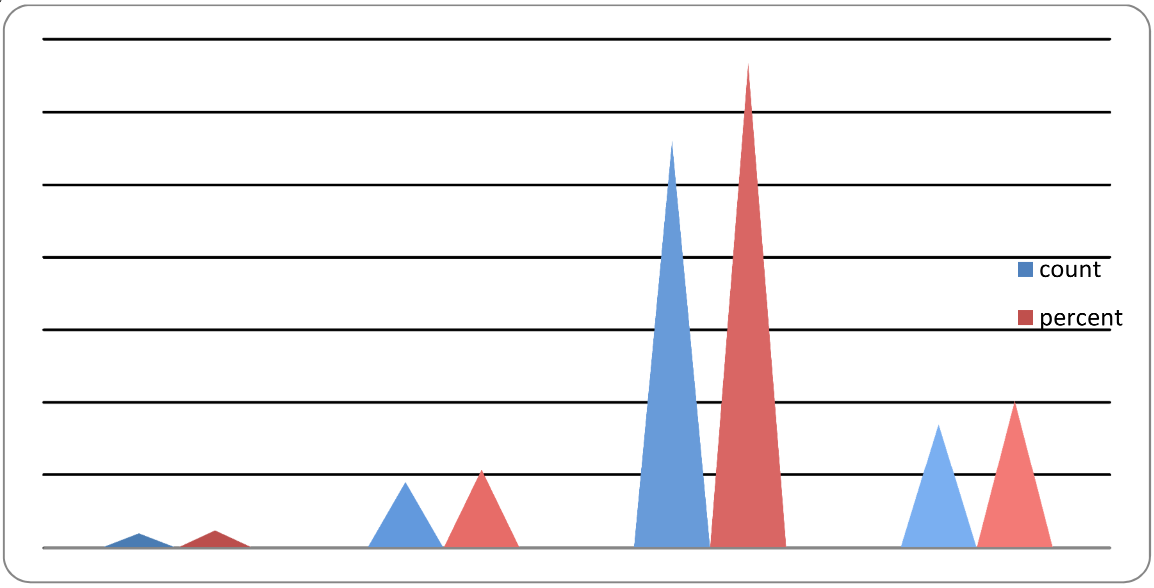

Figure 3. Bar chart on the rating of investment cost

3.3. Factors Influencing the Decision to Construct Biogas Technology

This sub topic was discussed under two small sub-sections first the reason to adopt was discussed and then factors influencing the use analyzed through logistic regression.

3.3.1. Reasons to adopt biogas technology

The biogas-users had various reasons for adopting biogas technology. Anderson (2002) stated that decisions that involve allocation of resources include consideration of multiple alternatives and reasons. Hence, the reasons given for adoption of biogas technology included: energy, economic, social, health, and environmental aspects. As table 6 indicates 76 (83.52%) of the interviewed households were adopted the technology because of the faster and more convenient biogas stoves strongest reason to adopt the technology while the other 18 (16.48%) adopt because of brighter biogas light. the reason why the use of light became lesser can be justified by the access of formal electric power and other sources like solar in both study areas, Surendra et al.(2014) stated that the primary uses of biogas technology in developing countries are cooking and lighting. Eshete et al. (2006) also pointed out that biogas is utilized both for cooking and lighting in Ethiopia.

Table 5. Use of biogas produced from biogas plant

	Frequency	Percent
For cooking	76	83.52
For light	18	16.48
Total	94	100.0

Source; Own survey result.

3.3.2. Factors influencing the use of biogas technology

The results of the analysis of the binary logistic regression model indicated that the model reasonably fitted with the observed data. The complete model comprising the full number of predictors was found to be statistically significant, where chi^2 =60.86 and Prob > chi^2 =0.0000.

The model correctly predicted more than 93% of the biogas-users and non-biogas users of the overall sample households. According to Kabir et al. (2013), a pseudo R2 value of 64% was fairly large to be robust and guaranteed the quality of the model. Among ten variables included in the model six age of household head, family size of the household, cattle heads, credit access, shortage of energy in the household and awareness about biogas technology were found statistically significant at less than five percent significance level and the rest four were not significant even though hypothesized to be significant (Table 7).

