African Biodigester Component

Biodigester functionality assessment - Kenya

SEE – Clean Cooking
African Biodigester Component

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This publication presents an assessment of the functionality of a sample of 300 domestic biodigesters in Kenya. This report was developed by Calvince Ouko, Dominic Sambuli and Stephen Mutimba, Consultants of Climate & Energy Advisory under the overall supervision of Florent Eveillé, African Biodigester Component manager in Kenya and Mark Rotich, Energy Adviser.

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Contents

Acronyms

Abbreviation	Description
4B-F	Biogas Business Boost Benefitting Farmers (EnDev project)
4B-F	Biogas Business Boost Benefitting Farmers
ABC	African Biodigester Component
ABPL	Africa Bioenergy Partnership Limited
ABPP	Africa Biogas Partnership Programme
BCE	Biodigester Construction Enterprises
BMZ	German Federal Ministry for Economic Cooperation and Development
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology (Tanzania)
CO	Carbon Monoxide
DANIDA	Danish International Development Agency
DGIS	Netherlands Ministry of Foreign Affairs
EESI	Environment and Energy Study Institute
EU	European Union
EnDev	Energising Development Partnership Programme
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gases
GIZ	German Organization for Development Cooperation
GPS	Global Positioning System
HH	Household
Hivos	Humanist Institute for Cooperation with Development Countries (Netherlands)
ICS	Improved Cooking Solutions
IFAD	International Agency for Agricultural Development
KBP	Kenya Biogas Programme
KES	Kenyan Shillings
KENBIM	Kenya Biodigester Model
LPG	Liquified Petroleum Gas
MoEP	Ministry of Energy and Petroleum
NGO	Non-Governmental Organization
NORAD	Norwegian Ministry of Foreign Affairs and the Norwegian Agency for Development Cooperation
NPS	Net Promoter Score
PBD	Prefabricated Biodigesters
PM	Particulate Matter
PSDA	Private Sector Development Agency
RVO.nL	Netherlands Enterprise Agency (RVO.nl).
SDC	Swiss Agency for Development and Cooperation
SE4ALL	Sustainable Energy for All project
SNV	Netherlands Development Organization (Netherlands)
ToR	Terms of Reference
WHO	World Health Organization

Executive summary

Funded by the Dutch Ministry of Foreign Affairs (DGIS), the Danish International Development Agency (DANIDA) and the European Union (EU), the African Biogas Component (ABC) in Kenya aims at facilitating a shift of the biodigester market from its pioneering to the expansion phase where 20,017 small and 250 medium-sized biodigesters will be constructed/installed. This will be achieved by means of a well-balanced mix of demand-side, supply side, financing and enabling environment interventions, geared at boosting demand and supporting small scale and medium scale biodigester companies in acquiring more clients. The component is implemented by a consortium between GIZ and SNV (the Netherlands Development Organisation) in cooperation with the Africa Bioenergy Partnership Limited (ABPL - ex-Kenya Biogas Programme). Over the past 10 years, biodigester companies have constructed and installed over 21,000 small scale biodigesters in Kenya.

A recent evaluation of the Biogas Business Boost Benefitting Farmers (4B-F) project indicated that digester functionality rates have increased from below 60% to 81% in Kenya. The ABC Project would like to raise even further this rate to 90%. In this report, we define biodigester functionality as the use of the biodigester for biogas production used by households for cooking. Biodigesters are enclosed vessels which take in organic matter, and in the absence of oxygen, the matter is transformed, through anaerobic digestion process, into biogas and bio-slurry. Biogas is used as a source of energy (thermal or transformed to electricity) and bio-slurry is used as organic fertilizer.

Functionality is defined as the biodigester producing gas for cooking and lighting or both, as well as bio-slurry which is increasingly important for farming households. It depends on numerous parameters linked to the construction/installation as well as on the biodigester feeding process. Functionality is a key parameter for the reputation of the biodigester sector in Kenya. Biodigesters have enormous potential for clean cooking access, agricultural productivity, or organic waste treatment. However, they remain expensive for small-scale farmers and non-functional biodigesters are endangering the reputation of the whole sector. The Kenyan Biogas Programme has made enormous progress on functionality by raising functionality rate from 60 to 81%. The ABC project has set an ambitious goal of reaching 90% functionality of the installed biodigesters. As such it is of major importance to measure the functionality rate of existing biodigesters to establish the current baseline and identify the main causes of non-functionality. This will in turn guide the ABC project in establishing mitigation measures for ensuring quality and functionality of the biodigesters, thus facilitating quality assurance and building trust for future end consumers.

In this report, we present a functionality assessment survey conducted between 16th May 2022 to 27th May 2022 for domestic biodigester systems in five sampled counties across Central, Western, Nyanza, Lower Eastern and Coastal regions of Kenya. The functionality of biodigesters was assessed based on use for cooking, lighting and use of the bio-slurry for agricultural activities. Through face-to-face surveys, a representative sample of 300 domestic biodigesters was assessed taking into consideration the number of plants per region, type of biodigester, model, sizes and age of the plants, among other indicators that defined the sampling strategy. Data analysis considered technologies, models, size, type, and gender inclusivity of the respondents, while at the same time deriving key inferences for functionality of biodigester.

The key findings of the assessment include:

Existence of biodigesters – Out of the 300 sampled households, 294 (98%) possessed biodigesters, six households, did not have a biodigester as they have sold their cows and move to another location or had the phone number of a former biodigester owner.

Biodigester Functionality – Eighty two percent of the biodigesters were functional representing 228 of the 278 households who responded to the questions on biogas functionality. Eighteen percent of the respondents (50 households out of the 278) had non-functional biodigesters and stated that their biodigesters stopped functioning between 0 to 7 years. In this sample, fixed dome biodigester types reported better functionality than prefabricated biodigester types at 84% (144 of 171) versus 79% (84 out of 107 respondents) respectively. However, prefabricated biodigesters has a 94% (44 of 47 biodigesters) functionality rate if one of the brands is excluded from the analysis.

Reasons for non-functionality – The main is pipe breakage (13), followed by poor construction (dome cracks, collapsed domes or unfinished – 11), lack of feeding (lack of cow dung or of labourer to feed the biodigester – 9), stopped by owner including cows sold (3), poor maintenance by household (2) and destroyed by children playing or pipes stolen (2). Six households did not provide an answer and four households indicated they have not yet discovered the technical problem.

Maintenance services – Twenty eight percent (82 of 294) of all respondents sought maintenance services and among those, 53% (8 of 15) usually go for firms that did the installation while 47% (7 of 15) seek for maintenance services from firm/individuals different from the installers of the biodigesters. Sixty-seven households did not give the name of the firm that offers the services. One of the reasons given to seek maintenance from a different company include non-responsiveness of the companies that installed the biodigesters when called for maintenance works. The mean maintenance cost was between KSH.500 to and KSH 1,000 per single maintenance service call, with the lowest costing KSH.200 and the highest costing KSH 34,000.

Use of the biodigester for Cooking – Seventy one percent (212 respondents) of the sampled households use biogas daily for cooking, 4% (12 respondents) hourly and 3% (9 respondents) said they use their biodigester for cooking once per week. The no response rate for this question reached 22% (66 respondents including the 6 households without biodigesters). Among the households using their biodigester for daily cooking (212 respondents), 70% of household use their biogas stove for cooking once to three times a day, while 29% use it more than three times a day for cooking and 1% did not respond to this question.

Biodigester feeding – Sixty four percent of the interviewed households (146) with functional biodigesters (228) reported that they feed their biodigesters daily, while 23% (53) serviced weekly. Thirteen percent of the households (29) did not respond to this question.

Bio-slurry Use and functionality – It was established that 89% (204) of households with functional biodigesters (228) use bio-slurry as an organic fertilizer for their crops. Ninety five percent (194 of 204) of those with functional biodigesters stated that there is an increase in quality and quantity of crops.

Level of satisfaction and recommendation – Of the 228 clients with functional biodigesters, 64% were very satisfied, 5% satisfied, 15% somehow satisfied, 1% least satisfied, 2% not satisfied and 1% very unsatisfied. Twelve percent did not answer this question. Among the 50 clients with non-functional biodigesters, 59% were very unsatisfied, 5% were least satisfied, 9% were fully satisfied and 27% did not answer the question.

Figure 1 - Satisfaction level for functioning and non-functioning biodigesters

Eighty-five percent of the clients are likely to very likely to recommend biodigesters to their friends, family and neighbours (Net Promoter Score of 5 to 9). Fifteen percent of the clients are unlikely or somehow unlikely to recommend the technology (Net Promoter Score of 0 to 5). There is a strict correlation between the satisfaction and the likelihood of recommendation. The main reasons to recommend biodigester is because cooking is effective and efficient (64%) followed by it is a cheap cooking energy (18%) and it increases agricultural yield (18%). Only a handful of households (11 over 300) answered provided a reason to recommend or not the technology.

Recommendations

Biodigester Functionality

The three recommendations on biodigester functionality are directed at the companies that instal and provide maintenance service to the biodigesters:

- Develop basic capacity of farmers and domestic labourer in charge of biodigester feeding through education and regular training on basic maintenance skills to avoid over reliance on enterprise technicians.
- Technical maintenance response to non-functional biodigesters reported in this study.
- Regular monitoring on the usage of biodigesters with a view to ensure that households are getting optimum performance of the biodigester.

Bio-slurry application

Bio-slurry is a particularly important bi-product of the biodigester as it has many applications ranging from organic fertilizer to specific animal feed. Organizations (companies and related agencies) involved in promotion, marketing and installation and service of the biodigesters should train farmers on the benefits of bio-slurry. Bioslurry also improve the business model of the biodigester for the farmer. Since it is an important investment for farming households in Kenya, the yield increase due to bioslurry grows farmer revenues and can reduce the economic burden of the instalments paid to finance the technology.

Satisfaction levels

To ensure that the satisfaction levels of households with biodigesters remain high it is recommended that biogas enterprises conduct the following:

- Deliberately reach out to households who registered a NPS between 0 and 4 to ascertain their concerns.
- Improve the communication channels between biodigester enterprises and their clients, especially on prompt and timely redress to concerns and calls from farmers for maintenance.
- A solution could be the creation and maintenance of a call centre for biodigester maintenance and repair, or the creation of an Operation and Maintenance platform based on USSD codes.

Definition of terms

Biodigester Functionality:
A biodigester system utilizes organic waste, particularly animal excretory products to produce biogas and an organic fertilizer called bio-slurry. Biodigester consists of an airtight, high-density container or chamber within which excreta is diluted in water flow continuously and are fermented by microorganisms present in the waste. Based on the definition of biodigester, functionality of biodigester can be defined as the optimal operation or performance of the biodigester to produce biogas and bio-slurry.

In this study the functionality of the biodigester is understood as the use of the biodigester for household kitchen use in cooking, for lighting and the use of bio-slurry for agricultural activities. In this report, functionality refers to those biodigesters that were working and producing biogas for cooking and where the bio-slurry was used for agricultural activities.

Existence of biodigester:
The report used the word existence of biodigesters to refer to those households who responded yes to the question “do you have a biodigester?” and followed up by responding to other questions.

Fixed Dome biodigester:
A fixed-dome biogas plant consists of an enclosed digester with a fixed, non-movable gas space often constructed from concrete and brick. The gas is stored in the upper part of the digester.

Prefabricated Biodigester:
These biodigesters come as a unit from the manufacturer ready for installation. They are prepared off-site and brought for installation on the ground. They are mostly made of light and easy to handle materials such as plastic. In Kenya, two types currently coexist: tubular and floating drum models.

Technical failures:
These are biodigester unable to perform optimally due to the biodigester components breakdown or malfunctioning of biodigester components which require technical skills to repair.

Non-Technical failures:
Inability of the biodigester to function arising from poor management and feeding practices such as lack of feedstock due to sale of animals, improper feeding, loss or death or relocation of key people in the family especially those that were the main users of the plants. These non-technical failures depend on the user and not on the construction or installing enterprise.

Technician:
In this report, technician refers to skilled masons tasked with the responsibility of maintenance and repair of non-functional biodigesters.

Biodigester Maintenance:
This refers to the practice of repairing malfunctioning biodigesters to restore services and functions.

