# Factors affecting the adoption and non adoption of biogas technology in semi-arid areas of Tanzania

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## ABSTRACT

*Tanzanian Government through its policies in response to energy crisis has been promoting among others, biogas as an alternative source of energy. However, the adoption of biogas technology has been reported to be low or not to the expected levels. This study examines the factors that affect the adoption and Non adoption of Biogas technology as an alternative energy source for rural population in Semi arid areas. Kongwa and Chamwino Districts in Dodoma region were used as case study. Data collection methods employed included interviews, focus group discussions and observation. The findings of the study revealed that there is little or no access to the factors hoped to facilitate adoption of biogas technology which implies weakness in promotion efforts. Little involvement of the Government has underestimated the importance of the biogas technology contributing to low adoption. Other factors include, poor performance of biogas plants associated to technical problems, having a negative implication in adoption process, high installation costs unaffordable to the majority of rural population, unreliable feed stocks and water shortage problems. It is recommended that Government should take intentional efforts to fully involve in promoting biogas technology and ensure the enabling environment for the adoption of the technology.*

## Introduction

Biomass, which includes traditional fuels like wood, charcoal, cattle dung and farm residues is the major source of energy in developing countries. For instance, in Tanzania, over 95 percent of the total population depends on wood as their only source of energy for cooking and heating (REA 2007). However, with the increase in population growth, the demand for fuel wood is automatically on the increase while the supply of the same is declining. In most cases, the need to meet the increasing demand for fuel wood leads to uncontrolled and indiscrimate felling of trees (Misana and Nyaki 1991). Unfortunately, forest shrinking is accompanied by inadequate afforestation measures and forest management. According to FAO (2007) deforestation in Tanzania has spread rapidly, affecting most of the semi-arid areas where forest and bush regeneration is slow. This is supported by recent national survey which has indicated that distances to firewood sources increased year after year. Further more, the collection and use of fuel wood are linked to heavy and often low-productive, time consuming work predominantly done by women and children (Ngwandu et al 2009). As demonstrated by The National Energy Policy (URT, 2003), the government of Tanzania is keen to solve the problem of excessive dependence on fuel wood for energy by promoting energy efficient buildings and facilitation of wider application of alternative sources of energy for cooking, heating, cooling, lighting and other applications.

In recent years, there has been a growing interest in developing alternative non conversional sources of energy particularly, biogas. Biogas technology has been acknowledged by many scholars as being simple and cheap (Rajeswaran, 1983). The technology does not require imported knowledge or components and is suitable for family and/or village scale use. It is one of the few technologies that utilize wastes as valuable resources. It is among the renewable non-conventional fuel technologies, which involves anaerobic digestion of biomass to yield biogas and organic fertilizer slurry. According to Rajeswaran, Semi-arid Zones could be ideal locations for biogas units because they have factors that are favorable for the operation of biogas plants. Such factors include the relatively high ambient temperature; a vast livestock population and fuel wood scarcity experienced in the area hence alternative energy sources are needed.

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The history of biogas dissemination in Tanzania dates back to 1975. Several stakeholders including CAMARTEC the government parastatal, religious organisations, NGOs and private sectors have been involved in promoting and construction of biogas plants. However Kauzeni et al. (1998) in their study on renewable energy sources found out that, despite efforts made in introducing Bioenergy programmes or interventions in Tanzania, such efforts have met with little success. Similarly, Kambele (2003) study in Arusha region found that despite its apparent advantages, biogas technology has yet to be taken as an alternative source of energy in Tanzania as a way out of energy crisis.

The available literatures suggest that there are several factors that influence the adoption of innovations. Tendler (1993) and Cramb (2000) mentioned a number of success stories in agricultural research and extension in poverty Northern Brazil as comprising of; strong demand from farmers for a solution to a particular problem, localized credits and subsidies to bring about rapid and wide spread adoption, the role of municipal and local actors, provision of technical assistance, rewarding good performers and keeping funds away from bad performers, use of entrepreneurial farmers as model farmers, use of experienced and well regarded extension workers and decisive influence of other developmental actors.

Based on feasibility study on biogas technology, Ngwandu et al (2009) identified several barriers for large scale biogas technology dissemination in Tanzania. The major barrier being high installation costs which are unaffordable to the majority poor farming households. Other barriers include centralized dissemination approach, limited awareness of domestic biogas, limited coordination between sector actors, declined financial support by the government, limited availability of water and unavailability of credit facilities. Although Tanzania has some microfinance infrastructures, biogas loans do not fit in the current services of most saving and credit organization.