Age of the household head: The age of the household head was found to have negative and a statistically significant at ($p < 0.05$) relation with the households' decision on adoption of biogas technology. Older ages of household heads appeared to have lesser probability of adopting biogas technology than the younger households were less likely to adopt biogas technology by a factor of 0.06 as compared to the young-counterpart. This seems to indicate that older household heads are more risk averse and they hesitate to accept new technology and lags for decisions. The result is supported by the findings of a study conducted by Mulu etal (2016) on biogas technology adoption in northern Ethiopia.

Family size: The presence of sufficient household-labor power, which is denoted by the household size, is vital both for the biogas digester construction process and post construction management activities. As part of cost sharing, the NBPE demand potential biogas adopters to: (a) present sufficient building materials including stones, gravels, and sands; and (b) excavate pit for the biogas digester that is required to be situated below the earth's surface Eshete etal (2006). After the completion of the con- structure, household-labor is also required for feeding the biogas digester daily as well as taking care of the cattle (livestock) to ensure sustained digester feeding. Thus, the effect of household size has positive influence on adoption of biogas technology. Accordingly, the result was found statistically significant at ($p < 0.001$) that positively influence the usage of biogas technology. A unit increase in the household size increases biogas usage by 0.58.

Heads of cattle: Cattle dung is the primary input for biogas digesters. The heads of cattle was found to be significant at ($p < 0.01$) factor that positively affected adoption of biogas technology. For each additional unit of cow or cow equivalent, the likelihood of adopting biogas technology increases by a factor of 0.31. The result is consistent with the findings of Kabir et al. (2013) in which cattle size was reported to have a significant positive association with that of adoption of biogas technology. Therefore, the surveyed households have more than four cow equivalent numbers of cattle which is required to feed at list $6m^3$ digester.

Credit access: Given biogas technology requires relatively high initial investment, having access to credit was supposed to positively influences adoption of the technology. Even though credit for biogas technology channeled through Omo microfinance institution access my depend on information, availability of microfinance offices in the vicinity or remoteness of the area etc. Regression result of table 14 shows that the variable is high significant at less than one probability level and the likelihood to use the technology increase by 5.02 percent.

Shortage of energy: The access and available of energy for cooking, heating and lighting affects the decision making of the household positively but the question was prepared to respond where there was shortage of energy in the past 12 months and the response implicate negative sign the result indicates that the variable is highly significant at less than one probability level and the sign is negative as it was expected

Awareness (information about biogas): The creation of awareness about the technology and the program has been made through media and house to house preaching (Mulu etal 2016). Therefore the effect of the variable was expected to have positive sign. The result was also indicating similar outcome and it was significant at less than 5% probability level and positive influence to the use of the technology.

Table 6. Binary logistic regression model results for the factors influencing adoption of biogas technology.

Use of BT	Coefficients.	Std. Err.	z	P>|z|
Sex of head	-1.30598	1.550155	-0.84	0.400
Age head	-.0597615	.031883	1.87*	0.061
Family size	.574706	.200838	2.86***	0.004
Education	-.012073	.0834236	-0.14	0.885
Major Occup.	-.3785119	.278853	-1.36	0.175
Annual income	-.0000223	.0000154	-1.45	0.147
head of cattle (TLU)	.3110653	.1039773	2.99***	0.003
Credit Access	5.021854	.8562191	5.87***	0.000
Shortage of Energy	-2.856343	.8742812	-3.27***	0.001
Awareness	4.17941	2.048156	2.04**	0.041
_constant	-4.631827	2.931123	-1.58	0.114

Source: survey data 2,016

Note: ***, **, and * significant at $p < 0.01$, $.01 < p < 0.05$, and at $.05 < p < 0.1$, respectfully.

