African Bio-digester Component
Organic Fertiliser Valorisation Implementer (OFVI)

Inception Activity 2: Baseline current bio-slurry and BEC usage by biodigester households and their barriers to increased organic fertiliser valorisation

Kenya – final report



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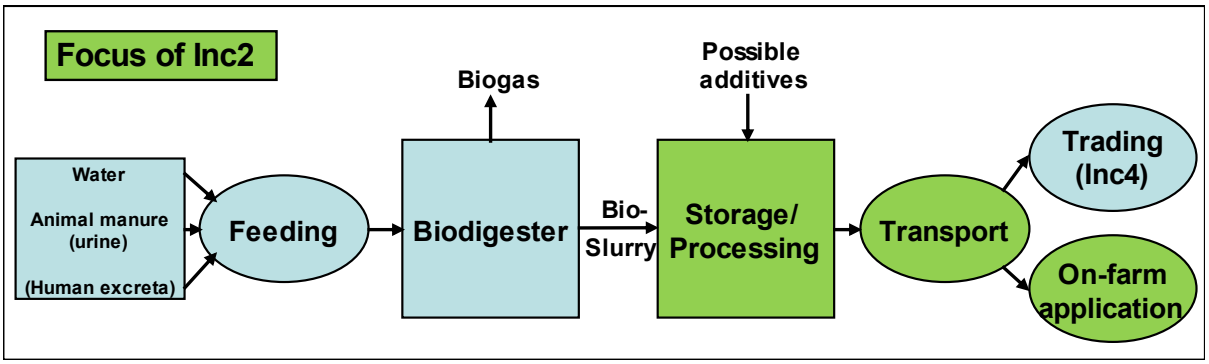
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Acronyms

ABC	African Biogas Carbon Programme
ABPL	Africa Bioenergy Programs Limited
ABPP	Africa Biogas Partnership Programme
BEC	Bio-slurry Enriched Compost
BR	Biomass Research
BUS	Biogas User Survey
CM	Carbon Monitoring
DB	DIBcoop
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GS	Gold Standard
KBP	Kenya Biogas Program
MP	Monitoring Period
NA	Not Available
NPS	Net Promoter Score
PoA	Programme of Activities
SNV	Netherlands Development Organisation
TBD	To Be Decided
VER	Verified Emission Reductions
VPA	Voluntary Project Activity

Summary

The main objective of the Organic Fertiliser Valorisation Implementer (OFVI) under the African Biodigester Component (ABC) is to support increased application and valorisation of organic fertiliser among existing and future owners of a biodigester. As part of the inception phase of OFVI, it is paramount to increase insight into the usage of bio-slurry among users of biodigesters: storage, processing, transport and application of bio-slurry and/or /Bio-slurry Enriched Compost (BEC), either on- or off-farm, see the below flowchart.



Likewise, it will be important to list the main barriers to the use of bio-slurry and/or BEC in the current situation. This report presents the findings of OFVI inception activity 2 for Kenya which is limited to on-farm application. OFVI's inception activity 4 (implemented by DIBcoop) will include trading and off-farm application of bio-slurry and BEC.

This activity was implemented based on four steps: 1) review of existing publications presenting specific data and information on the current use of bio-slurry and BEC by biodigester households; 2) an inventory of national stakeholders to be used as input for the selection of participants to validate the findings of the baseline report; 3) a workshop with national stakeholders to validate the findings of the baseline report; and 4) issuance of a knowledge brief based on the baseline and workshop reports (to be done, possibly including results of other inception activities).

The main conclusions on the baseline usage of bio-slurry and BEC by biodigester households in Kenya are the following:

Installation and functionality rate of biodigesters:
From 2009 up to 2021, over 26,000 biodigesters have been installed in Kenya. The functionality rate of these digesters is estimated to be 79-88%. This rate means that about 22,000 households with a biodigester in Kenya produce bio-slurry on a regular (daily) basis. Digesters with a capacity of 8 m3 are in the majority.

Feeding of the biodigesters:
Most biodigesters are fed with manure from dairy and other cattle; some with swine manure. Households do not feed all manure to the digester, mainly because they avail more manure than the digester requires to produce gas for cooking. Other reasons included inability to collect all dung (e.g., when animals are free ranging) and alternative use of manure. Most households feed their digester every day (54-66%) but feeding about 3 times per week is also widely practiced (34-46%). Toilet attachment is estimated to be maximum 5%.

Storage and processing of bio-slurry produced by biodigesters:
Most households (between 41 and 79%) use bio-slurry directly (on a daily basis) on crops. Between 17-57% of the households first store the bio-slurry. Households first storing bio-slurry said that they mainly kept the slurry in an uncovered lagoon (7-20%), in liquid form (30-43%), solid form (5-18%), sun-dried (24-27%) or composted it (8-12%), with (1-9%) or without (4-

11%) roof. They often practiced different storage methods at the same time. An estimated 20% of the households are keeping double compost pits.

Transport of bio-slurry and/or BEC:
Bio-slurry is mainly transported through pipes, channels and with cans, and tanks. BEC is transported by wheelbarrows, bags, containers and pick-ups.

Application of bio-slurry and/or BEC:
The majority of the households reported that bio-slurry was mainly applied as fertiliser (94-98%), while others reported use as animal feed (0-1%) or insecticide/pesticide (0-1%). Trading of bio-slurry or BEC was hardly practiced, assumingly 3%. Most households (41-68%) directly applied the liquid slurry while others first collected it in a tank and applied it progressively on crops (7-31%). Other modes included drying (14-34%) and composting (1-7%). Households often combined different application modes.