Seemingly, the factors mentioned by other researchers are a manifestation of promotional problems, which need thorough investigation. This study therefore, intends to find out the possible explanation for the low adoption rate of Biogas technology in semi -arid Tanzania with particular focus on existing promotion strategies in Bahi and Kongwa districts where Biogas activities have been in existence since 1994 after the establishment of MIGESADO project. According to Ngwandu et al (2009), MIGESADO is the largest biogas disseminator in Tanzania operating in Dodoma and surrounding regions, being in operation for about 15 years MIGESADO project was expected to have a substantial influence in biogas dissemination in semi arid areas of Tanzania.

## Methodology

The sampling frame for this study comprised wards and villages in Kongwa and Bahi districts (Fig 1 & 2). Multi-stage sampling technique was used where the first sampling stage involved selection of divisions, wards and villages using purposive sampling technique. The choice of divisions, wards and villages was based on availability of biogas users. The second stage involved differentiating households into two groups, namely, users and non-users of biogas technology using a list of users available at MIGESADO project offices. In every village register was used as sampling frame and from the register 25 names of respondents were drawn in order to obtain a fair representation of the population. Purposive sampling was also employed at village level where the biogas users (households) were identified and given priority of being interviewed in order to explore the experiences from the adopters of the technology. In total, 320 households heads were interviewed.

The methodology was based on household survey which involved interviews and focus group discussions, participatory observation and questionnaire monitoring as data collection tools. Similarly, checklists were used to guide discussions with key informants such as MIGESADO officers, ward and village leaders in the study area. The information generated from these discussions were used to confirm some findings from respondents and making relevant recommendations.

Collected data were coded and entered into the Statistical Package for Social Sciences (SPSS) for windows versions 11.5. The Statistical Package for Social Sciences (SPSS-PC) software was used to analyze most of descriptive statistics while Microsoft Excel software was used to generate figures such as histograms.