Bio-slurry:
Bio-slurry is the liquid or semi-solid matter discharged at the biodigester outlet after gas has been tapped for energy. Bio-slurry can be applied directly as a fertilizer, mixed into the soil or with

compost. Solid bio-slurry can be used as a mixture for non-cattle animal feed such as poultry and pigs[1]. Liquid bioslurry can be used as insect repellent.

Clean Cooking:
Clean cooking means cooking with clean fuels and technologies which are those that attain the fine particulate matter (PM2.5) and carbon monoxide (CO) levels recommended in the WHO global air quality guidelines (2021). The WHO Guidelines for indoor air quality: household fuel combustion (2014) provide PM2.5 and CO emission rate targets for devices, which are linked to the levels from the Air Quality Guidelines. The following fuels and technologies are known to be clean for health at point of use and are categorized as clean for PM and CO household emissions: solar, electric, biogas, natural gas, liquefied petroleum gas (LPG), and alcohol fuels including ethanol. For other fuel/technology combinations including biomass, the cooking system is classified as clean if it meets the emission rate targets in the WHO Guidelines (2014), as confirmed in laboratory testing following an international laboratory testing protocol with tests conducted by a third party.

Juakali cook stove:
This statement refers to locally assembled cooking stoves from fabricated metals. According to literature, it could be cast iron, steel, non-ferrous metal as per the Domestic biogas stoves — Specification - KS 2520:2013.

Satisfaction with biodigester services:
Satisfaction which was defined as optimal working condition of the biodigester, rated on a scale of 0 to 5, where 0 was very unsatisfied and 5 (100%) fully satisfied.

Figure 2 - Preparation of the feedstock - © RVO

[1] https://www.biru.or.id/en/about-bioslurry/application-bioslurry

Background

The African Biodigester Component

The African Biodigester Component (ABC) project in Kenya aims at facilitating a shift of the biodigester market in Kenya from its pioneering to the expansion phase where 20,017 domestic and 250 commercial biodigesters are to be constructed/installed. This will be achieved through a well-balanced mix of demand-side, supply side, financing and enabling environment interventions, geared at boosting demand and supporting small and medium-scale biodigester companies in acquiring more clients. The ABC component is funded by the Netherlands Ministry of Foreign Affairs (DGIS), the Danish International Development Agency (DANIDA) and the European Union, managed by RVO and implemented by GIZ, SNV and the African Bioenergy Partnership Limited (ABPL).

ABC Kenya is a successor of a long list of biogas development programmes:

- In the 1980's, the German Development Cooperation (GDC) started the first Biogas extension project in Kenya as part of the Special Energy Program (SEP) under the Ministry of Energy (MoE) and in cooperation with the Kenya Industrial Estates (KIE).
- In 2006 the agricultural GTZ program "Promotion of Private Sector Development in Agriculture - PSDA" incorporated the component "Resource Friendly Technologies" in its portfolio, under which the use of Biogas and Improved Cookstoves Stoves (ICS) were promoted. This project ended in 2012.
- The African Biogas Partnership Program (ABPP) ran from 2009-2014 (phase I) and 2015-2019 (phase II). In Kenya, it was called the Kenya Biogas Programme (KBP). While the first two programmes focused on large domestic and commercial fixed dome biodigesters, KBP focuses on smaller and more affordable systems. In 2018, KBP introduces the first prefabricated biodigesters in Kenya.

Penetration of biodigesters in Kenya

Since 2007 to date, it is estimated that biogas companies have constructed and installed over 21,000 small scale biodigesters in Kenya. This includes the most recent figures reported under KBP of 5,016 small scale biodigesters built between 2018 and 2020. The KBP-sales figures were reported in 40 of the 47 counties of Kenya and 91% of the size biodigesters sold ranged between 4 to 12m^3. It is important to note that 79% of all these total sales under KBP were reported in 10 counties with top 5 counties (see Figure 3) accounting for 59% of the sales.

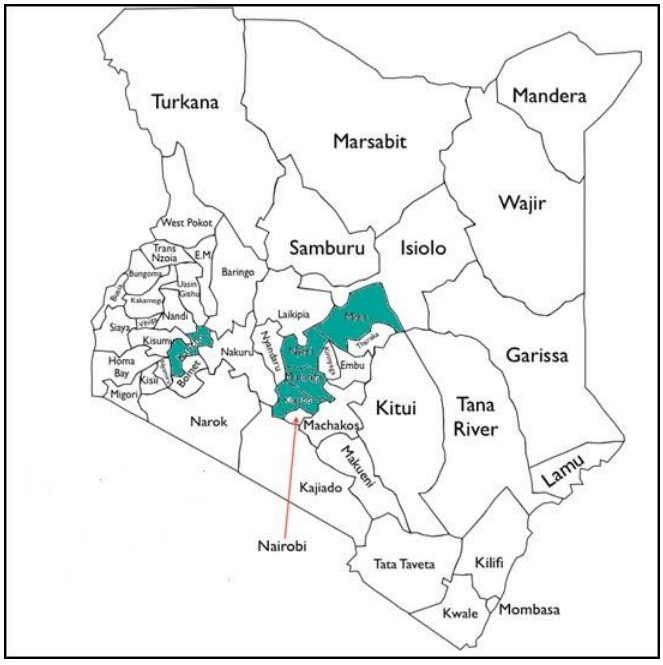

Figure 3 - Top 5 selling counties of the 4B-F project 2018 - 2020

Introduction to biodigester technologies

Biogas is produced after organic materials (plant and animal products) are broken down by bacteria in an oxygen-free environment, a process called anaerobic digestion. Biogas systems use anaerobic digestion to degrade these organic materials, turning them into biogas and valuable soil products (liquids and solids) called bioslurry. Anaerobic digestion already occurs in nature, landfills, and some livestock manure management systems, but can be optimized, controlled, and contained using an anaerobic digester. Biogas contains 50-70 percent methane, 30-40 percent carbon dioxide, and trace amounts of other gases (EESI, 2022[2]). The liquid and solid digested material, called bio-slurry or digestate, is produced as a by-product of the digestion process in a biodigester. The slurry is a nutrient rich material often used as soil amendment or biofertilizer. The bio-slurry is also effective due to its pathogen free nature.

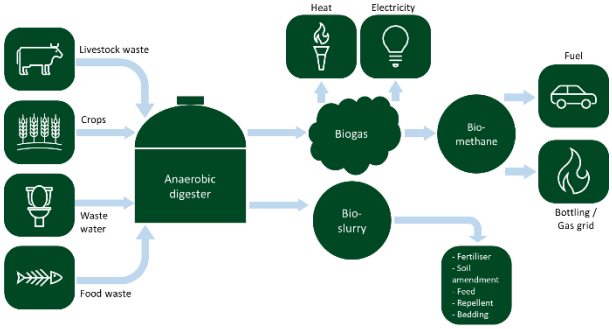

Figure 4 –Biogas production system - © GIZ

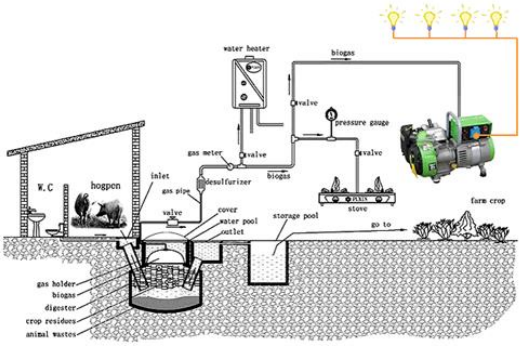

Figure 5 - Biogas plant used for power generation - © CC

Biogas is a versatile, renewable fuel that can be used for production of heat, electricity and/or vehicle fuel. It can be combusted in gas boilers to produce heat or in gas turbines to produce electricity. It can also be upgraded to vehicle fuel quality by increasing the methane content through the removal of most of the other compounds present. The Calorific value of biogas is about 6kWh/m^3 (20 mega joule), 20% lighter than air and has an ignition temperature in the range of 650°- 750°C. It is an odourless and colourless gas that burns with a clear blue flame like LPG.

The design of biodigesters varies depending on the country, climatic conditions, and the feedstock availability; moreover, design also depends on the policy regulations such as waste and energy programs and energy accessibility and affordability. Thus, biogas production may vary from backyard systems to large industrial plants. In developing countries, domestic small-scale biogas installations are common with system volume ranging from 2 to 12 m^3. The digester size is limited by the availability of feedstock. The most common feedstocks are manure from animal husbandries, food waste, small-agriculture waste, and sewage sludge. The household systems represent an effective strategy to enhance rural household life quality because it simultaneously advances sanitation and rural ecology and increases energy availability and incomes from the small agricultural activities (Pilloni & Hamed, (2021)).

[2] Environment and Energy Study Institute (EESI). https://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy

Types of biodigester

Whereas biodigester technology has tremendous benefits and the potential to counteract diverse social, economic, health and environmental impacts connected with traditional biomass energy use in Kenya, there is however a challenge in determining the country's overall capacity due to insufficient consolidated data on biogas plants in the country. The ABC project will collect data on the biodigestion potential for domestic and commercial systems in Kenya. Further, installed systems may not be functioning as expected or at all: the biogas is either not produced or in low quantities while in other, the bio-slurry is not effectively managed and used. Effectiveness of biodigesters may also vary depending on the different technologies that exist across the globe. Some of the technologies involve high engineering and investment. However, low-cost biodigesters are available. In Kenya, the most common biodigesters are fixed dome and prefabricated.

The table 1 presents different types of biodigesters available in the market.

Table 1 - Types of biodigester

Biodigester Type	Description	Sample Photo
Fixed dome biodigester	A fixed dome biodigester is a dome shaped, constructed underground and is immovable. Construction materials are mainly brick, mortar, reinforcement such as heavy gauge wire mesh or grills, galvanized iron for gas outlet and rigid Polypropylene Random Copolymer plastic for the gas line. It is composed of a feeding pit connected through a 4" PVC (Polyvinyl chloride) pipe to the dome (the lower part of the dome holds the slurry while the upper part is the gas chamber). The dome connects to the expansion chamber through a steps channel, then a spill-over to the bio-slurry pit. Most of the Construction raw materials are locally available. The main advantage is that the gas is stored and flows in high pressure to the point of use. It performs better than other models in colder climate. The major technical challenge is cracks leading to leakage and failure in case of poor workmanship or inadequate material combination	 *Figure 6 - A fixed dome biodigester in construction - © RVO*

Floating Drum Biodigester	A fabricated metallic / plastic tank open on one end fitting into a concrete semi underground tank also open on top. The underground concrete will serve as the slurry holding part of the biodigester, while the metallic / plastic tank is the gas chamber The gas chamber floating level is determined by the gas pressure inside. A sunken gas chamber means less gas and therefore lower gas pressure, while a raised gas chamber means more gas and at a higher pressure. The main advantage is that the gas is stored and flows under high pressure due to the weight of the metallic / plastic gas chamber. Furthermore, it can be agitated by rotating the gas chamber hence minimizing formation of scum in the biodigester. Major technical challenge experienced with this type is the reaction of hydrogen Sulphide (H_2S), an impurity in biogas, with Iron (Fe) in metallic gas chamber, resulting in rusting, perforation, leakage and ultimate failure. Hybrid models made with plastic gas chambers have been introduced and are available in Kenya. To increase the gas pressure in the plastic floating drum, weight can be increased by adding sandbags. Using PVC gas chamber solves rusting issues, but lifespan remain shorter that fixed dome.	 *Figure 7 - Floating drum plant - © CC*