Number of obs = 166 LR chi2(8) = 143.54 Prob > chi2 = 0.0000 Pseudo R2 = 0.6440

3.4. Challenges Which Limits the Use of Biogas Technology

From field visit and key informant discussion it was understood that more than 60% biogas plants constructed in urban and Pire-urban areas were not working or stop gas production because of many reasons among which shortage or absence of space to dispose biogas bi-product (slurry), awareness, management problems and absence of appliances (injera Mitad, and others). Field survey report also support the same truth, as shown in table 5 below, among 72 biogas plants constructed in rural areas of Wondogenet 16(22.22%) were not working where as 6(54.55%) of 11 biogas plants constructed in Tula sub-city were not working at the time of the survey. National Biogas Program implementation document indicated that the program focus on rural area and has no program to promote the technology in the urban setting, as the substrate (dung) available and slurry could be promoted as organic fertilizer. Therefore the office

Table 7. Is the plant working now?

		household woredas		Total
		Tula k/Ketema	Wondo-Genet	
Is the plant working now	No	6(54.55%)	16(22.22%)	22(26.51%)
	Yes	5(45.45%)	56(77.78%)	61(73.49%)
Total		11(100%)	72(100%)	83(100%)

Source; own survey analysis.

Lack of technical skill to maintain appliances and damaged part of the plant, shortage of substrate (dung) during first filling, Absence of Injera Mitad and shortage of other appliances like light bulb and lack of space to dispose the slurry. This is true in urban and pier urban area where there they have no farm land, shortage of construction material like cement and rise in price because of inflation was considered as major challenges during focus group discussion and key informant interview. More over the awareness about of slurry application and credit discernment and repayment was also seen as limitation of biogas development

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

More than 90% of energy used in rural area of Ethiopia is biomass, wood, agricultural residue, animal dung and other organic matter which otherwise would be used as organic fertilizer. Expansion of decentralized modern renewable energy systems like biogas technology can address the cyclical problems of energy poverty, land degradation and agricultural productivity. However, the pace of adoption of biogas technology is low in Ethiopia.

The study assessed the existing practices, identified the factors which influences the usage and the challenges that prohibit the expansion of the technology both at the rural and urban settings. Even though decades passed since the technology introduced the technology is still at its infant stage Eshete etal. (2007). Institutional setup is well done after the national biogas program established and starts its implementation by coordinating multiple stallholders at different administrative level. In southern region the program commences before ten years and 3112 biogas digesters were constructed

Ten variables were fitted to logistic regression model and six variables were identified that influences decision making to use biogas technology. Those variables were age of the household head which was considered one among an important factor influencing adoption of biogas technology. Younger household heads were more likely to adopt biogas technology than the older ones. Availability of labor in the household plays important role during construction and day to day feeding process of the plant therefore households with larger family were more likely to adopt biogas technology than smaller one. The heads of cattle holding awareness about biogas technology were identified to have significant at ($p < 0.01$) positive influence in the decisions of households on adoption of biogas technology. Households having access to credit and has shortage of energy for cooking and lighting were more likely to adopt the technology than those have this opportunity.

Major challenges of biogas were, shortage of space to dispose biogas slurry at urban and pier-urban setting where there is no farm land, and absence of policy and strategy to promote the technology at the above mentioned condition, Absence of Injera Mitad and shortage other important appliances at some markets (absence of suppliers), rise of cement price which in turn inflate construction cost of the technology, low performance of loan repayment by expectation of donation.

4.2. Recommendations

Based on the results of the study, the following recommendations are forwarded in order to improve the use of biogas technology in the study area.

- National biogas program should give due attention for urban and pier-urban users and set up strategy to promote the technology in away it may not spoil the environment and contribute for urban waste management.
- The program should find suppliers for appliance especially, ‘‘*Injera’’* backing Mitad as *Injera* is the major consumption item in the household.
- Skill training and awareness creation programs are very important to promote the at all level and it should be strengthened
- For further promotion of biogas technology, attention should be given towards, households' access to credit
- The National Biogas Program Coordination Office should give due attention for how words of mouth from the satisfied or dissatisfied biogas-users can enhance or retard adoption of biogas technology.
- The office should ensure the proper functioning of the already installed biogas plants through monitoring and evaluation services.

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