Figure 2: Bahi District: Location of Villages covered by study

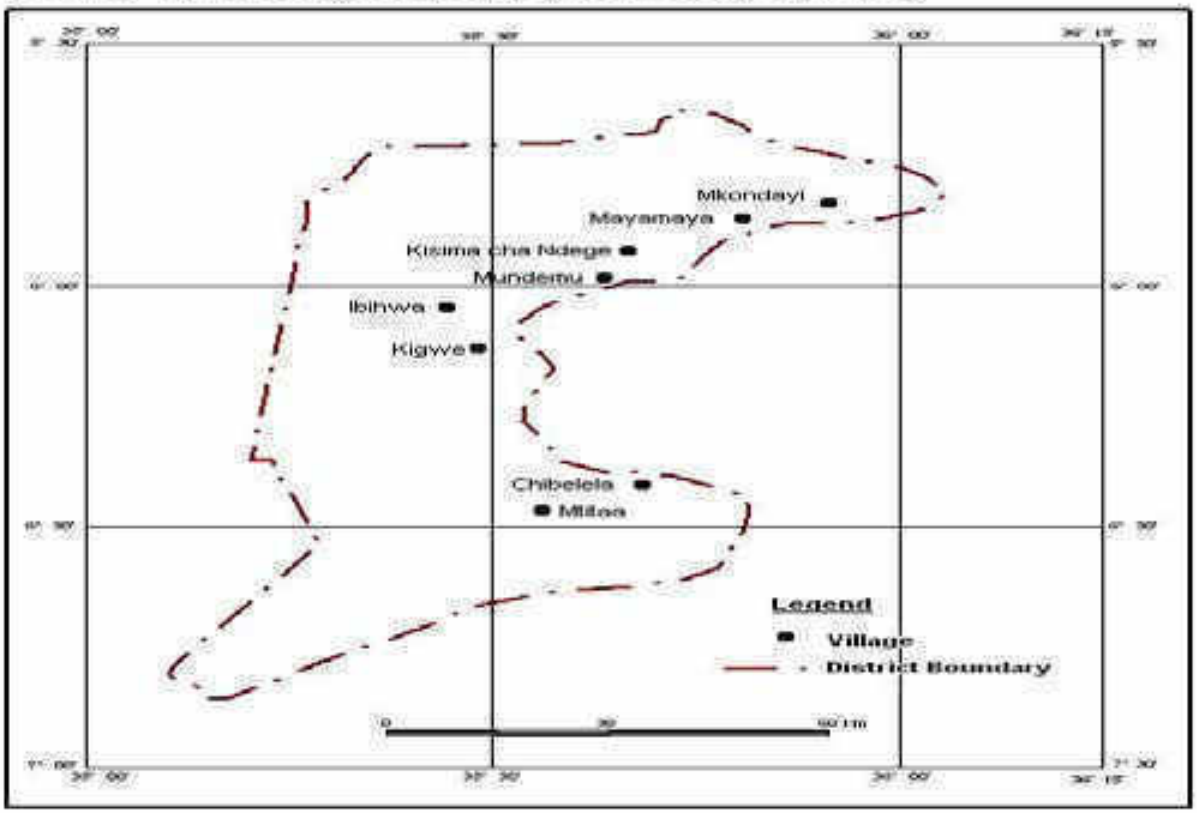
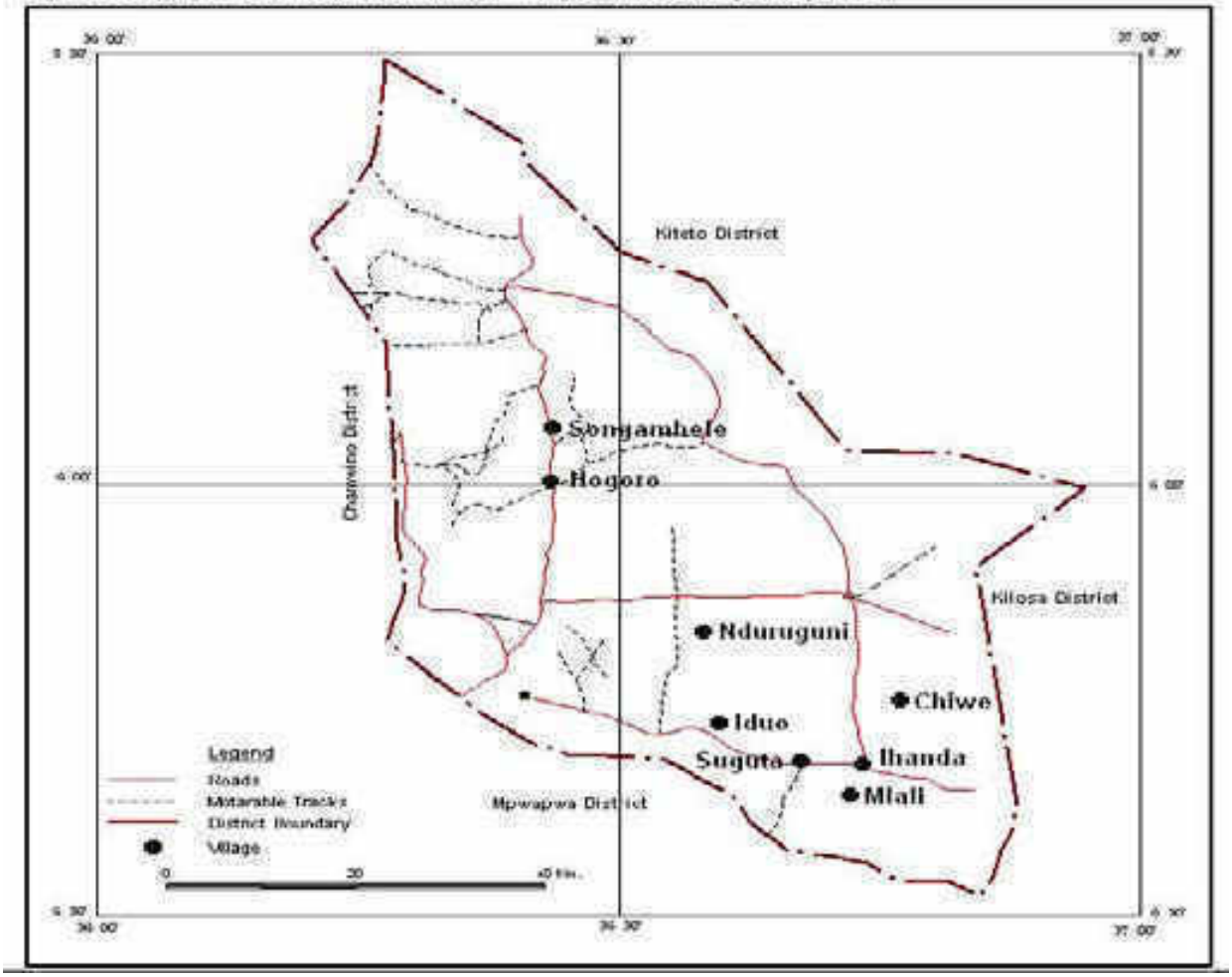