Tubular Biodigester	Welded from geomembrane PVC or premium dam liners into large tubular chambers with slurry inlet and outlet, and gas outlet on top. This a plug flow model. The lower half of the tube along the length is sunk below the ground level (slurry chamber) and the other upper half (gas chamber) is exposed above the ground level. The geomembrane is often black in to increase absorption of sunlight heat during the day. This catalyses the methane biochemical production process. In addition, the flexible tubular enables agitation hence minimizing the formation of scum. The tubular biodigester requires protection from unwanted access since it is prone to tampering by piercing or cutting of the liner. Holes can be fixed through patching or welding the liner back. The materials for manufacture are imported and the welding of the liner requires expertise and modern technology. The lifespan of the biodigester varies, depending on the chemical strength of the material; from less than 5 years for PVC to over 25 years for HDPE (High-density polyethylene).	 *Figure 8 - A tubular biodigester - © GIZ*
Balloon Biodigester	The biodigester is prefabricated in a balloon shape using dam liner PVC material and installed in a pit, half of which holds the bio slurry, while the other half exposed above ground is the gas chamber. Weights are put on the biodigester to boost flow of gas at higher pressure to the point of use. Like the tubular biodigester, it requires protection from access since it's prone to easily tampering	 *Figure 9 - A balloon biodigester - © RVO*

	by pricking or cutting of the liner. This can be fixed through patching to welding the liner. The materials for manufacture are imported and the welding of the liner requires expertise and modern technology. The lifespan of the biodigester varies, depending on the chemical strength of the material.	
Commercial or Industrial Biodigester	From medium to large capacities usually set up for commercial purposes in firms with large quantities of biomass, such as flower farms, fruit farms, breweries, municipal wastewater plants etc. The biogas generated is often used for heating and power generation which in some cases is fed into the national grid.	 *Figure 10 - Industrial biodigester - © GIZ*

Figure 11 - Prefabricated biodigester in Kenya - © HomeBiogas

Methodology

Overview of the study

This report details key findings from the biogas functionality assessment data collection undertaken between the 14th to 30th May 2022. The overall goal of the study was to:

- define the functionality rate of small-scale biodigesters in Kenya
- record the end-user satisfaction levels, using the Net Promoter Score (NPS) method
- establish the functionality database and write the functionality report

Define the functionality rate of small-scale biodigesters in Kenya

- Define a representative sample of 300 small-scale biodigesters considering the representativity of the different models, geographic localization, size, concentration of installed plants
- Define a list of indicators to understand biogas end-user practices in Kenya.
- Establish at least (1) the functionality rate in 2022 of the biodigesters built in past development projects (gas in the kitchen), (2) the main reasons for non-functionality, (3) the duration of non-functionality in months and (4) the absence/existence of a maintenance contract with the builder or another company through direct interviews with clients

Record the end-user satisfaction levels, using the Net Promoter Score (NPS) method.

- Develop a questionnaire in collaboration to assess the end user satisfaction levels
- The questionnaire must contain at least the two following questions:
    - How likely would you be to recommend the product, technology or service? The customer can answer on a scale of 0 (not at all likely) to 9 (very likely).
    - Why would you/would you not be likely to recommend biogas to other people? (open answer)

Establish the functionality database and write the functionality report

- Establish a database representing the sample of 300 small-scale biodigesters analysed that will define the current functionality rate of small scale biodigesters in Kenya.
- Draft a report explaining the main findings from the analysis such as the type of digester, the main feedstock, the functionality rate, the total NPS and per digester type, workload and gender, the use of bio-slurry, the types of crops grown, awareness methods on biodigesters, other uses of biogas.

Biodigester functionality

The functionality is expressed as the use of a the biodigesters by the household for cooking. The Biogas Business Boost Benefitting Farmers (4B-F) project (or ABPP – Phase 2) evaluation in 2021 indicated that the functionality rates of all installed biodigesters in 2009 was 61%. At the end of the KBP project (including its phase II called 4B-F), this rate had increased to 81% in 2020 in Kenya. Functionality of the constructed biodigesters has been a key focus area for biodigester support program. The ABC Project objective is to ensure that 90% of biodigesters constructed or installed through the project are technically functional one year after installation. In 2018, a review

publication[3] indicated that about 73% of biodigesters constructed between 2009 and 2013 were functional. In response, ABPP implemented call centres and launched campaigns to repair non-functioning plants.

To support the sampling, ABPL provided the database of biodigesters developed from the evaluation survey conducted in 2021. This database was used to produce sampled household data used for the present survey reported. The database provided the necessary contacts and locations of farmers across the sampled counties in Kenya.

Approach to the assignment

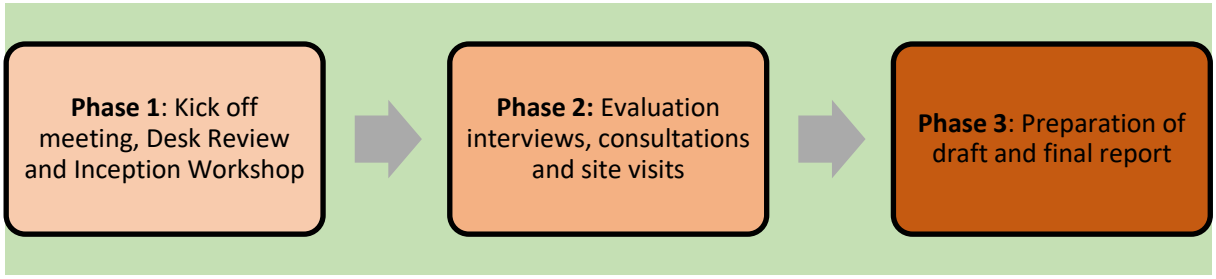

Figure 12 - Approach to the assignment

Desk review

Document analysis was undertaken to provide an understanding of the project background, scope and ongoing activities. The documents reviewed included the project documents such as the Kenyan Biogas Programme sales database, concept note and reports available from the Africa Biogas Partnership Program (ABPP) website as well as the national Bio-slurry Extension Conference Report and journal publications cited in this document.

Proposed sampling design

A stratified random sampling strategy was used to identify the counties and samples of interest. The counties were first sampled out of the total counties in the project area. Households were then sampled based on:

- Size of biodigesters
- Technology used
- Models used

Sampled counties

Five out of forty-seven counties were sampled: Kiambu, Meru, Taita Taveta, Kisumu and Kakamega. The sampled counties accounted for more than 10% (out of 40 counties) of all the targeted population, which is an acceptable representation for a population that is less than 1000.[4] Five out of the six regions (Western, Lake Victoria, Central, Lower Eastern, Coast and Northern) were purposively sampled so that, each of the selected regions produces a county to be surveyed. Sub-counties in each of the sampled counties were surveyed based on the availability of the installed

[3] Clemens, H., Bailis, R., Nyambane, A. and Ndung'u,V. (2018). Africa Biogas Partnership Program: A review of clean cooking implementation through market development in East Africa. Energy for Sustainable Development 46 (2018), 23-31. https://doi.org/10.1016/j.esd.2018.05.012

[4]Tools4dev.org (2022), How to Choose a Sample Tool (for the Statistically Challenged): Practical tools for International Development

biodigesters and the targeted stakeholders, climate and geographic differences, and availability of plants for the survey.

Sampling based on plant capacity

A total of 300 households were sampled from the list of 21,000 biodigesters available in the database provided by ABPL. The list represents the population of biodigesters that had been installed in Kenya between 2009 and 2021 through the KBP and 4BF programs, according to the project documents. Considering that the installed biodigesters were in different sizes, we distributed the sample of 300 to plant sizes based on their percentage of distribution. The samples were allocated to the plant sizes as shown in Table 2 below.

Table 2 - Plant Size and Sample Size

Plant Size (m^3)	Population Represented	Percentage Distribution	Allocated Sample Size
6	5,880	28%	84
8	4,830	23%	69
10	3,360	16%	48
4	2,730	13%	39
12	2,310	11%	33
Others (13 – 48)	1,890	9%	27
Total	21,000	100%	300

The sampled plant sizes were proportionately distributed in each of the five counties based on the number of biodigesters installed as shown in Table 3 below.

Table 3 - Sample Distribution per County by Plant Size

County	Total Plants	Plant sample size (m^3)						Total
		6	8	10	4	12	Other	
Kakamega	68	2	2	1	1	1	0	7
Kisumu	101	3	2	2	1	1	1	11
Kiambu	1,879	55	45	32	26	22	18	197
Meru	714	21	17	12	10	8	7	75
Taita Taveta	97	3	3	1	1	1	1	10
Total	2,859	84	69	48	39	33	27	300

Technology used

The 300 samples were further stratified into fixed domes and prefabricated biodigesters depending on the percentage of each technology constructed / installed in each county. The data from ABPL used to generate samples were distributed based on the percentage of installation (Table 4).

Table 4: Sample Distribution Based on the Technology in Use

County	Fixed Dome		Prefabricated		Total Sample
	Number Installed	Sample	Number Installed	Sample	
Kakamega	42	5	26	2	7
Kisumu	32	5	69	6	11
Kiambu	770	118	1109	79	197
Meru	268	42	446	33	75
Taita Taveta	92	10	5	0	10
Total	1204	183	1655	117	300

Sampling based on biodigester model

Based on models used, the 300 samples were allocated to different models as shown in Table 5.

Table 5: Distribution of sample per model in each County

Model	Percentage	Proposed Sample Size	Kakamega	Kisumu	Kiambu	Meru	Taita Taveta	Total
AKUT	7%	**15**	1	0	14	0	0	**15**
CAMARTEC	7%	**15**	0	1	14	0	0	**15**
KENBIM	7%	**39**	2	4	14	9	10	**39**
New KENBIM	25%	**78**	3	5	49	21	0	**78**
Prefabricated	54%	**153**	1	1	104	45	0	**153**
Total	**100%**	**300**	**7**	**11**	**197**	**75**	**10**	**300**

Data collection approach

The data was collected through a face-to-face survey involving a questionnaire with 92-questions. The questionnaire was built into Kobo toolbox digital questionnaire tool. The data collection exercise was undertaken within a duration of 10 working days and involved 16 enumerators. Recruited enumerators were trained on the procedures of data collection and usage of the tools developed (Figure 13). After the training, the questionnaires were pre-tested before being coded into the Kobo toolbox then deployed to enumerators who visited the households. Each interview took approximately 45 minutes.

Data management and reporting

Data was received in real-time from enumerators upon submission, the data received was screened and sorted before analysis. Data was analysed qualitatively and quantitatively, and final outputs and analytics organized and presented in this report.

Figure 13 - Enumerator training session during piloting of the tools for data collection – © C&E

Key findings

Summary of primary data collected

A total of 300 households were selected randomly for this survey spread across 5 counties of Kakamega, Kisumu, Meru, Kiambu and Taita Taveta counties of Kenya. The data analysis was conducted while ensuring representation of all the sampled counties, biodigester technologies used, biodigester models, size, and type. Meaningful statistical inferences were derived from the data and presented in later sections. In terms of the existence of biodigesters, our findings indicated that 98% of all households of the sample have a biodigesters. Six households did not have a biodigester as they have sold their cows and move to another location (2) or had the phone number of a former biodigester owner (4). Of these, 82% of them were confirmed to be functional. The table 6 provides a summary of the biodigesters sampled per county and the quantities per key indicators.

Table 6: Summary of Primary Data Collected

Category	Sub-category	Kiambu	Meru	Kisumu	Taita Taveta	Kakamega	Total
Gender	Male	126	46	7	5	7	191
	Female	70	30	4	5	0	109
Technology	Prefabricated	69	39	5	1	2	116
	Fixed Dome	121	37	6	9	5	178
	No response	4	1	0	1	0	6
Plant Size (m^3)	4	9	4	1	1	0	15
	6	43	30	6	2	1	82
	8	40	14	1	4	0	59
	10	26	6	0	1	2	35
	12	8	0	0	1	3	12
	Others (13 – 48)	15	13	3	1	0	32
	No Response	49	9	0	0	1	59
Model	AKUT	5	0	0	0	0	5
	KENBIM	36	3	4	8	5	56
	New KENBIM (MKD)	30	23	0	2	0	55
	Prefabricated	53	39	7	0	2	101
	Other (not known)	2	0	0	0	0	2
	No response	65	10	0	0	0	75

Existence of biodigester

Out of the 300 sampled households, 98% (294 households) had biodigesters while the rest (2%) or 6 households indicated not to have any biodigesters. From the data collected, out of the six, 2 households deliberately stopped the biodigester and sold the cows. Four households had the phone number of a former biodigester owner.

Figures 14 and 15 below provide the spatial outlook of the distribution of the samples across the five counties, there was a GPS success rate of 70%. About 90% of farmers in Meru and 100% in Taita

Taveta with biodigesters were clustered within few sub-counties, while in Kiambu, Kisumu, Kakamega the farmers were spatially distributed. This being randomly sampled; it was therefore still representative of the orientation of the population within these areas.