Crops:
Bio-slurry and/or BEC is mainly applied to the following crops: maize (10-28%), Napier grass (8-18%), vegetables (21-31%), bananas (12-17%), coffee (5-15%) and tea (2-21%). OFVI may consider fruit trees and Irish potatoes as potential crops in near future. Households predominantly noted that the quality of their crops has improved (97-100%) while 1-3% said that the crop quality remained the same.

Other fertilisers:
Prior to the installation of biodigesters, 63 to 89% of the households were using other types of fertilizers while 11-37% applied no fertilizers at all. The main types of fertilizers used by then were chemical fertilisers (53-62%), farm-yard manure (25-34%) and compost manure (9-15%). After the installation of the biodigester, 67% of the households were still using other types of fertilizers because bio-slurry was insufficient to achieve higher yields and/or to meet different plant needs. The other fertilizers used were chemical fertiliser (64%) and organic fertiliser (36%). Expenditure on chemical fertilizers for households who continued to use them after the installation of the biodigester reduced for most households (79-99%), while this expenditure remained the same for 1-20% of the households.

Bio-slurry training:
A minority of the households (13-35%) received training on slurry handling and application. No information was gathered on which household members (female/male) were trained. The trainings were conducted by organisations or companies including KBP/ABPL (0-63%), masons or technicians (9-72%), others (17-39%) and family or friends (0-3%). Likely more training has been provided, as the surveyed respondents may be different from the household members being trained. ABPL reports that over 10,000 bio-slurry usage and management trainings have been provided since 2016, with 46% of the trainees being female.

Appreciation of bio-slurry:
Almost all household with a functioning biodigester would recommend the technology to others. Bio-slurry as a source of fertiliser is however recommended by 3-11% of these households only. Possible explanation for this discrepancy may be that households carry a low perception about bio-slurry & BEC, despite the benefits, as their application requires more efforts compared to chemical fertiliser.

Gender:
In Kenya, 60% of the biodigesters are owned by men; 39% by women; and 1% by institutions. After the installation of the biodigester, both female (93-99%) and male (94-100%) household

members reported time savings. The saved time was mainly spent on income generation activities, social activities and recreation/leisure. Male workers are identified as the main actors for storage/processing, transport and on-field application, followed by male adults, female adults and female workers. The participation of children in all bio-slurry and BEC related activities is limited. It appears that the three distinguished activities are somehow linked, as the actor who stores/processes may also be the one who transports and applies.

Main barriers for improved usage of bio-slurry and BEC:
The barriers to the (improved) use of bio-slurry and/or BEC by households are manifold, but the following may need the attention of OFVI in the implementation phase:
-storage: limited space.
-processing: lack of tools & equipment.
-transport: lack of tools & equipment and high cost.
-application: lack of knowledge, in particular on application rates.
-trading: limited demand and difficulty in packaging.
-storage/processing, transport and application in general: lack of knowledge and labour-intensive.

Based on the findings of this inception activity 2, the following baseline data can be presumed for related OFVI result indicators in Kenya, see the Table below.

ABC/OFVI result indicator	Baseline	Notes
% of households applying bio-slurry and/or BEC	90%	Note 1: Though almost all households apply bio-slurry and/or BEC, there is room for improvements Note 2: The IVA will verify data submitted by biodigester enterprises at second verification (use of bio-slurry (yes/no/unclear); amount of bio-slurry produced; amount of BEC produced; and trading of bio-slurry (yes/no/unclear)
% of households with double compost pit installed	20%	Note 1: It will be important to distinguish bio-slurry pits from compost pits in the case of Uganda, as bio-slurry is often applied in liquid form Note 2: The IVA will verify data submitted by biodigester enterprises at first verification (number of bio-slurry pits; number of double compost pits). It would be good to have this last number verified at second verification as well
Tons of (excess) bio-slurry and/or BEC traded	TBD	Note 1: Bio-slurry and/or BEC is traded by 1-5% of the households, but the amount is not documented. An estimate could be made assuming the most popular size of the digesters (8 m3) and stipulated feeding rate. Alternatively, the share of households (%) trading bio-slurry and/or BEC could be considered as an alternative result indicator Note 2: The IVA will verify data submitted by biodigester enterprises at second verification (use of bio-slurry (yes/no/unclear); amount of bio-slurry produced; amount of BEC produced; and trading of bio-slurry (yes/no/unclear)