Figure 3: Kongwa District: Location of Villages covered by study area




***Source:*** *Geological Institute of Statistics*

## Findings and Discussion

### Factors influencing adoption of biogas technology in the study area

***Technology awareness in the study area***

From the findings of the study (Fig. 1), 81.5% of the respondents acknowledged that they have at least heard about biogas technology. This might be due to the existence of biogas project (MIGESADO) in the area since 1994. However when asked about their knowledge on biogas technology, 40% (Bahi District) and 42.4% (Kongwa District) of respondents claimed to have little access to biogas knowledge (Table 2). Seminars and continuous campaigns on biogas technology would facilitate knowledge hence promote the adoption, but table 1 indicates that, 51.5% of respondents expressed that there are no campaigns for biogas technology in their area while 38.5%of respondents revealed that seminars on biogas were held only once during the beginning of the project and no more seminars afterwards. Even biogas users claimed to have little knowledge on operations of biogas plants as well as on emerging obstacles. These arguments were also supported by key informant (MIGESADO staff) who confessed that the project focused more on construction of biogas plants, but little was done on promotion and maintenance services.

These findings indicate that though people in the study area have heard about biogas technology they do not have enough knowledge hence the majority are no convinced of adopting the technology. Further more, little knowledge reduces the possibility and confidence of biogas adopters of being good ambassadors for the technology. Adoption Theories suggests that the awareness and the knowledge of innovation are very important stages in the adoption process of any innovation.