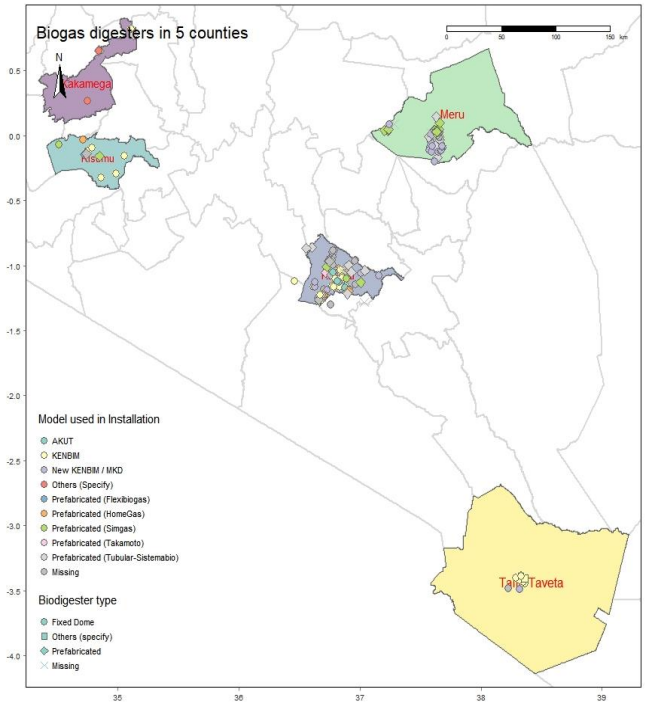

Figure 15 - Spatial distribution of bio-digesters in the five selected counties – © C&E

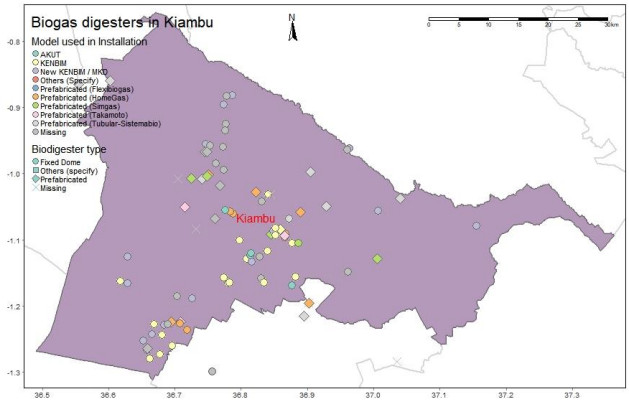

Figure 14 - Distribution of biodigesters in Kiambu County - © C&E

Biodigester functionality rate

In this study, the functionality of biodigester was defined as biogas use in cooking and bio-slurry for agricultural activities and where applicable other relevant applications.

The findings indicate that 82% of all available biodigesters were functional. The 18% (50 respondents out of the 278 households providing a response to this question) non-functional biodigesters stopped functioning between 0 to 7 years.

The main reason for non-functionality is pipe breakage (13), followed by poor construction (dome cracks, collapsed domes or unfinished – 11), lack of feeding (lack of cow dung or of labourer to feed the biodigester – 9), stopped by owner including cows sold (3), poor maintenance by household (2) and destroyed by children playing or pipes stolen (2). Six households did not provide an answer and four households indicated they have not yet discovered the technical problem.

From the households providing a reason for non-functionality, we can distinguish between technical failures (pipe breakage and poor construction) and non-technical failures (lack of feeding, stopped by owner, household poor maintenance and destruction). Technical failures in this sample account for 60% and non-technical for 40%.

The functionality rate of biodigesters has been improving over the years as explained by the different evaluation studies of ABPP Phase 1 and Phase 2. Figure 16 shows the functionality rate per year of installation. Years with less than five biodigester commissioned per year were not taken into account for the calculation of the yearly functionality rate in this figure as they are considered non

representative. It is important to note that there was a drop in number of plants installed due to COVID19 pandemic in 2020-2022. Figure 17 shows the functionality rate in the five selected counties.

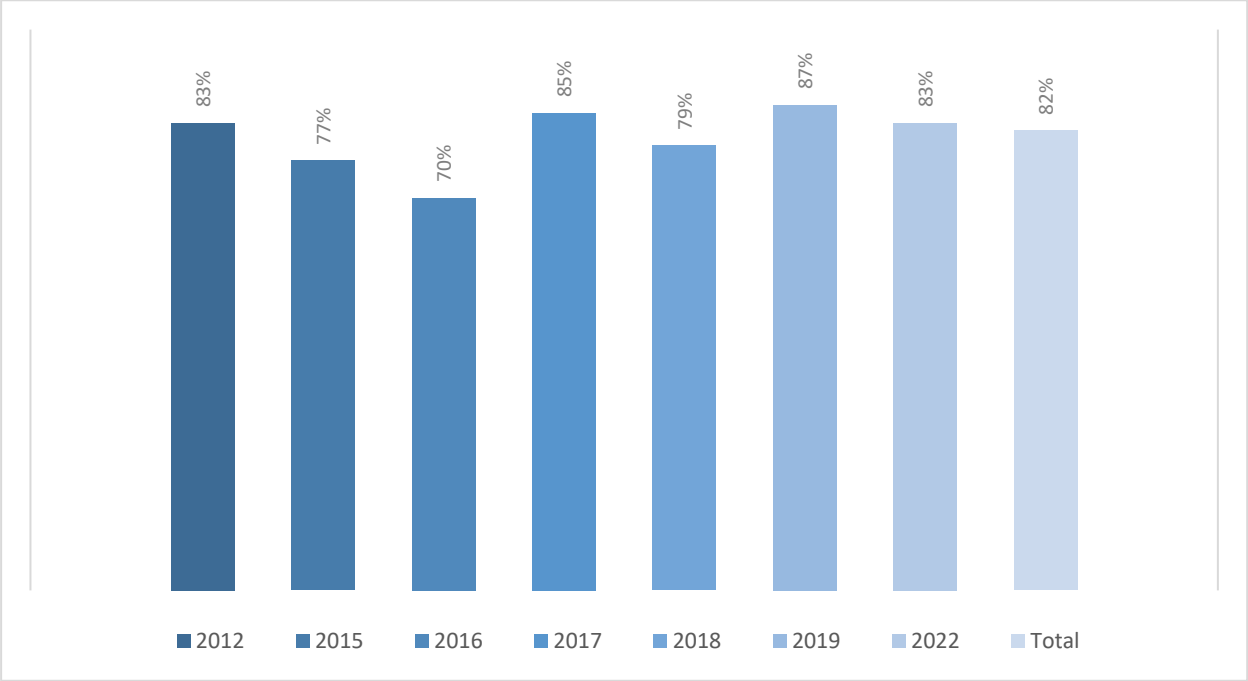

Figure 16 - Functionality rate per year of installation (NB years with n>5 were not considered)

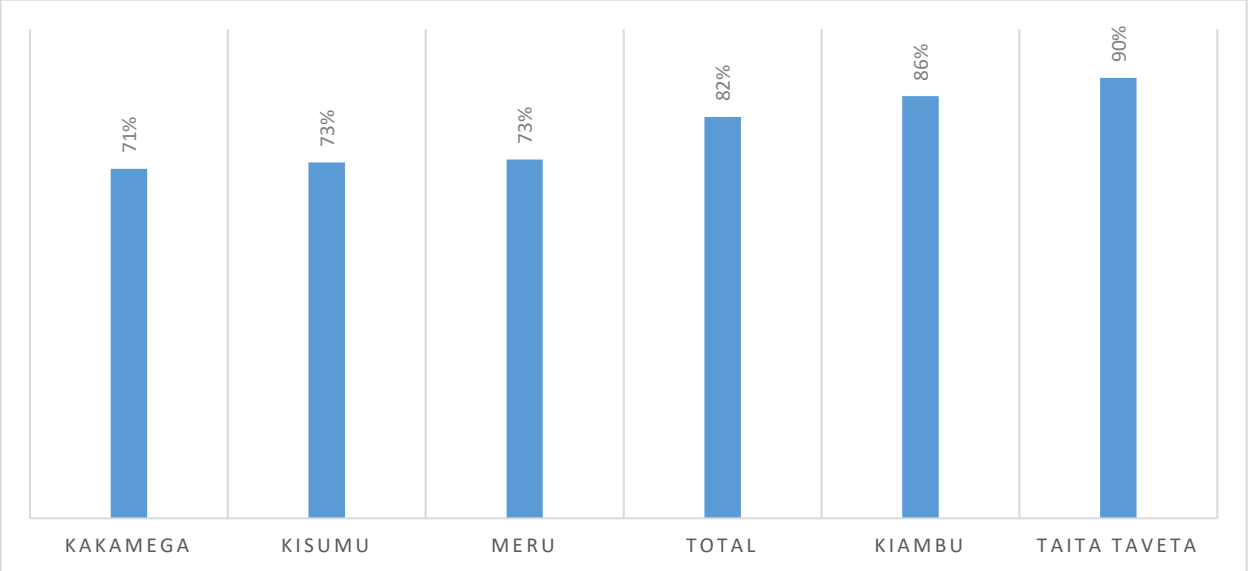

Figure 17 - Functionality rate per county

Non-Functionality of biodigesters

As aforementioned, about 18% of all households with biodigesters (50 of 278 of whom responded to the question on functionality) reported their biodigester as non-functional. The duration of non-functionality of biodigesters was between 0 to 7 years (Figure 18). Fifty households confirmed that their biodigesters were non-functional. Out of this number, 45 gave a duration when the biodigesters have not been functional and five household did not respond to the question. We can see a drop in non-functionality after the third year. It can probably be the sign that the biodigesters that can be fixed has been fixed after this date.

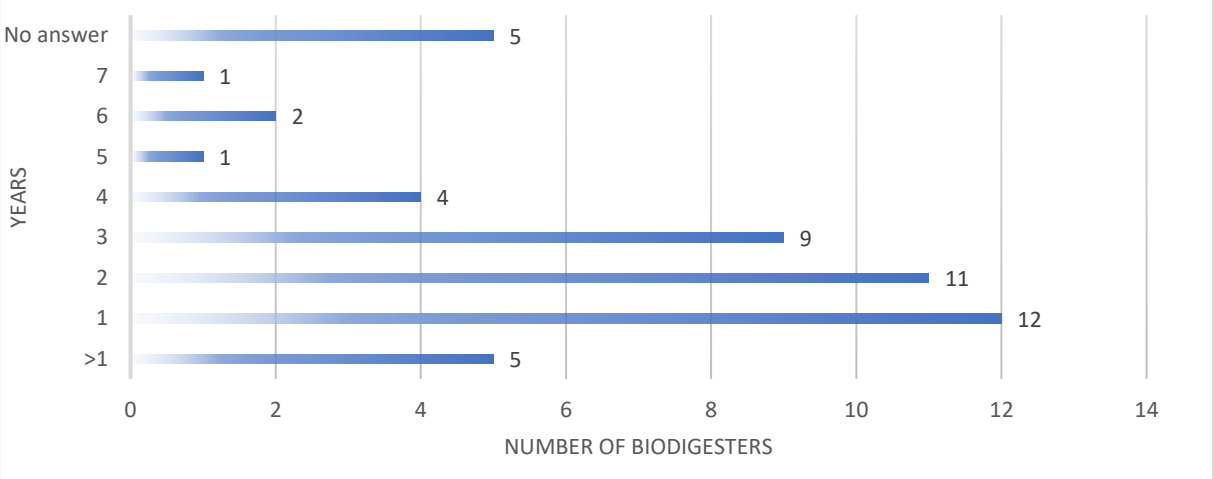

Figure 18 - Years of non-functionality per biodigester

The main reason given for non-functionality of the biodigesters was malfunctioning of biodigester components like gas piping system (41%) and leakage of gas chambers (17%) as shown in figure 19. The other reasons provided included poor maintenance and servicing by the technicians and biodigester owners (8%), lack of enough biomass material/feedstock for the biodigesters (16%), and in some situation the biodigesters were deliberately stopped by owners (10%) because the animals were sold thus there was no biomass material to put in the biodigesters. Some households lost interest in biodigesters usage and became less enthusiastic in servicing their plants as well as any other reason (8%).