1 Introduction

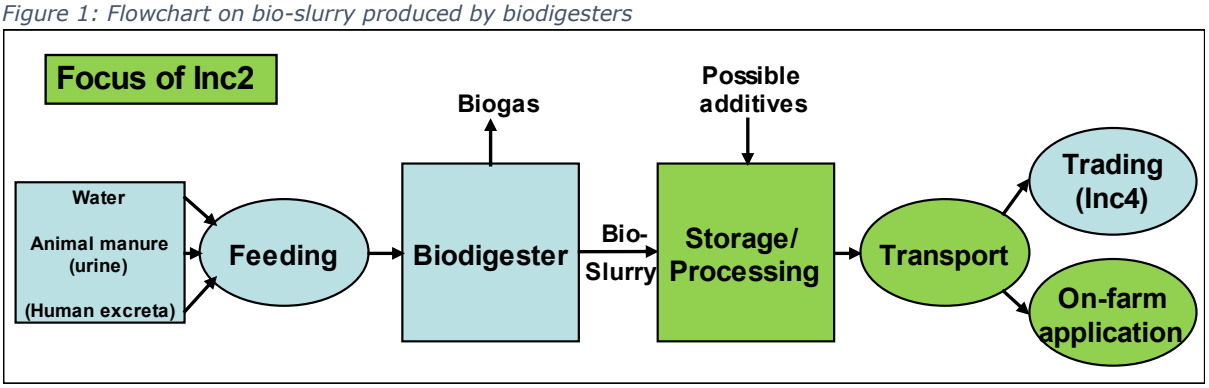
The main objective of the Organic Fertiliser Valorisation Implementer (OFVI) under the African Biodigester Component (ABC) is to support increased application and valorisation of organic fertiliser among existing and future owners of a biodigester. This is expected to improve the business case of investment and thereby sustain demand for and use of biodigesters in the target markets. Since the start of the African Biogas Partnership Programme (ABPP) in 2009 about 27,000 household digesters have been installed in Kenya up to 2021, see Table 1. Digesters with a capacity of 8 m3 are in the majority.

Table 1: Number of digesters installed in Kenya since 2009

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Up to 2021
Units	3	701	2,292	3,510	4,744	2,528	1,895	1,340	1,006	2,139	2,315	1,962	2,333	**26,768**

As part of the inception phase of OFVI, it is paramount to get a realistic view on the current usage of bio-slurry among users of biodigesters, in particular the storage, processing, transport and application of bio-slurry and/or Bio-slurry Enriched Compost (BEC), either on- or off-farm, see Figure 1.

Figure 1: Flowchart on bio-slurry produced by biodigesters



Likewise, it will be important to collect and validate information about the barriers of the biodigester households to the use of bio-slurry and BEC in the current situation. This report presents the *final draft* findings of OFVI inception activity 2 for Kenya which is limited to on-farm application. OFVI's inception activity 4 (implemented by DIBcoop) will include trading and off-farm usage of bio-slurry and BEC.

2 Methodology

This activity was implemented based on four (4) steps. As a first step, existing publications presenting specific data and information on the current use of bio-slurry and BEC by households in Kenya have been collected in close cooperation with Africa Bioenergy Programs Limited (ABPL)[1], being OFVI's National Partner (NP); Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), being ABC's Lead Implementer (LI) in Kenya; and SNV Netherlands Development Organisation, being consortium partner of the LI in Kenya. The main source for such data and information have been user surveys commissioned ABPL in the framework of carbon finance projects. All collected publications have been reviewed by SNV staff and documented in a draft

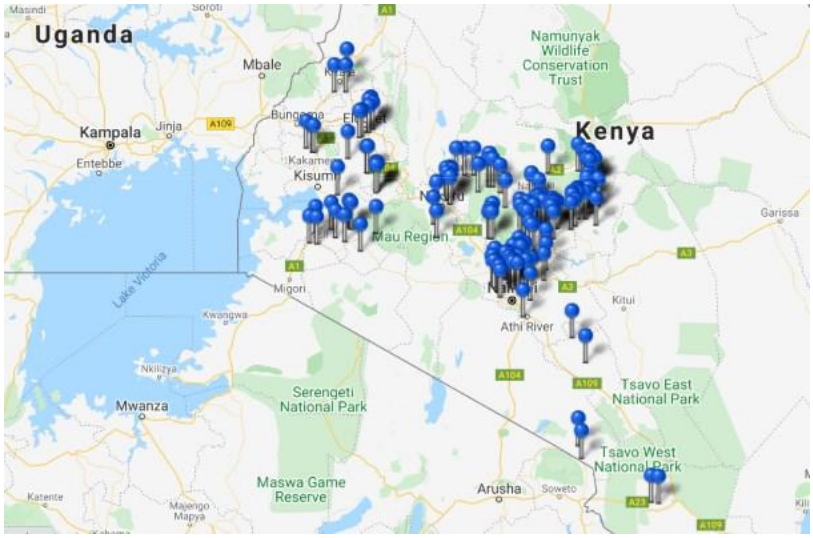
[1] ABPL evolved from the Kenya Biogas Program (KPB)

report. Where available, related gender data have been included. The draft report was circulated among selected consortium, national and implementing partners for comment. Some data were derived from the ABPL database with digesters installed since 2015. Step 2 consisted of an inventory of national stakeholders including producer organisations, government, private sector and NGOs in Kenya. This inventory was prepared by ABPL and used as input for the selection of stakeholders for participation in a workshop to validate the draft findings of the baseline report. Step 3 consisted of a half-day workshop which took place on 23 November 2022 in Nairobi and was attended by 26 participants. The proceedings of this workshop were laid down separately in a brief report. The last step (step 4) will be the issuance of a separate knowledge brief for Kenya, based on the baseline and workshop reports (to be done, possibly including results of other OFVI inception activities).