**Figure 1. Awareness of biogas technology to household head**

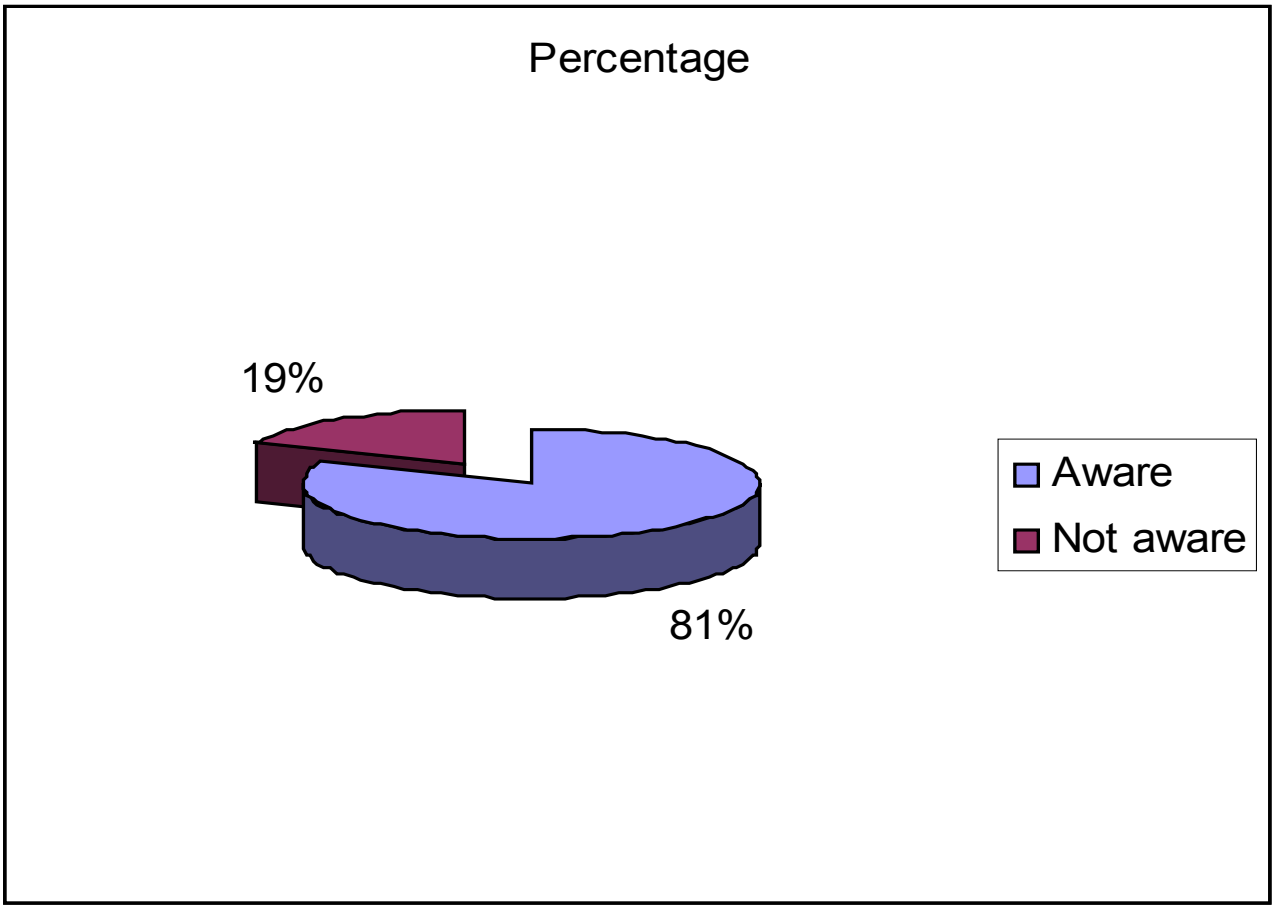


**Table 1. Responses on how frequent biogas campaigns being held in the study area**

| Frequencies of Biogas Campaigns | Frequency | Percent |
|---|---|---|
| None | 135 | 51.5 |
| Only once during project introduction | 101 | 38.5 |
| More than once a year | 26 | 9.9 |
| Total | 262 | 100.0 |

## Promotion of Biogas technology

From existing literatures several factors has been identified to promote adoption of any innovation. These include access to knowledge, access to credit and subsidies, access to technical support, advertisements, encouragement and support from the government and rewarding of good performers. This study has assessed these factors, and recorded the views of respondents on the status of access to such factors in the study area (Table 2). From the findings the majority of respondents indicated that they either have no access or little access to such factors (responses ranges from 40% - 96% of the respondents).

**Table 2. Responses on Factors influencing adoption and non adoption biogas technology in a study area**

| | Study District | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bahi | | | | Kongwa | | | | |
| **Factors** | No access | Little access | Moderate Access | Big Access | No access | Little access | Moderate Access | Big access | Chi-square |
| Access to biogas techno knowledge | 25<br>16.1% | 62<br>40.0% | 54<br>34.8% | 14<br>9.0% | 20<br>12.7% | 67<br>42.4% | 64<br>40.5% | 7<br>4.4% | 0.272 |
| Access to credit and subsidies | 84<br>53.5% | 57<br>36.3% | 12<br>7.6% | 4<br>2.5% | 82<br>51.9% | 65<br>41.1% | 11<br>7.0% | 0<br>0% | 0.045 |
| Access to technical services | 103<br>65.6% | 41<br>26.1% | 9<br>5.7% | 4<br>2.5% | 73<br>46.2% | 72<br>45.6% | 8<br>5.1% | 5<br>3.2% | 0.003 |
| Access to district council encouragement | 97<br>62.6% | 37<br>23.9% | 18<br>11.6% | 3<br>1.9% | 75<br>47.5% | 75<br>47.5% | 7<br>4.4% | 1<br>0.6% | 0.000 |
| Access to advertisement through media | 60<br>38.2% | 72<br>45.9% | 23<br>14.6% | 2<br>1.3% | 98<br>62.0% | 54<br>34.2% | 6<br>3.8% | 0<br>0.0% | 0.000 |
| Access to rewards for good performers | 140<br>89.2% | 12<br>7.6% | 4<br>2.5% | 1<br>0.6% | 152<br>96.2% | 4<br>2.5% | 1<br>0.6% | 1<br>0.6% | 0.980 |
| Access to demonstrations by good performers | 133<br>84.7% | 18<br>11.5% | 5<br>3.2% | 1<br>0.6% | 149<br>94.3% | 5<br>3.2% | 3<br>1.9% | 1<br>0.6% | 0.033 |