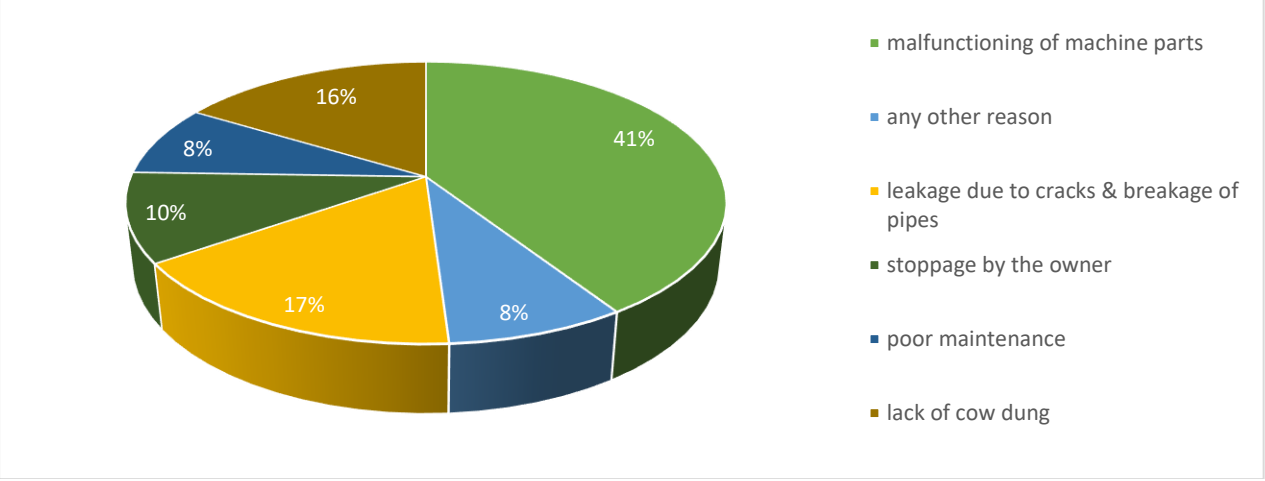

Figure 19 - Reason for non-functionality

Net Promoter Score of Biodigester

There has been a gradual increase in rates of functionality, household satisfaction and recommendation from the users to other potential customers. We see a strong correlation between the functionality rate, the NPS and the likelihood of recommending the use or installation of biodigesters to other potential customers as shown in figure 20. Correlated to the functionality, fixed dome biodigesters tend to have higher NPS as compared to prefabricated types (Figure 21). It is important to note that the functionality rate for prefabricated biodigesters in this figure still include one company which is no longer active in Kenya with a high number of non-functioning biodigester. Without this company, the functionality rate for prefabricated biodigesters reaches 94%.

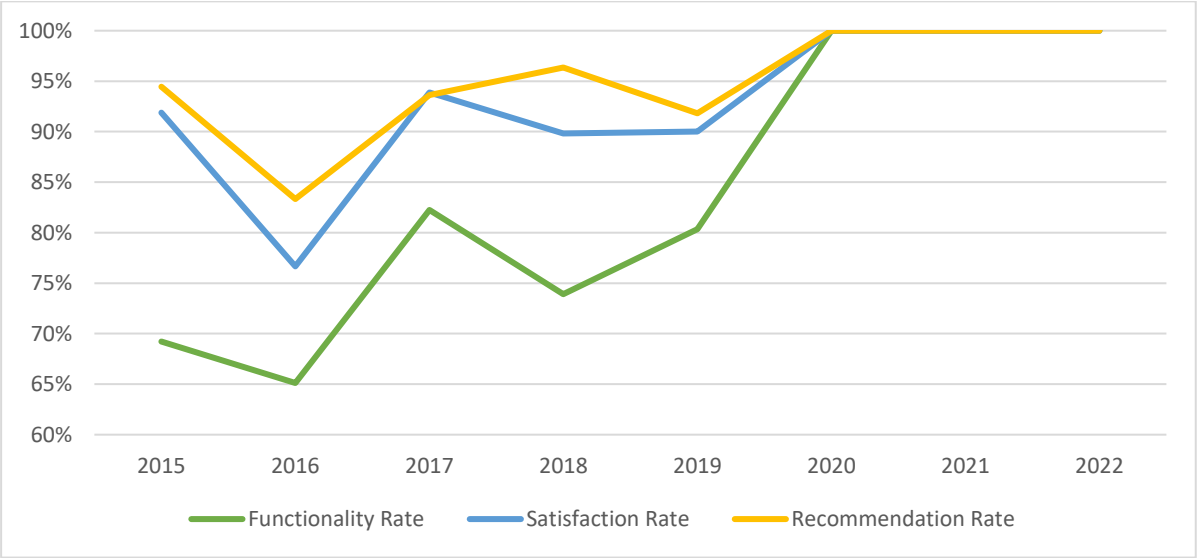

Figure 20 - Yearly functionality, satisfaction, and recommendation rates

Figure 21 - Functionality, satisfaction and recommendation rates per type of biodigester (NB - the functionality rate for prefabricated biodigesters include one company with many non-functioning biodigesters – without this company, the functionality rate reaches 94%)

Maintenance Services

The study found that about 34% (82 of 239) of respondents had sought for maintenance services, among those that sought maintenance services, 53% (8 of 15) usually go for firms that did the installation while 47% (7 of 15) seek for maintenance services from firm/individuals different from the installers of the biodigesters. Fifty households did not provide an answer to this second question (same firm or a different firm for maintenance service). Of the households that were interviewed, approximately 70% did not sign contracts for repair and maintenance of the biodigesters with the firms that did the installation.

For the households with non-functional biodigesters, 54% have never sought for maintenance services, while 46% have. Some of the reasons given included the fact that companies that installed the biodigesters were non-responsive when called, others cited the lack of local after-service maintenance or high costs demanded by technicians for repair and maintenance services. Seventy two percent of interviewed households explained that they lack training on maintenance of biodigesters. They also mention that they do not have enough laborers for the biodigester feeding process and/or not enough time to separate the manure entering the biodigester from other undesirable particles. They pointed out that incomplete installation of the biodigester, poor management by the company assigned with the responsibility of biodigester maintenance services and partly repaired but still unfunctional biodigesters were all challenges preventing them from seeking for operations and maintenance services.

The mean maintenance cost was between KSH 500 and KSH 1,000 per single maintenance service call. The lowest price asked was KSH 200 and the highest KSH 34,000 (the household did not disclose the maintenance service connected to this fee - Figure 22).

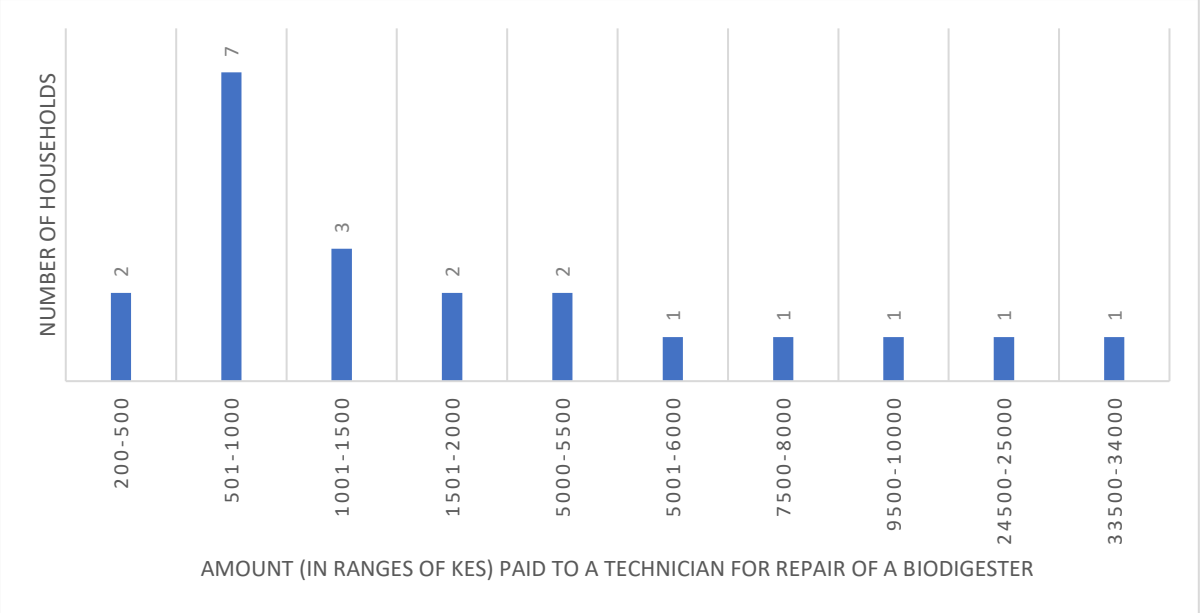

Figure 22 - Number of households and maintenance fee paid

In our sample, the relationship between the functionality of the digesters and the payment for the maintenance services do not reveal any trend (Figure 23): the payment for maintenance services do not increase the functionality in our sample. Only the following year after the payment for maintenance services does the functionality increase.

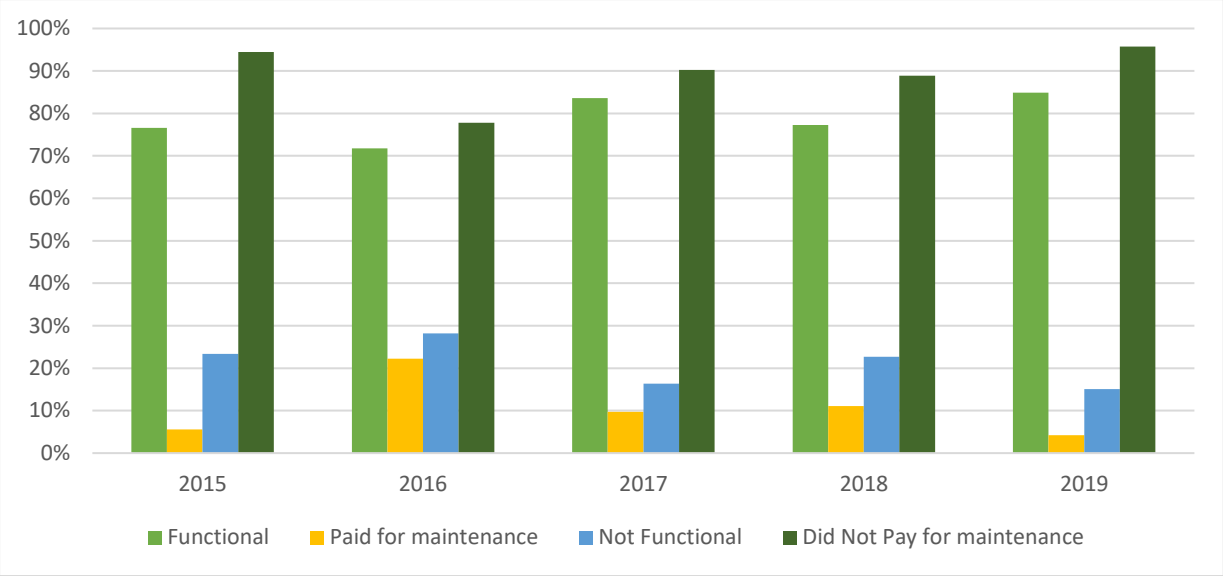

Figure 23 - Functionality rate and payment for maintenance services per year

Main feedstock for biodigesters

We assessed the frequency of biodigester feeding and who renders the service. The results indicated that 159 households, which is 64% of the sample size of respondents with functional biodigesters, feed their biodigesters daily while only 23% said they feed it weekly (Figure 24). Some of the reasons given for not feeding biodigesters daily include the fact that some families have low demand for biogas, or the biodigester is oversized. More than 87% of households with functional biodigester use domestic workers or hired laborers to feed the biodigester. Considering the hard labour involved in biodigester feeding, most women, especially the elderly ones have no capability to handle.