3 Results

Commissioned by ABPL, several Biogas User Surveys (BUS) have been conducted over the period 2016-2021 by Eco-Frontier Kenya Limited (Eco-Frontier Kenya, 2017; Eco-Frontier Kenya, 2019; Eco-Frontier Kenya, 2020; Eco-Frontier Kenya, 2021; Eco-Frontier Kenya, 2022). These surveys were conducted in multiple locations throughout Kenya among households having installed biodigesters. The survey data were required to calculate and monitor emission reductions by African Biogas Carbon Programme (ABC) – Kenya – VPA006 (GS5801) for the issuance of Verified Emission Reductions (VERs). The sampling techniques used for these surveys comply with the monitoring requirements for the Programme of Activities (PoA). Respondents were drawn from the database provided by ABPL, stratified by year, further clustered by county, proportionally to the total number of digesters in each county, see for example Figure 2 for the units sampled for the BUS 2020.

Figure 2: Location of biodigesters sampled for the Survey A of the BUS 2020



The different surveys collected data through field visits and/or phone interviews. Usage surveys ("B") were conducted to capture data about the actual functioning of the biogas digesters. User surveys ("A") captured household data of functioning biodigesters, see Table 1 for the sample sizes of both surveys. Specifically related to bio-slurry, the survey A questionnaire included some questions relevant for bio-slurry and BEC. The questionnaires also contained a question on gender

equality. This question was however limited to time availability of women and men and focussed more in general on the effect of the biodigester rather than the use of bio-slurry and BEC.

In addition to the BUS reports, data from the baseline survey 2021 for the Africa Biogas Carbon Programme VPA01 in Kenya have been included (Eco-Frontier Kenya, 2022a). This survey collected data from 130 households without biodigesters owning at least two cows, six pigs or 170 poultry. The sampled households neighboured with households which were operating biodigesters. The baseline survey was executed to support the project renewal for the second crediting period of VPA01 under the Gold Standard. The baseline survey made an effort to define/describe different methods for manure storage/handling, see Figure below.

Figure 3: Different methods for manure storage/handling (Eco-Frontier Kenya, 2022a)

***Uncovered anaerobic lagoon**:* A type of liquid storage system designed and operated to combine waste stabilization and storage. Manure is collected into a specific storage lagoon, which is large and deep enough to hold manure for at least 1 year. Although the tank is not covered, the manure inside is hardly mixed. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields (black watery system).
Liquid/slurry: Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year. (Looks like brown porridge)
Solid storage: The storage of manure, typically for several months, in unconfined piles or stacks. Manure is stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Dry lot: A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Pasture/Range/Paddock: The manure from pasture and range grazing animals is allowed to lie as-deposited, and is not managed.
Daily spread: Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Burned for fuel: The dung and urine are excreted on the fields. The sun-dried dung cakes are burned for fuel.
Composting: composting in piles, an enclosed channel, or windrows with either daily or no mixing.

Also included are data from the ABC bio-digester functionality assessment in Kenya commissioned by GIZ (Climate & Energy Advisory, undated). This assessment was based on a face-to-face survey conducted in May 2022 among 300 households in five counties with biodigesters installed between 2009 and 2021. Finally, data have been derived from the ABPL database with digesters installed since 2015 (7,908 units)

3.1 Functionality rate

Table 2 provides an overview of the functionality rate of the surveyed digesters for several years, with survey A providing the most reliable data collected through in-person visits. Between 79 and 88% of the digesters were functioning; 12 to 21% were out of operation due to various technical and non-technical reasons.

Table 2: Sample size of User ("A") and Usage ("B") Surveys, and functionality rate of digesters

BUS year	Sample size of "A" survey	Age of the digesters	VPA	Sample size of "B" survey	VPA	Functionality rate
2016	135	01/11/2009-31/12/2016		243		82%-77%
2018	207	01/11/2009-22/10/2015	01+intermediary	207	01+intermediary	71%
	117	23/10/2015-31/05/2018	06	117	06	88%
2019	-	01/11/2009-22/10/2015	-	207	01+intermediary	76%
	130	23/10/2015-31/01/2020	06	160	06	82%
2020	-	01/11/2009-22/10/2015	-	207	01+intermediary	54%
	155	23/10/2015-31/07/2020	06	194	06	81%
2021	-	01/11/2009-31/05/2017	-	139	01	71%
	164	23/10/2015-28/02/2022	06	209	06	79%

Note: Survey A was mostly conducted through in-person field visits while survey B was mostly conducted through phone calls

The ABC functionality assessment (Climate & Energy Advisory, undated) found a corresponding figure of 82% of the digesters being functional. This functionality rate means that about 22,000 households in Kenya produce bio-slurry on a regular basis.

3.2 Feeding of the digester

Table 3 provides the data on the number of animals owned by the households. Most of the households (85-97%) own 3-5 heads of dairy cattle. Other animals reared by fewer households include other cattle (3-5 heads), market swine (4-29) and sows (4-23). Households also keep poultry, sheep and goats, but their excreta are not or hardly fed into the digester. No data are available on the attachment of a toilet to the biodigester.

Table 3: Number of animals owned by households

BUS year		Dairy cattle	Other cattle	Market swine	Breeding swine
2016	Share of households (%)	97%	27%	6%	3%
	Number of animals by household	5.5	3.7	5.6	4.3
2018	Number of households	95%-90%	32%-37%	5%-5%	3%-5%
	Number of animals by household	4.7-4.5	3.7-4.8	11.6-29.0	23.1-3.5
2019	Share of households (%)	97%	17%	2%	1%
	Number of animals by household	4.2	4.1	4.0	4.0
2020	Share of households (%)	94%	5%	7%	5%
	Number of animals by household	3.6	3.4	21.5	4.9
2021	Share of households (%)	92%	21%	5%	2%
	Number of animals by household	4.3	3.6	9.8	4.8
Baseline 2021	Share of households (%)	85%	22%	11%	5%
	Number of animals by household	3.4	2.8	6.9	5.1

Note on number of animals: The mean value is provided

The ABPL database provides data on the number of animals kept on average by the households: rounded number of zero-grazing cattle: 5; of night-stabled cattle: 3; of stabled pigs: 2; and of night-stabled pigs: 3.