From the table above it is evident that in the study area people have little or no access to factors which promote the adoption of biogas technology. This implies that there are weaknesses or little efforts in promotion of the technology in the study area, by stakeholders

### Factors which motivated biogas users to adopt the technology in the study area,

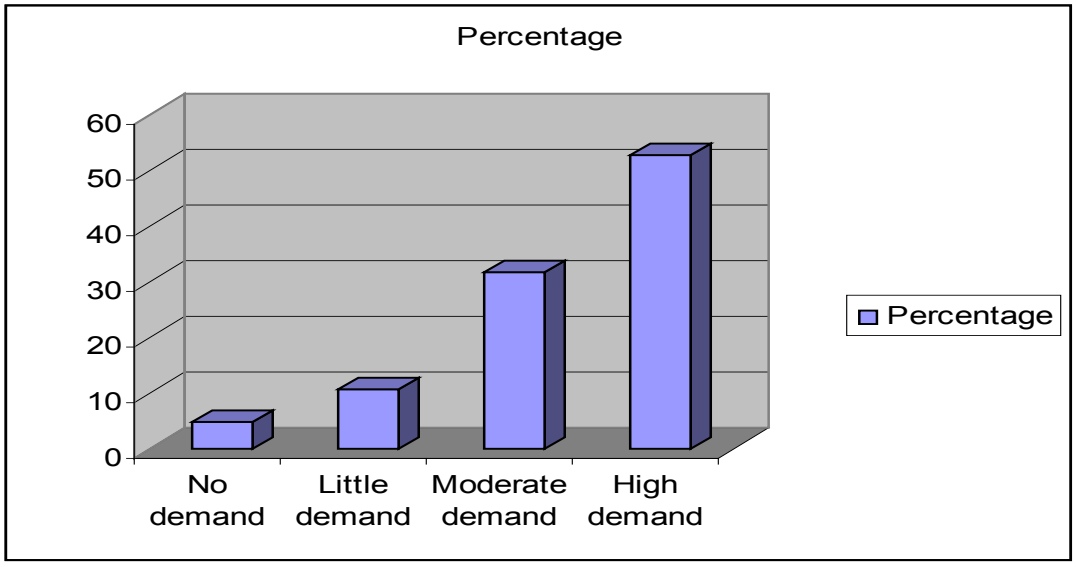
From the findings (Table 3), shortage of wood fuel was a major factor (60.1%) which motivated people in the study area to adopt biogas technology. This factor was further supported by the responses on a demand for a solution for energy crisis (Figure 2) where 52.7% of respondents declared that there is a high demand for energy problems solution in the study area. From the adoption theories, a strong demand for a solution to a certain problem motivates people to look for alternatives to the problem. Figure 2 further indicates that only 1.3 % of respondents were motivated by extension officers to adopt the technology. An extension officer here represents the government; this implies that there is a little involvement of the government in awareness creation towards biogas technology.

Another motivation which was revealed during Focus group discussion is the promises given by biogas project staffs during the promotion, that biogas energy in addition to provide energy for cooking, will also provide power for lighting, ironing and refrigeration. This promise created excitement and high expectation towards the technology. Unfortunately, among the expected benefits only lighting was appreciated, while the remaining promises never came to pass and turned to be a disappointment to both users and non adopters of the technology.

**Table 3. Factors motivated biogas users to adopt the technology**

| | Count | % of Responses | % of Cases |
|---|---|---|---|
| Need for a modern energy source | 23 | 15.3 | 30.3 |
| Shortage of wood fuel | 90 | 60.1 | 118.3 |
| Motivated by Extension Officers | 2 | 1.3 | 2.6 |
| Encouraged by biogas user | 19 | 12.7 | 25 .0 |
| Motivated and Supported by NGOs | 15 | 10.0 | 19.7 |
| High Cost of Other Energy Sources | 23 | 15.3 | 30.3 |
| | ----- | ----- | ----- |
| Total responses | 150 | 100.0 | 197.4 |

**Figure 2. Demand from people for energy crisis solution**



## Limiting Factors for non adoption of biogas technology in the study area

From the findings there was a slight difference in responses from adopters and non adopters on the factors for non adoption of biogas technology. Table 4 indicates that biogas adopters mentioned unreliable technical services as a major factor (26.4%) followed by high installation costs (20%) while Non adopters mentioned unaffordable installation costs as a major factor for low adoption rate (39.5%) followed by the technology not given a priority by the government (20.9%).