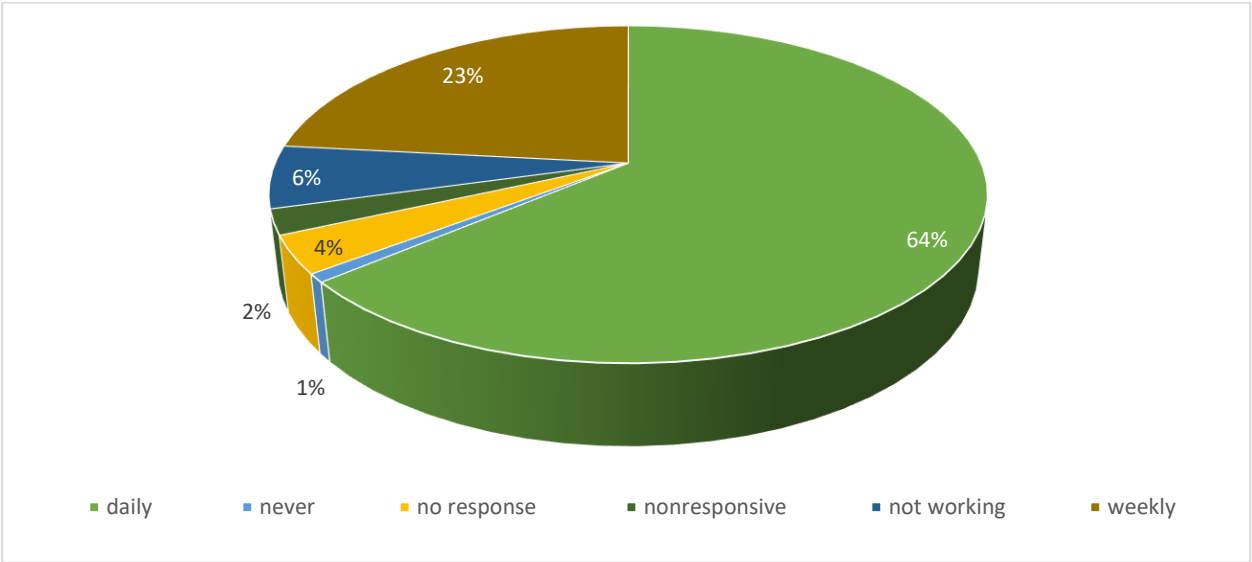

Figure 24 - Biodigester feeding frequency

Figure 25 - Cow manure transport for biodigester feeding – © RVO

Biogas Usage in Cooking

Seventy one percent (212 respondents) of the sampled households use biogas daily for cooking with 48% (101 respondents) of the 212 saying they use it three times a day. The remaining households said that they use it either once, twice or several times per week while 22% (67 of 300 including the 50 households with non-functioning biodigesters) of them did not respond to the question. Figure 26 shows the frequency of biogas usage for cooking at household level.

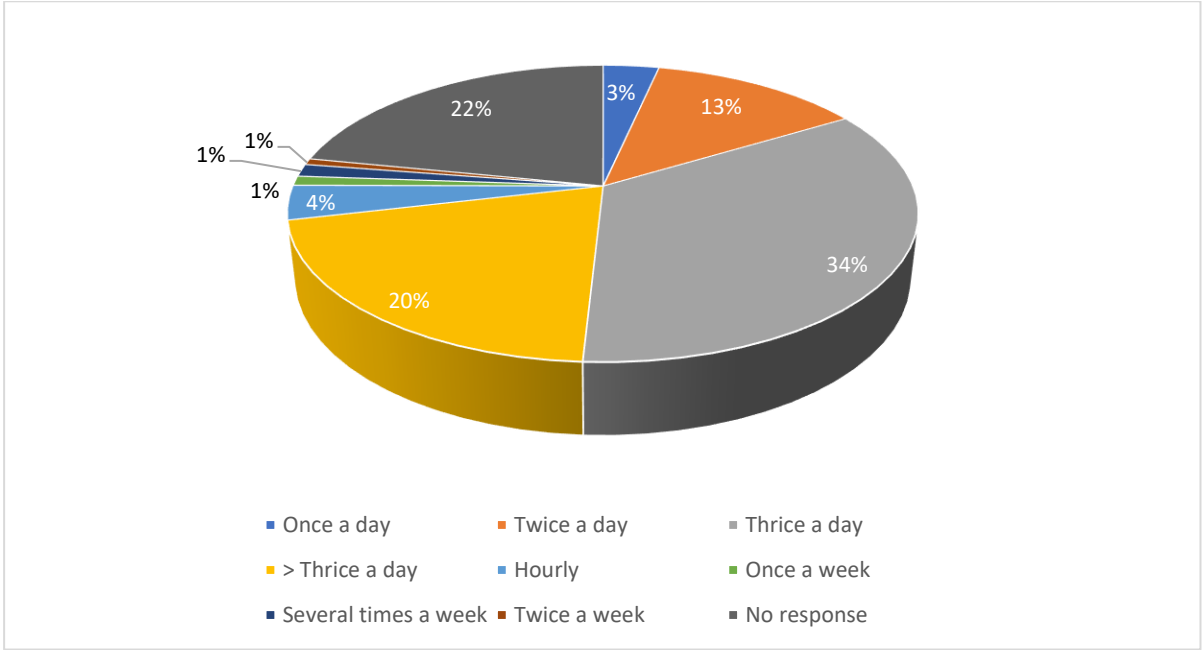

Figure 26 - Frequency of biogas usage for cooking

Figure 27 - User of biogas for cooking - © RVO

Cooking stoves burners functionality

Ninety four percent of the cook stoves had two burners. The main stove model is Ramtons Biogas Cooker (22%), followed by the Sistema biogas stove (21%) and the Juakali (17%). Figure 28 shows the number of burners reported in the study, figure 29 illustrates the conditions of most of the burners.

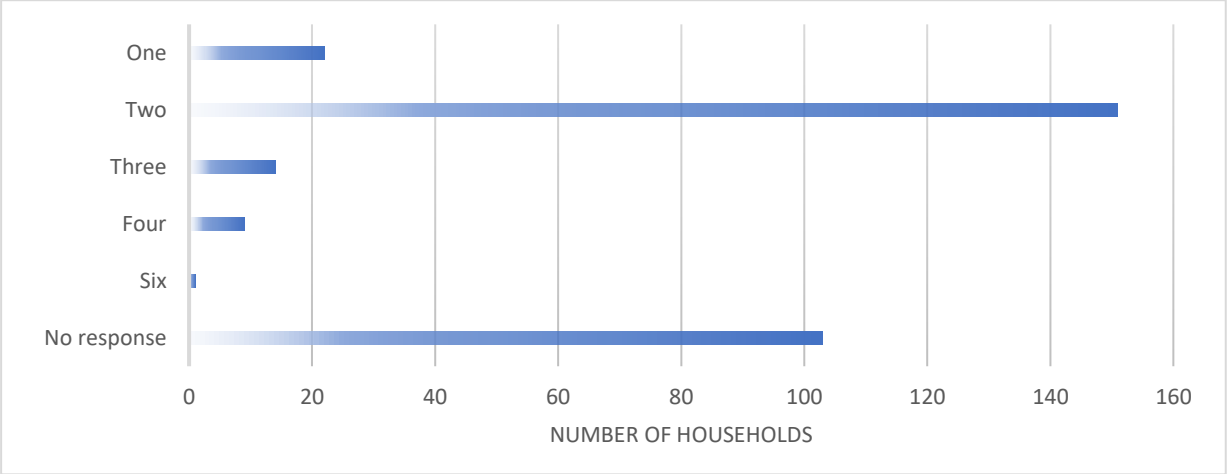

Figure 28 - Number of burners per stove

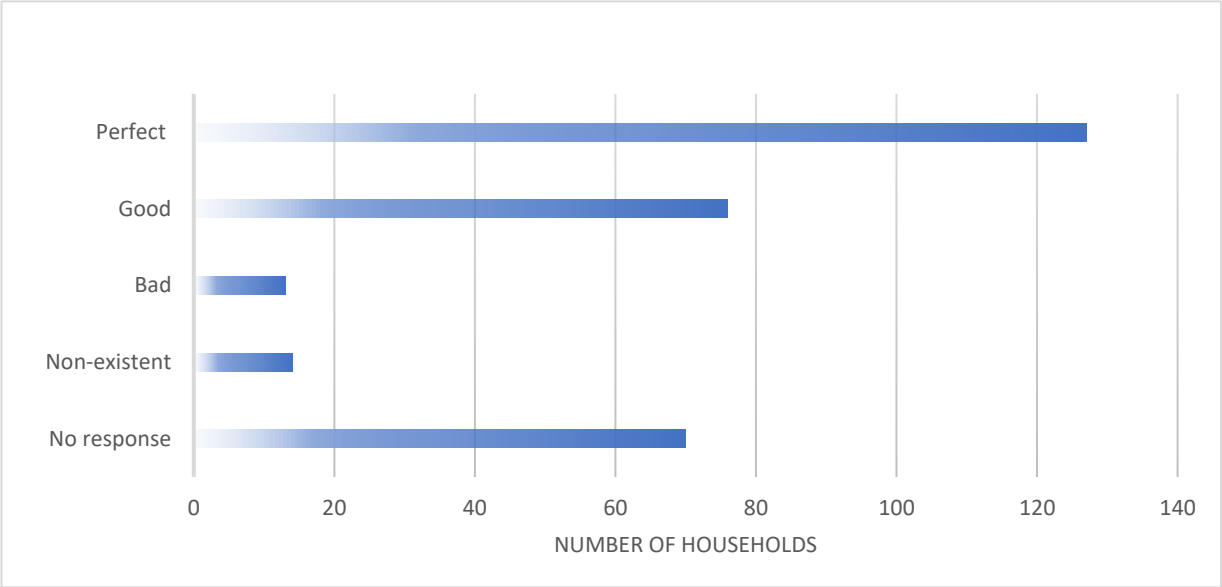

Figure 29 - Condition of kitchen stove

Workload and gender

In terms of change in time availability after the biodigester was installed, 72% of respondents indicated that their time availability for other activities had reduced while 28% reported that the time availability had not changed. All response on this question came from women respondents.

Use of bio-slurry

Besides biogas for cooking as a parameter for biodigester functionality, bio-slurry is an equally important consideration. The study established that 89% (204 of 228) households use bio-slurry as an organic fertilizer for their crops, with 95% (194 of 204) of them stating that there is an increase in quality and quantity of crop yields as compared to when crops are grown without any fertilizer. Eighteen percent of respondent confirmed that the slurry makes crops grow healthier and faster. Nineteen percent of the farmers transport bio-slurry to be used outside of their farm. Out of 247 households that answered the question related to the transport of the slurry outside of the farm, 20 of them (9%) confirmed to add material to it. The 22 respondents add non-digested animal dung (cow and poultry) (7), inorganic fertilizers (4), kitchen, crop or fish remains (2), traditional herbs (1) and water (8).

Figure 30 indicates the frequency of spreading the slurry onto the farms, the majority (about 81%) of farmers do the spreading weekly while 19% do it monthly. Moreover Figure 31 indicates that the main source of labour force for bio-slurry spreading is a hired labourer (worker) at 32% followed by family labour (31%). The availability of labour was identified as a key factor in defining the frequency of spreading.