Households raising dairy cattle fed between 86 and 93% of the dung generated from the cows while this percentage ranged between 5 and 82% for households with other types of cattle, see Table 4. The proportion of pig manure from market swine fed in digesters amounted from 7 to 100% while that from breeding swine was 0 to 100%. Very small proportions (if any) of manure from other animals like poultry, sheep and goats were fed.

Table 4: Share of manure fed by households in the digester

BUS year		Dairy cattle	Other cattle	Market swine	Breeding swine
2016	Share of households (%)	80%	15%	3%	2%
	Manure fed into digester	86%	82%	100%	83%
2018	Share of households (%)	95%-90%	32%-37%	5%-5%	3%-5%
	Manure fed into digester	89%-88%	60%-40%	36%-57%	79%-60%
2019	Share of households (%)	97%	17%	2%	1%
	Manure fed into digester	93%	82%	33%	100%
2020	Share of households (%)	94%	5%	7%	5%
	Manure fed into digester	90%	100%	39%	71%
2021	Share of households (%)	92%	21%	5%	2%
	Manure fed into digester	86%	5%	7%	0%

Households mentioned several reasons for not feeding all manure into the digester. Manure from poultry, sheep and goats is available in small quantities only and often difficult to collect. The latter applies also for manure produced by free ranging (other) cattle. Some households preferred to avoid feeding of swine manure because of its smell. Other households explained that not all manure was required to produce the gas needed for cooking.

Attachment of a toilet to the digester is not common in Kenya. The workshop participants estimated that maximum 5% of the households did connect a toilet. The ABPL database reports just 1%.

Table 5 provides data on the frequency of feeding the digester by the households. Most households feed their digester every day (54-66%); however, weekly feeding (mostly 3 times) is also widely practiced (34-46%). Workshop participants mentioned the following reasons: weekly feeding is sufficient to satisfy the cooking needs, manure has to be collected remotely and labour constraints. Mostly buckets are used to feed the digester, but also wheelbarrows, sacks, spades and basins.

Table 5: Frequency of feeding the biodigester by households

BUS year	Daily (mostly 1 time)	Weekly (mostly 3 times)
2019	63%	37%
2020	66%	34%
2021	54%	46%

The ABC functionality assessment (Climate & Energy Advisory, undated) found a somewhat higher figure of 73% of the digesters fed daily; somewhat lower on weekly feeding (27%).

3.3 Storage and processing of bio-slurry

When asked what they were doing with the bio-slurry discharged from the digestors, most households (between 41 and 79%) reported that they used it directly almost all as fertiliser while 17 to 57% reported that they first stored the slurry, see Table 6.

Table 6: Direct application or storage of bio-slurry discharged from the digester by households

BUS year	Direct use as fertiliser	First stored	Discarded	Other
2018	62%-68%	35%-31%	1%-0%	2%-1%
2019	79%	17%	3%	1%
2020	52%	46%	1%	1%
2021	41%	57%	3%	0%

Since 2020, ABPL is monitoring the storage and processing of bio-slurry. As per date, 81% of the households practice direct use; 3% prepare BEC; and 16% do both direct use and composting.

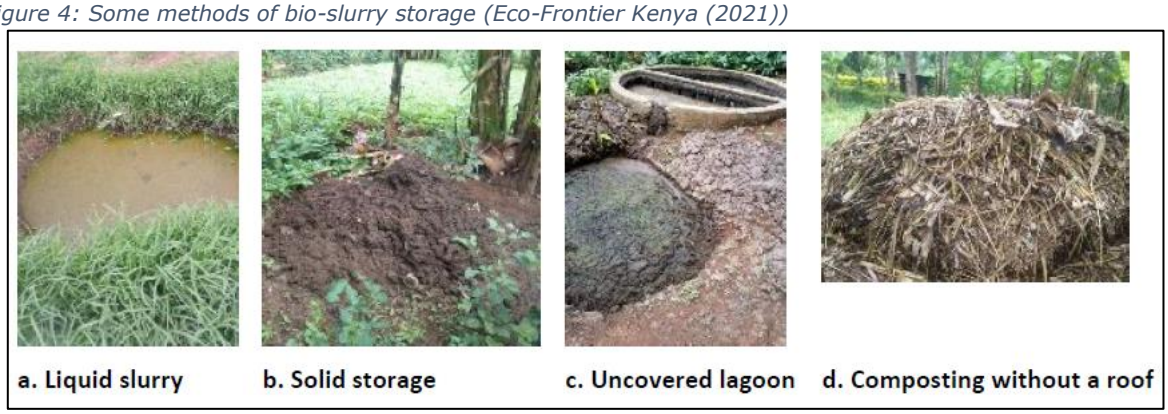
Households first storing bio-slurry said that they mainly kept the slurry in an uncovered lagoon (7-20%), in liquid form (30-43%), solid form (5-18%), sun-dried (24-27%) or composted it (8-12%), with (1-9%) or without (4-11%) roof, see Table 7. They often practiced different storage methods at the same time. The workshop participants estimated that 20% of the households have installed double compost pits. When bio-slurry is applied in liquid form, there are no compost pits required.