From Adopters perceptions, unreliable technical services have lead to poor performance of biogas plants which in turn discourage both biogas users in continual use of the technology also discourage potential adopters to adopt the technology. This perception was supported by focus group discussion, where biogas users expressed their grievances that poor performance of biogas plants have made them being laughed at, by non adopters and labelled as losers. Further more their struggle for technical services have no any support from either village or district Government.

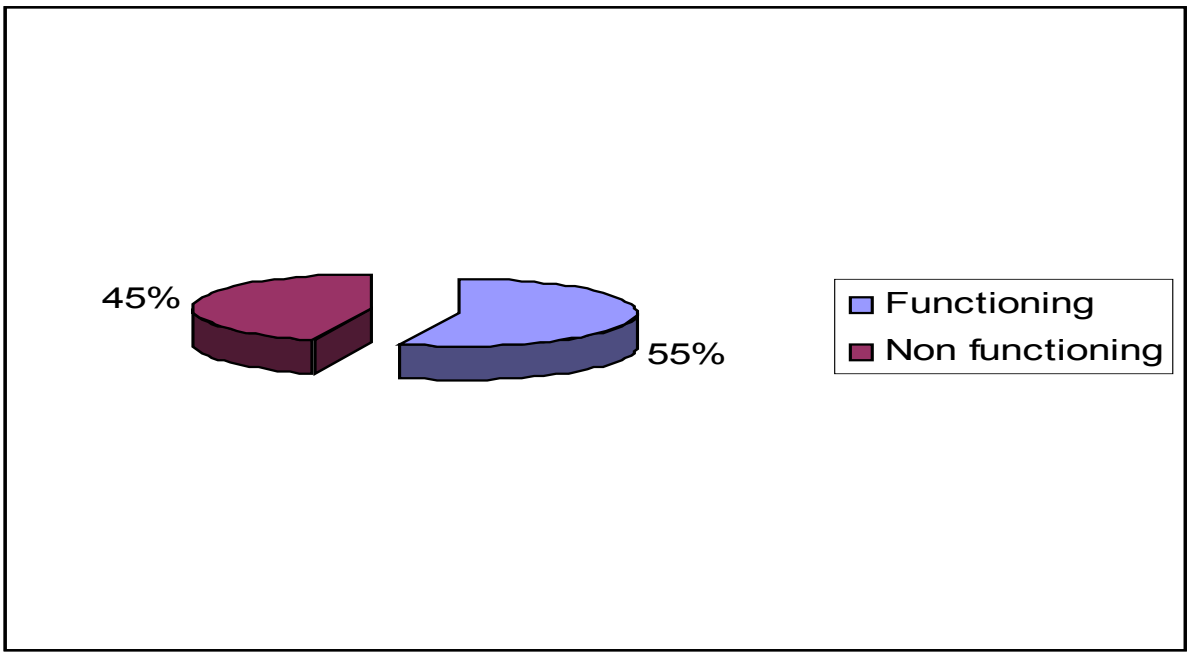
Poor performance of biogas plants is confirmed by the findings in Figure 3, where 44.7 % of constructed biogas plants are not functioning. However, these findings differ from the comment given by Tanzania Biogas Stakeholders Group Mission who did the technical assessment in a country. The mission's field investigation revealed that even with little training to masons and minimum supervision the quality of construction and workmanship of biogas plants has been good, resulting in the majority of the users being satisfied with the performance of their biogas plants" (Ngwandu et al 2009). Ngwandu, further comment that, in rural settings particularly, a household that is satisfied with the benefits of biogas technology is by far the most powerful promotional tool for the technology.

In the study area, however, dissatisfaction due to poor performance of biogas plants was clearly expressed during household interviews and in focus group discussions. Major reason for non functioning plants is technical problems mainly; incomplete construction, lack and or expensive appliances e.g. stoves, biogas lambs, gas taps and pipes which are not easily available locally. A researcher witnessed a biogas plant, almost completely constructed; only missing pipes, being abandoned in the farm after the death of household head and remaining family members were unable to make follow up. In another incidence, a household turned the biogas plant to underground crop storage tank after waiting for 5 years for completion of plant construction. From such cases one can easily assess the disappointments the biogas adopters face which have negative implications to promotion of the technology.