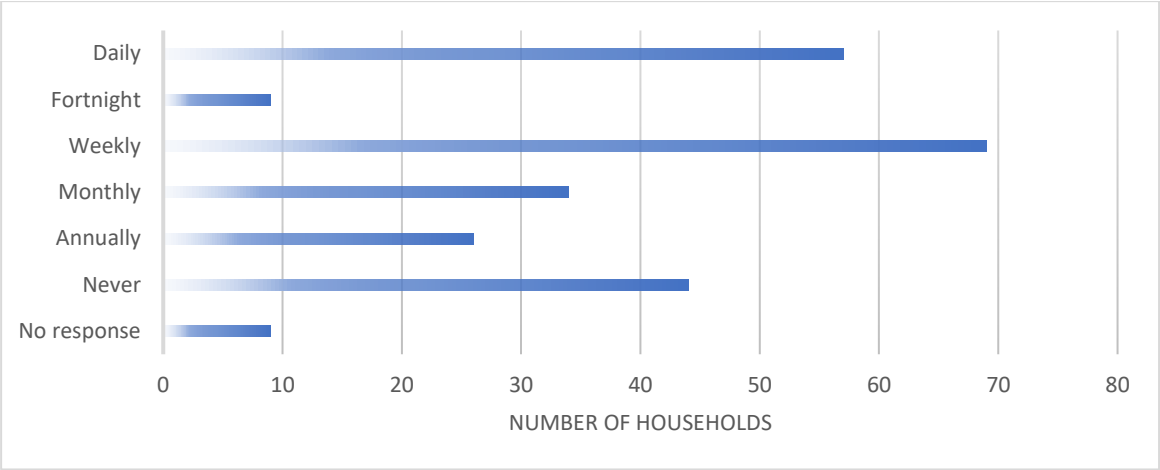

Figure 30 - Frequency of spreading bio-slurry

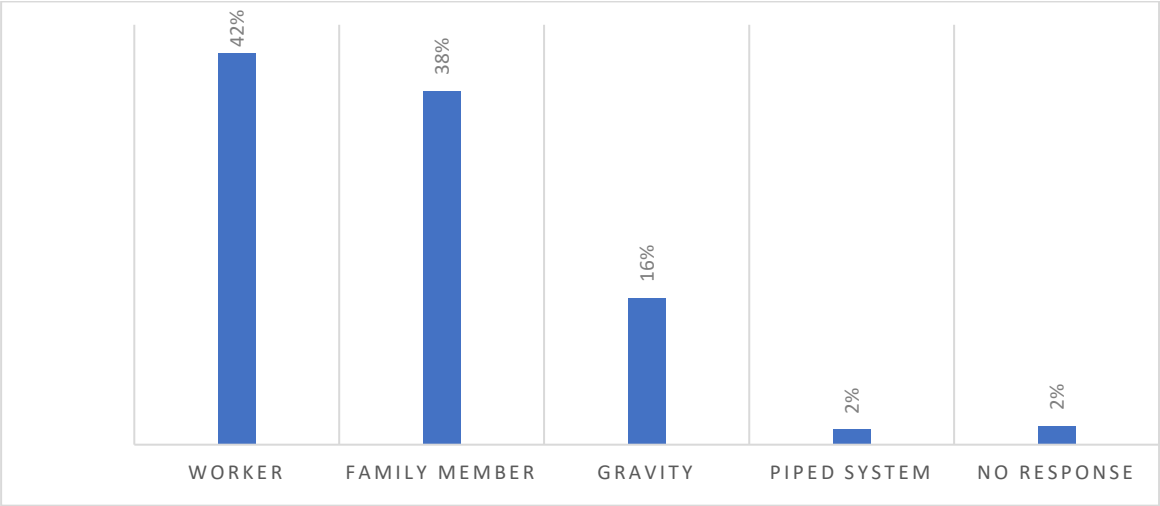

Figure 31 – Mode of bio-slurry appliance

Types of crops grown in the study area

In the five counties, the agriculture structure is different. Kiambu and Kakamega have both intensive dairy cow husbandry system whereas semi-intensive systems are more common in Kakamega and Kisumu (Figure 32). This is one of the reasons explaining the density of biodigester systems in the two counties with intensive dairy production system. Dairy cattle production is extensive in Taita Taveta.

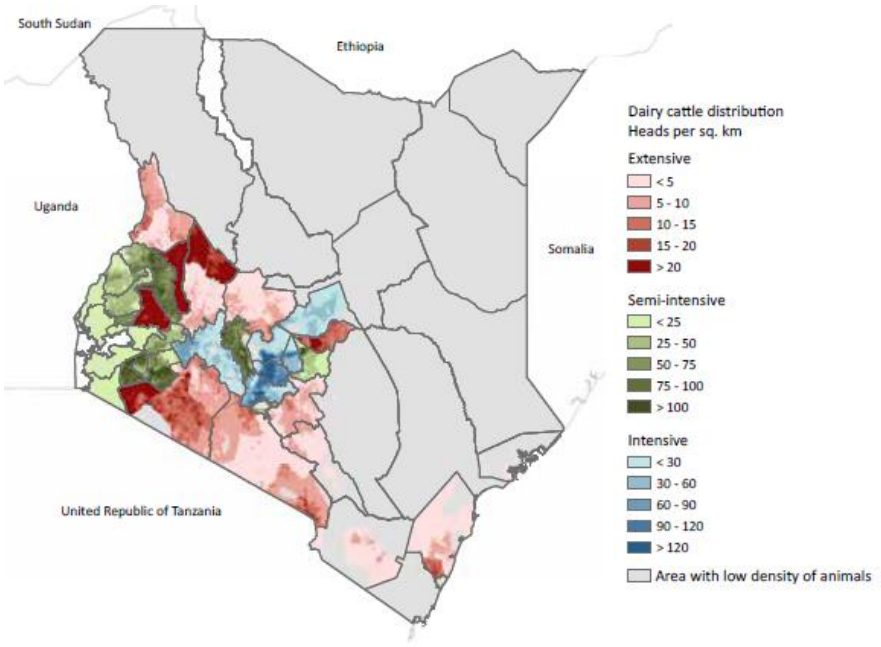

Figure 32 - Dairy cow density in Kenya - © FAO[5]

Crops grown in the area are more dependent on agro-ecological zones than biodigester density, but the staple crops presented in table 7 are usually grown in mixed farms where animals are kept and bioslurry produced. Except for banana and groundnut, the other cash crops are grown in larger farms. This gives indications on which crops to prioritise to support organic fertiliser valorisation.

County	Staple crops	Cash crops	Husbandry system
Kakamega	Bean, cassava, maize, millet, sorghum and sweet potato	Banana, sugarcane, tea and tomato	Semi-intensive
Kiambu	Cabbage, bean, maize and potato	Coffee, tea and pineapple	Intensive
Kisumu	Bean, maize and sorghum	Cotton, rice and sugarcane	Semi-intensive
Meru	Maize, millet, potato, sorghum and wheat	Banana, coffee, groundnut, miraa (khat), tea and different varieties of fruits and vegetables	Intensive
Taita Taveta	Bean, cassava, maize, sorghum and sweet potato	Cowpea, green grams and pigeon pea	Extensive

Table 7 - Crops grown in the five sampled counties

Level of satisfaction with biodigester

The study assessed the level of satisfaction by households with the installation and service of the biodigesters. Satisfaction was assessed on a rating basis – on a scale of 0 to 5 where 0 represented "very unsatisfied" and 5 represented "fully-satisfied" scenario. Out of the functional digesters (82% of all biodigesters surveyed), the analysis indicates that 73% of the households (that responded to the question) are fully satisfied with the plant services and usage while less than 2% reported non-satisfaction with the services of the biodigesters (Figure 33). Among the 50 clients with non-functional biodigesters, 59% were very unsatisfied, 5% were least satisfied, 9% were fully satisfied and 27% did not answer the question.

[5] Source : https://www.fao.org/3/i7669e/i7669e.pdf

Figure 33 - Satisfaction level for functioning and non-functioning biodigesters

Eighty-five percent of the clients are likely to very likely to recommend biodigesters to their friends, family and neighbours (Net Promoter Score of 5 to 9). Fifteen percent of the clients are unlikely or somehow unlikely to recommend the technology (Net Promoter Score of 0 to 5). There is a strict correlation between the satisfaction level and the likelihood of recommendation. The main reasons to recommend biodigester is because cooking is effective and efficient (64%) followed by it is a cheap cooking energy (18%) and it increases agricultural yield (18%). Only a handful of households (11 over 300) answer the reasons to recommend or not the technology.

Additional observations and comments from households

This section highlights some key observations during the field visits as summarized below:

- Besides the use in cooking, lighting and bio-slurry provision, the following other uses of biodigester were reported during the study: source of income for masons and local workers, improvement in general quality of life of rural women by providing clean gas for cooking and reducing the time spent looking for firewood collection.
- Close to 50% of farmers indicated that the companies which did their biodigester installations were not responsive to their calls when called for repairs or maintenance, this has led to loss of trust and apathy among some farmers. On this account, some farmers had constructed their own biodigesters while others were lying idle.
- Non-technical failures were identified as contributing to 40% of non-functional biodigesters in this sample. They represent failures attributed to the biodigester client or end-user. There is a need to conduct education campaigns and operations and maintenance training to build the skills of farmers since 10% of the households interviewed expressed this concern. With such capacity training, farmers would be empowered to handle light maintenance works thus saving the cost and losses that occur while they wait for maintenance responses from companies.
- The data collection process faced some challenges with a few unresponsive contacts provided and some farmers requesting their non-functional biodigesters fixed before they could engage in the interview. Finally, some farmers declined to be interviewed.
- The study established that most farmers are aware of biodigester usage which they have learned through various approaches including participation in training activities, learning from the experiences of neighbors or farmer demonstration by biodigester companies. Most of the respondents were aware of the benefits and contribution of biodigesters to livelihoods and environmental conservation.

Recommendations

The following recommendations have been proposed for the ABC project to increase biodigester functionality:

Biodigester Functionality

The three recommendations on biodigester functionality are directed at the companies that installed and provide maintenance service to the biodigesters:

- Develop basic capacity of farmers through education and regular training on minor maintenance and repairs skills to avoid total reliance on biodigester technicians.
- Provide technical maintenance and response to the non-functional biodigesters due to technical failures reported in this assessment
- Regular monitoring on the usage of biodigesters with a view to ensure that clients are getting full value of the biodigester (biogas and bioslurry and associated usages)

Bio-slurry application

Bio-slurry is a particularly important by-product of the biodigester as it has many applications ranging from organic fertilizer to specific animal feed (chicken, pig or fish). Some farmers did not particularly have good knowledge of the benefits of bio-slurry. Organizations (companies and related agencies) involved in promotion, marketing and installation and service of the biodigesters should train farmers on the benefits of bio-slurry.

Satisfaction levels

To ensure that the satisfaction levels of households with biodigesters remain high it is recommended that maintenance companies conduct the following:

- Deliberately reach out to households who registered satisfaction levels below 40% to ascertain their concerns
- Improve the communication channels, especially on prompt and timely redress of concerns and calls from farmers for maintenance to reduce reputational risk for the enterprise and for the whole biodigester sector in general

Annexes

Annex 1 - References

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Annex 2 - Questionnaire for data collection

BIOGAS FUNCTIONALITY ASSESSMENT QUESTIONNAIRE

Assessment of The Functionality of Existing Small-Scale Biodigesters in Kenya

Introduction

The GIZ in collaboration with the Climate & Energy Advisory is carrying out a survey on Assessment of the functionality of existing small-scale biodigesters implemented under the African Biodigester Component (ABC) program in Kenya. This questionnaire is directed towards getting an insight into the functionality of the biodigesters in your possession. Your open and genuine responses will be highly appreciated and treated with confidentiality.

(GIZ kwa ushirikiano na Ushauriwa Climate & Energy Advisory inatekelezauchunguziwaTathminiyautendakaziwavichochezividogovilivyopovinavyotekelezwachini yaMpangowaKipengele cha Kipengele cha GesiyaKiafrika (ABC) nchini Kenya. Hojajihiiinaelekezwakatikakupatamaarifakuhusuutendakaziwavichocheovyakusagaviumbehaiulic ho nacho. Majibuyakoyawazinayakweliyatathaminiwasananakutibiwakwausiri)

Preliminary questions (Maswaliyaawali)

I. Name: (Jina)
……..

II. Mobile number (Namba ya simu ya rununu)
……

III. Name of County (Jina la Kaunty)
[ ]Kakamega
[ ]Kisumu
[ ]Kiambu
[ ]Taita Taveta
[ ]Meru

IV. Name of Sub-County: (Jina la Kaunti Ndogo) …….

V. Village:(Kijiji)……

VI. Sex (Jinsia)
[ ]Male (Mwanaume)
[ ]Female (Mwanamke)
[ ] other (Nyingine)

Questions on Biogas Plant (MaswalijuuyaKiwanda cha Biogesi)

1. Do you have a Biodigester (Je, una Biodigester)?
   [ ] Yes (Ndio)
   [ ] No (Hapana)

2. What type of biogas plant (or biodigester) do you have? (Je, unamtambowaainaganiwa biogas (au biodigester).
   [ ] Fixed Dome (Dome isiyohamishika)
   [ ] Prefabricated (Imetungwa)
   [ ] Others (Specify) (Nyingine (Bainisha)

3. Biodigestor Code (KBP Code) (Msimbowa Biodigestor (KBP Code)……
4. Brand (Aina) ……
5. Commission Date (Tarehe ilipo anzishwa)…….
6. Size (Ukubwa)…….
7. What is the name of the firm/company that installed your biodigester? (Jina la kampuni iliyo sakinisha biodigester yakoinaitwaje?)
   ……
   ……

8. Which type of model was used to install the ABC? (Ni aina gani ya modeli ilitumika kusakinisha ABC?)
   [ ] AKUT
   [ ] CAMARTEC
   [ ] KENBIM
   [ ] New KENBIM(KENBIM Mpya)
   [ ]Prefabricated(Imetungwa) (Tubular-Sistemabio)
   [ ] Prefabricated (Iliyotungwa) (Simgas)
   [ ] Prefabricated(Iliyotungwa) (Flexibiogas)
   [ ] Prefabricated (Iliyoundwa)(Takamoto)
   [ ] Prefabricated (Imetungwa) (HomeGas)
   [ ] Prefabricated (Iliyotungwa)(Kentainers)
   [ ] Others (Specify)(Nyingine(Bainisha)_____)

9. How did you learn/know about biodigester (Ulijifunza/ulijuajekuhusu biodigester)?
   ……
   ……
10. Which year was the biodigester installed? (Biodigester ilisakinishwamwakagani?)
    ……
    ……

Questions on biogas Plant Functionality (MaswalikuhusuUtendajiwaMitamboyabiogesi)

11. Is your biodigester functional? (Je, biodigester yakoinafanyakazi?) (Presently being used for cooking or heating) (Hivi sasa inatumika kwa kupikia au kupashajoto)
    [ ] Yes(Ndiyo)
    [ ] No- skip to question 9(Hapana- rukaswali la 9)
    [ ] Do not know(Sijui)

12. How long has the biodigester been in use/functional? (Je,biogesterimetumikakwamudagani?)
    [ ] One year (Mwakammoja)
    [ ] Less than 1 year (Chiniyamwaka 1)
    [ ] Since Installation (TanguUsakinishaji)
    [ ] Do not know (Sijui)

13. How frequent do you use the biodigester gas for cooking and heating? (Je, ni marangapiunatumiabiodigesterkwakupikia na kupashajoto?)