Table 7: Methods for storing bio-slurry

BUS year	Lagoon	Liquid slurry	Solid storage	Sun drying	Composting with roof	Composting without roof
2019	18%	30%	16%	27%	9%	NA
2020	20%	38%	5%	25%	1%	11%
2021	7%	43%	18%	24%	4%	4%

As per the baseline survey (Eco-Frontier Kenya, 2022a), dairy cattle dung from stables is mostly stored in solid form (31%), used as a daily spread (17%) or composted (12%). The manure from other cattle is dependent on being produced in the dry or wet season largely composted (45-27%) or stored in solid form (30-35%).

Figure 4: Some methods of bio-slurry storage (Eco-Frontier Kenya (2021))



In the application of the slurry as fertiliser, several methods were used. Most households (41-68%) directly applied the liquid slurry while others first collected it in a tank and applied it progressively on crops (7-31%), see Table 8. Other modes included drying (14-34%) and composting (1-7%). Households often combined different application modes.

Table 8: Mode of application of bio-slurry as fertiliser by households

BUS year	Directly in liquid form	Collected in slurry tank and applied progressively	Dried	Composted	Various
2016	64%	0%	30%	3%	3%
2018	42%-41%	7%-11%	21%-24%	1%-1%	29%-23%
2019	68%	15%	34%	5%	-
2020	51%	28%	14%	7%	-
2021	41%	31%	23%	5%	-

Note: BUS 2019-2021 includes multiple modes applied by one household

3.4 Transport of bio-slurry and BEC

The workshop participants provided input on how households are transporting bio-slurry and BEC. Bio-slurry is mainly transported through pipes, channels and with cans, and tanks. BEC is transported by wheelbarrows, bags, containers and pick-ups.

3.5 On-farm application of bio-slurry and BEC

The majority of the households reported that bio-slurry was mainly applied as fertiliser (94-98%), while others reported use as animal feed (0-1%) or insecticide/pesticide (0-1%), see Table 9. The surveys did not provide a qualification of the use of bio-slurry and/or BEC by households but indicate room for improvements.

Table 9: Main application of bio-slurry

BUS year	Fertiliser	Animal feed	Insecticide/ pesticide	Sold	Other
2016	94%	0%	0%	1%	5%
2020	97%	1%	1%	1%	0%
2021	98%	0%	1%	1%	0%

The ABC functionality assessment (Climate & Energy Advisory, undated) found that 89% of the households with a functional digester used bio-slurry as an organic fertiliser. In addition, 19% of the households reported that they transported bio-slurry to be used off-farm, a much higher figure than found in the BUS surveys. The workshop participants stated that trading (sale) of bio-slurry and BEC by households is still limited, definitely less than 5%. Overseeing everything, we assume 3% trading.

Households reported the following crops on which bio-slurry was mainly applied: Maize (10-28%), Napier grass (8-18%), vegetables (21-31%), bananas (12-17%), coffee (5-15%) and tea (2-21%), see Table 10.

Table 10: Crops to which bio-slurry is mainly applied (>4% of crops mentioned)

BUS year	Maize	Napier grass	Vegetables	Bananas	Coffee	Tea
2018	28%-18%	18%-16%	21%-26%	12%-12%	5%-15%	3%
2019	23%	15%	25%	17%	6%	2%
2020	10%	8%	31%	14%	5%	21%
2021	14%	13%	30%	12%	8%	2%

Note: BUS 2016 included a graph with crops but values could not be retrieved from this graph

Workshop participants confirmed vegetables, maize, Napier grass, bananas and coffee being the main crops for the current application of bio-slurry and/or BEC. However, they recommended OFVI to also consider fruit trees and Irish potatoes as potential crops in near future.

Dependent on the crop, various methods are used by households to apply bio-slurry and BEC to the fields. Workshop participants remarked that pouring along crops may turn bio-slurry into dry and rather ineffective 'cakes'. Households also apply bio-slurry in holes or small ditches then covered with soil. Dependent on the season, it can be applied at planting or during plant growth. Bio-slurry is sometimes also sprayed. BEC is often off-loaded on the field at the time of land preparation.

Households predominantly noted that the quality of their crops has improved (97-100%) through the application of bio-slurry while 1-3% said that the crop quality has remained the same, see Table 11.

Table 11: Effect of bio-slurry on the quality of the crops

BUS year	Quality increased	Quality stayed the same	Quality decreased
2016	98%	1%	1%
2018	97%-97%	2%-3%	1%-0%
2019	100%	0%	0%
2020	99%	1%	0%

The ABC functionality assessment (Climate & Energy Advisory, undated) found 95% of the households stating an increase in the quality and quantity of the crops compared with crops grown without any fertiliser.

Prior to the installation of biodigesters, 63 to 89% of the households were using other types of fertilizers in their gardens while 11-37% applied no fertilizers at all. The main types of fertilizers used were chemical fertilisers (53-62%), farm-yard manure (25-34%) and compost manure (9-15%), see Table 12.