**Table 4; Responses on factors for limiting adoption of biogas technology in the study area**

| Factor | Adopters (N=121) | Non adopters (N=152) |
|---|---|---|
| High installation costs | 20.7 | 39.5 |
| Inefficiency of existing biogas plants | 16.5 | 9.0 |
| Unreliable technical services | 26. | 11.6 |
| Unavailable feed stocks | 17.4 | 9.0 |
| Not given a priority by the Government | 14.1 | 20.9 |
| Water problems | 0.0 | 5.0 |
| Availability of firewood | 5.0 | 5.0 |
| **Total** | **100** | **100** |

**Figure 3. Status of biogas plants constructed in the study area from 1994 to 2009**




From Table 4, Non adopters on the other hand mentioned unaffordable installation costs as a major factor for low adoption rate (39.5%). High installation costs are a factor which has also been mentioned by other studies (Ngwandu 2009 and Kambele 2003). In the study area, a key informant, explained that the project started by demonstration plants where the beneficiaries paid only Tsh 15,000/= in 1994, from then the costs of biogas plants started raising to Tsh 30,000/=, 80,000/=, 160,000/= to present cost of 350,000/= for low income households which are subsidized by the donors. High income earners pay full cost of Tshs 650,000/=. These rates seemed to be unaffordable to the majority of rural population hence potential adopters declined.

The second factor as perceived by non adopters is that the technology is not given the priority by the government (20.9%) (Table 5). This is also indicated in table 5 where 85.3% of respondents showed that the Government is not fully participated in promotion of biogas technology. The perception on little government involvement in biogas activities was also expressed by focus group participants who commented that, district council leader are reluctant on biogas issues, the biogas activities have been left with NGOs only. Non involvement of Government made people in the study area feel that the technology might not be that much important hence people too become reluctant to the technology. Furthermore focus group discussion expressed that during promotion, project staff through village leaders identified livestock keepers with high income who can pay for installation costs. The promotion approach was perceived to be selective by the villagers and thought to be somebody's business hence the majority of villagers didn't bother about it. Ngowi and Sudi in Kambele (2003), having the same observation, pointed out that biogas in Tanzania have not been incorporated in national energy policy plans because of its importance being underestimated by the government.

**Table 5. Responses on government participation in promoting biogas technology**

| Government participation | Frequency | Percent |
|---|---|---|
| Fully participated | 41 | 13.1 |
| Not fully participated | 266 | 85.3 |
| I don't know | 5 | 1.6 |
| Total | 312 | 100.0 |

## Conclusion

The findings of the study have revealed that there is a high demand for a solution to energy problems. Due to potentiality of the area, as revealed by other studies, biogas technology could be an appropriate solution for energy problems in semi arid areas. However the study has revealed that the majority of respondents in the study area have little or no access to factors hoped to promote adoption of biogas technology. The study revealed that promotion was not sustainable only done at the beginning of the project and the respondents doesn't see the seriousness of the government in promoting this technology hence feel that the technology might not be of that much importance. It is therefore recommended that for effective biogas technology adoption, Government should take intentional efforts in ensuring enabling environment for the technology, also in coordination of biogas activities done by other stakeholders. Potential customers should be well informed of the benefits as well as limitations of the technology, technical services should be locally available

Other factors revealed by the study are of technical nature these include; poor performance of existing biogas plants accompanied by low gas production, Incomplete construction of biogas plants, unavailable technical services when needed by biogas users and other interested potential adopters, unmet promises or expected benefits of biogas, like biogas being a source of power for lighting, ironing and for refrigeration. All these factors demoralize both adopters and potential adopters of biogas technology. A thorough technical examination is required which will come up with strategies for improvements. Monitoring and maintenance services are very important to ensure continuity of the technology. Since poor performance of biogas plants has already caused negative effects, extra efforts will be required to revive the existing plants so as to motivate the disappointed biogas adopters and potential adopters. Other factors which should not be ignored include insufficient feed stocks and water shortage. These are very important ingredients for biogas technology hence the responsible Ministries should cooperate with biogas stakeholders to ensure their availability.

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