    [ ] Hourly(Kila saa)
    [ ] Daily (kila siku)
    [ ] Twice a week (mara mbilikwa wiki)
    [ ] Once in a week (mara mojakwa wiki)
    [ ] Several time in a week(mara kadhaakwa wiki)
    [ ] Monthly(kilamwezi)
    [ ] Never (kamwe)

14. In a day, how many times do you use the biodigester gas for cooking and heating? (Kwa siku, ni mara ngapi unatumiagesiya biodigester kupikianakupashajoto?)

    [ ] Once(Mara moja)
    [ ] Two times (Mara mbili)
    [ ] Three times(Mara tatu)
    [ ] More than three times(Zaidi ya mara tatu)

15. For how many hours per day on average do you cook with the biogas stove? (Je, kwawastaniunapikakwasaa ngapi kwa siku kwakutumiajiko la biogesi?)
    ……

16. Has your time availability changed for other activities compared to the situation before you had a biodigester? (female)(Je, upatikanajiwakowamudaumebadilikakwashughulinyingineikilinganishwanahaliilivyokuwakabla yakuwana biodigester? (mwanamke)
    [ ] Yes(Ndiyo)
    [ ] No(Hapana)

17. If not functional, answer the following? Ikiwa haifanyi kazi, elezani

a. When did it stop functioning? (Provide month/year)liniiliachakufanyakazinakwanini?Je, iliachakufanya kazilini? (Toa mwezi/mwaka)

……

b. For what reason did it stop functioning? (Ni kwa sababu gani iliacha kufanykazi?)

[ ] Lack of manure/feedstock(Ukosefu wasamadi/malishe)
[ ] Malfunctioning of machine parts (Ufanya kazi vibaya kwasehemu za machine)
[ ] Poor maintenance(Matengenezoduni)
[ ] Deliberately stopped by owner (Imesimamishwakwamakusudinammiliki)
[ ] Any other reasons (Sababu nyingine zozote)

18. (a) If the problem stated is technical e.g., did you contact any mason/company/KBP for help?(Ikiwatatizolililotajwani la kiufundik.m. uliwasilianananamwashi/kampuni/KBP yoyotekwausaidizi?)

[ ] Yes (Ndio)
[ ] No (Hapana)

(b) If yes, what response did you receive from the source of help you contacted? (IkiwaNdiyo, nijibuganiulilopokeakutokakwachanzo cha usaidiziulichowasilianananaye)?

……
……

c) If no, why did not you contact Mason/KBP/ (IkiwaHapana, kwaninihukuwasilianana Mason/KBP/)

……
……

19. What is the stove brand used by your biogas (observe from Kitchen) (Je, nichapayajikoganiinayotumiwanabiogesiyako (angaliakutokaJikoni)……..?

a) Number of Burners on the stove: IdadiyaVichomajikwenyejiko:) (Observe) (Angalia)
……
b) pressure gauge installed (Kipimo cha preshakilichosanikiwa)
……

20. What is the status of the biogas kitchen stove? (Je, hali ya jiko la jiko la biogesiikoje?)

[ ] Perfect (Kamilifu)
[ ] Good(Nzuri)
[ ] Bad(Mbaya)
[ ] Non-existent(Haipo)
[ ] Do not Know(Sijui)

21. How many burners does the stove have? (Jikolinavichomeovingapi)

……..

[ ] one (moja)
[ ] two(mbili)
[ ] three (tatu)
[ ] four (nne)
[ ] more than four(zaidiyawanne)

22. Apart from domestic usage, do you use your biogas for other commercial purposes?
(Mbalinamatumiziyanyumbani, je,
unatumiabiogesiyakokwamadhumunimengineyakibiashara?)
[ ] Yes (Ndiyo)
[ ] No (Hapana)

23. What commercial purposes do you use your Biogas?
(UnatumiaBiogesiyakokwamadhumunigani ya kibiashara?)
……
……

24. Have you ever sought for Maintenance Services from the firm that installed the biodigester?
(Je, umewahikutafutaHuduma za Matengenezokutokakwakampuniiliyosakinishabiodigester?)
[ ] Yes (Ndio)
[ ] No (Hapana)

25. Do you usually pay for maintenance services? (Je, huwa unalipia huduma za matengenezo?)
[ ] Yes (Ndiyo)
[ ] No (Hapana) —skiptoQn 13(rukahadiQn 13)
[ ] Do not know (Sijui)

26. How much do you pay whenever the service is offered?(Je, unalipakiasiganikilahuduma inapotolewa?).....

27. Did you sign the maintenance contract with the firm that installed the biodigester or any other company? (Je, ulitia saini mkataba wa matengenezo nakampuni iliyosakinisha biodigester au kampuni nyingine yoyote?)
[ ] Yes (Ndio)
[ ] No (Hapana)

28. If the firm that offers maintenance is different from the firm that installed the biodigester, please provide its name? (Iwapo kampuni inayotoa matengenezo nitofauti naile iliyosakinisha biodigester, tafadhali toa jina lake?)
……..

29. Kindly, I would like to take the photo of the contract signed. [*Take photo-promise the respondent confidentiality of the information in the contract*] (Tafadhali, ningependa kuchukua picha yamkataba uliotiwasaini. [*Piga picha-muahidi mhojiwa usiriwata arifa katika mkataba])*

30. Do you have any skills on Biogas maintenance? (Je, unaujuzi wowote kuhusu matengenezo ya Biogesi?)
[ ] Yes (Ndiyo)
[ ] No (Hapana)

31. If yes, who provided the training on biogas maintenance? (Kama Ndiyo, ninanialiyetoamafunzoyautunzajiwabiogesi?)

……
……

32. How likely are you satisfied with the biodigester installation and usage? (Je, kuna uwezekano gani wakuridhishwa nausakinisha jinamatumizi ya mtambo wakuota chakula?)

[ ] Fully satisfied(Nimeridhikakikamilifu)
[ ] Moderately Satisfied (NimeridhikaKiasi)
[ ] Somehow satisfied (Nimeridhikakwanamna Fulani)
[ ] Least Satisfied (Sijaridhika Zaidi)
[ ] Not satisfied (Sijaridhika)
[ ] Very Unsatisfied (Sijaridhika Sana)

33. How likely are you to recommend the product, technology or service to your friends and neighbours? Je, unauwezekanoganiwakupendekezabidhaa, teknolojia au hudumakwamarafikinamajiranizako?

[ ] Not at all likely (Haiwezekanihatakidog)
[ ] Not likely (Haiwezekani)
[ ] Moderately unlikely (haiwezekanikwawastani)
[ ] Least unlikely(Haiwezekanikabisa)
[ ] Likely(Huenda)
[ ] Somehow likely (Uwezekano Fulani)
[ ] Moderately likely (uwezekanowawastani)
[ ] Highly likely (uwezekanomkubwa)
[ ] Very likely(Uwezekanomkubwasana)
[ ] Very high likely (Uwezekanomkubwasana)

34. Why are you not likely to recommend biogas to other people? (Kwa ninihunauwezekanowakupendekezabiogesikwawatuwengine?)

……
……

35. Why are you likely to recommend biogas to other people? (Kwa niniunauwezekanowakupendekezagesiyabayogesikwawatuwengine?)

……
……

36. What type of fodder do you feed your animals on? Je, unawapamifugoyakolisheainagani?……
……

37. For the fodder used (in thirty-six above), how much of it do your animals use per day? (Kwa lisheiliyotumika (katika thirty-six hapo juu), mifugowakohutumiakiasiganikwa siku?)

……
……

38. Do you usually feed the digester? (Je, huwaunalishamtambowakusagachakula?)

    [ ] Yes(Ndio)
    [ ] No (Hapana)

39. What have you been feeding the digester on?(Umekuwaukiwekaninikwenyemtambowako?)

……
……

40. How much time do you take to feed the biodigester during each feeding? (minutes)?(Je, unachukuamudaganikulishabiodigesterkwakilaulishaji? (dakika)

    ……
    ……

41. How much feed is fed into the biodigester? (Kiasigani cha lishekinaingizwakwenye biodigester?)

    ……
    ……

42. How often do you feed the digester? Je, unalishadigestermarangapi?

    [ ] daily(kila siku)
    [ ] weekly (kila wiki)
    [ ] monthly(kilamwezi)
    [ ] quarterly (kilarobomwaka)
    [ ] semi-annually (nusumwaka)
    [ ] annually (kilamwaka)
    [ ] never(kamwe)

43. In the family, who usually services the digester?Katikafamilia, ninanianayehudumiamtambowakusagachakula?
    [ ] Father(Baba)
    [ ] Mother (Mama)
    [ ] Child/children(Mtoto/Watoto)
    [ ] Domestic worker (Mfanyakaziwandani)
    [ ] Relative (Jamaa)
    [ ] Other (specify)(Nyingine (taja))

44. What is the gender of the person who usually services the biodigester?(Je, nijinsia gani ya mtuambaye kwa kawaida huhudumia mtambo wa kusaga chakula?)
    [ ] Male(Mwanaume)
    [ ] Female(Mwanamke)

45. During feeding, what volume (in m^3) is usually added into the digester? (Wakati wakulisha, nikiasigani (katika m^3) kinaongezwa kwenye digester?)

……
……

46. Do you have any other comment? (Je, una maoni mengine?)

……
……

Additional Questions

1. Number of Dairy Cattle
2. Dairy Cows manure Fed into the bio digester
3. Dairy Cows manure Not Fed into the biodigester
4. Dairy Cows Reason if 100% of manure is not fed
5. Number of Poultry
6. Poultry manure Fed into the biodigester
7. Poultry manure Not Fed into the biodigester
8. Poultry Reason if 100% of manure is not
9. Do you add anything to your bioslurry before spreading?
10. If you add anything, please state.
11. If you mix with water, at what ratio?
12. Who is assigned the responsibility of applying bioslurry to your crops?
13. If you use Bio-slurry for fertilizer, how often do you spread it?
14. Do you see a difference on the crop you applied bioslurry?
15. What difference do you see on the crop with applied bioslurry (quantity, quality)?
16. Do you transport bioslurry outside of your farm?
17. How likely would you be to recommend the use of bioslurry to other people? (On a scale of 0 (not at all likely) to 10 (very likely)).
18. Why would you/would you not be likely to recommend the use of bioslurry to other people?

Notes and Observation from enumerator (Vidokezo na Uchunguzi kutoka kwa mdadisi)
Photo of Biodigester (Picha ya Biodigester)
Photo of Biogas Stove (Picha ya Jiko la Biogas)

Thank you so much (Asante sana)

SEE – Clean Cooking

African Biodigester Component

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