Table 12: Fertilisers used by households before the installation of the digester

BUS year	No fertiliser used prior to digester	Fertiliser used prior to digester	#Farm-yard manure	#Compost manure	#Chemical fertiliser
2016	37%	63%	NA	NA	NA
2018	27%-21%	73%-79%	25%-30%	13%-12%	62%-58%
2019	13%	87%	27%	13%	59%
2020	24%	76%	32%	15%	53%
2021	11%	89%	34%	9%	57%

Only the BUS 2021 asked the households whether they applied any other fertiliser in addition of bio-slurry after the installation of the digester. As per this survey, 67% of the households were using other types of fertilizers as bio-slurry was insufficient to achieve higher yields or to meet different plant needs. The other fertilizers used were chemical fertiliser (64%) and organic fertiliser (36%), see Table 13.

Table 13: Fertilisers used by households after the installation of the digester

BUS year	No other fertilisers used	Other fertilisers used	#Chemical fertiliser	#Organic fertiliser
2021	33%	67%	64%	36%

Expenditure on chemical fertilizers for households who continued to use them after the installation of the biodigester reduced for most households (79-99%), while this expenditure remained the same for 1 to 20% of the households, see Table 14. Almost none of the households reported an increase in fertilizer expenditure.

Table 14: Effect of biodigesters on expenditure on chemical fertiliser

BUS year	Expenditure decreased	Expenditure stayed the same	Expenditure increased
2016	79%	20%	1%
2018	89%-94%	10%-6%	1%-0%
2019	99%	1%	0%
2020	95%	5%	0%
2021	89%	11%	0%

3.6 Bio-slurry training received by households

Only a minority of the households (13-35%) received training on storage/processing and application of bio-slurry. No information was gathered on which household members (female/male) were trained. The trainings were conducted by organisations or companies including KBP/ABPL (0-63%), masons or technicians (9-72%), others (17-39%) and family or friends (0-3%), see Table 15. Workshop participants remarked that likely more training has been provided, as the survey respondents may be different from the household members being trained.

Table 15: Training received by households on bio-slurry management and application

BUS year	No training received	Training received	#KBP	#by masons	#others	#by family or friends
2016	87%	13%	0%	61%	39%	0%
2018	70%-69%	30%-31%	7%-6%	62%-72%	31%-22%	0%-0%
2019	78%	22%	28%	52%	17%	3%
2020	65%	35%	63%	9%	28%	0%
2021	69%	31%	53%	27%	20%	0%

Note: BUS 2018 included the contractors under 'masons'

As per the ABPL database, more than 10,000 bio-slurry use and management trainings have taken place since 2016, with 46% of the trainees being female. Some of the trainees did receive this training more than once.

3.7 Recommending biodigesters to others

Almost all households with a functioning biodigester said they would recommend the technology to other people. The Net Promoter Score (NPS) ranged between 96% and 99%. Reasons mentioned relate to biogas: It saves fuel/is cheap (35-61% of all reasons); it saves time for cooking (27-41%; is a clean fuel (12%); and is a safe fuel (5-12%). The biodigester as a source of organic fertiliser/bio-slurry is mentioned by a minority of the households only (3-11%), see Table 16.

Table 16: Reasons why households would recommend biodigesters to others

BUS year	Saving fuel costs (%)	Convenient/easy/ fast/time saving (%)	Clean cooking fuel (%)	Bio-slurry (%)	Safe cooking fuel (%)	Other reasons (%)
2019	42%	41%	NA	4%	12%	1%
2020	61%	27%	NA	3%	NA	9%
2021	35%	29%	12%	11%	5%	8%

The ABC functionality assessment (Climate & Energy Advisory, undated) found that households with a digester would 'likely' to 'very likely' recommend biodigesters to others, as cooking with

biogas is effective and efficient (64%); biogas is a cheap cooking fuel (18%); and bio-slurry increases agricultural yield (18%).

Invited to reflect on the difference between the high share of households claiming an increased crop quality and reduced expenditures on chemical fertiliser at one hand and the low share of households recommending bio-slurry as a source of fertiliser, the workshop participants stated that the perception among farmers about bio-slurry & BEC is low, despite the benefits, as their application requires more efforts compared to chemical fertiliser.

The non-biogas households interviewed in the baseline survey (Eco-Frontier Kenya, 2022a) believed that bio-digesters could save the cost of fuel (72%), offer a faster way of cooking (67%), provide a clean fuel (59%), include environmental benefits (32%) and/or produce a good fertiliser source (24%).

3.8 Gender

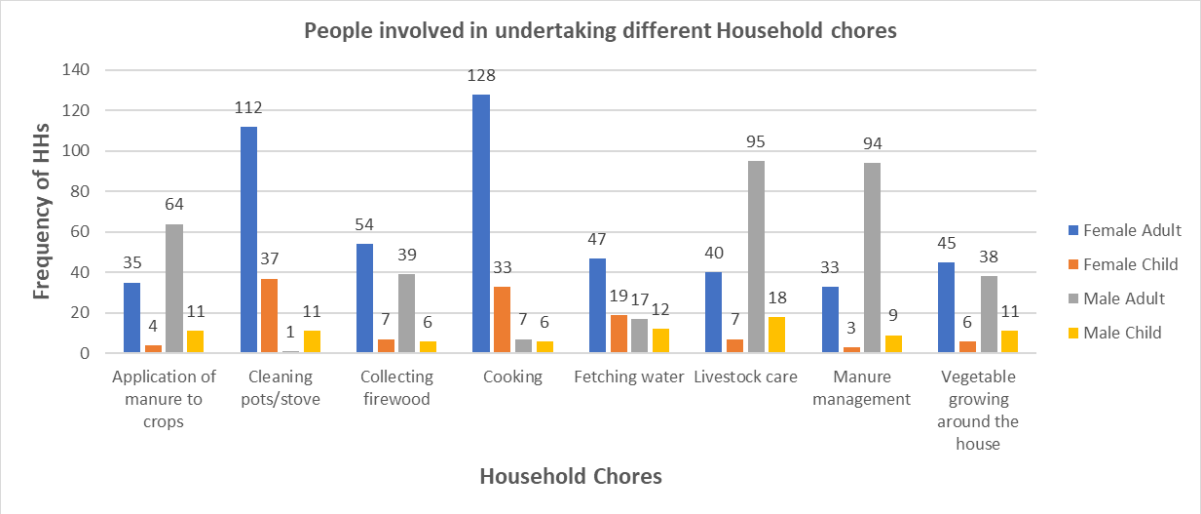
As per the ABPL data base, 60% of the digesters are owned by men; 39% by women; and 1% by institutions. The BUS reports did not provide gender data specifically related to the storage/processing, transport and application of bio-slurry, but rather on the effect of the installation of the biodigester in general on the time availability of women and men, see Table 17. Both female (93-99%) and male (94-100%) household members reported time savings. The saved time was mainly used for income generation/farming activities, social activities and recreation/leisure.

Table 17: Gender effects on the installation of the biodigester by households

BUS year	General gender findings
2016	-Reduced workload of feeding digester compared to collecting firewood reported by 95% of the households
2018	-More time available reported by 97-99% of the households -Saved time mostly spent on farming activities (40%), cattle feeding (23%) and household's chores (23%)
2019	-More time available reported by female (94%) & male (98%) household members -Saved time mostly spent on income generation (39% & 36%), social activities (14% & 14%) and farming/animal keeping (16% & 11%)
2020	-More time available reported by female (93%) & male (94%) household members -Saved time mostly spent on income generation (74% & 55%) and social activities (12% & 13%)
2021	-After the installation of the biodigester, 98% of the households experience reduced workload -Women and men do have more time for other activities like income generation

The baseline survey (Eco-Frontier Kenya, 2022a) found that female members of the household without biodigesters are mainly involved in cooking activities (98.5% of the households), cleaning pots (86%), collecting firewood (42%), fetching water (36%), and growing vegetables or farming around the house (35%). But they also participate in a minor way in applying manure to crops, livestock care, and manure management. Male adults are mainly responsible for the application of manure to crops (49% of households), livestock care (73%), and manure management (72%), but they also support fuel collection in 30%; vegetable farming around the house in 29%; and fetching water in 13% of households. Female children are mainly responsible for cleaning pots (28%), cooking (25%), and fetching water (14%), but also assist in the application of manure, collecting firewood, livestock care, and growing vegetables. Male children are mostly responsible for livestock care (14%), and vegetable growing (8%), but also help in cleaning pots and collecting firewood as pictured in Figure 5.

Figure 5: Distribution of household chores for different household members in households without bio-digesters (Eco-Frontier Kenya, 2022a)



On average adult males of households without biodigesters spend 2.28 hours on manure management, 3.19 hours on livestock care, and 3.76 hours on manure application to crops, and 3.62 hours on vegetable growing per day. Cooking and cleaning pots were minor tasks for adult males. Women on the other hand were mainly responsible for cooking and cleaning pots, fetching water, collecting firewood, and growing vegetables. On the latter, they spend 2.65 hours per day. Compared to men, less time is allocated to manure management (1.36 hours), livestock care (2.61 hours) and manure application to crops (3.03 hours).

Both male and female members of the households without biodigesters equally preferred biogas because it saves the cost of fuel (71% females and 72% males), coupled with the fact that it burns clean (58%-females, 60% males). However, more male members preferred biogas for being environmentally friendly (42%) and a fertilizer source (33%) compared to women with 22% and 15% respectively. Also, more men compared to women did prefer biogas because it cooks faster.

Surprisingly, the ABC functionality assessment (Climate & Energy Advisory, undated) found that time availability for other activities has reduced for 72% of the households after the installation of the biodigester; 28% of them reported no change.

Divided in six groups, the workshop participants were invited to provide an answer to the question who in the Kenyan biodigester household is taking care of storage/processing, transport and on-field application of bio-slurry and BEC. These groups arrived at big differences in scoring (see Annex 8, which may be explained by the very different background of the participants. After consultation with ABPL, it was decided to conduct this exercise among their field officers as they are very close to the practice. A total of 19 ABPL field officers participated in the exercise, see Table 18 for the averaged figures.

Table 18: Actors in biodigester households taking care of storage/processing, transport and application of bio-slurry and BEC as estimated by ABPL field officers

Activity/ Actor	Female Adults	Female Children	Female Workers	Male Adults	Male Children	Male Workers
Storage/ processing	19%	2%	11%	32%	4%	32%
Transport (to field)	18%	2%	10%	22%	4%	38%
Application (on field)	20%	2%	14%	26%	5%	33%

Note: Percentages were provided for each of the listed actors, totalling to 100% for each activity, with the average scores of the field officers presented for each box

The average figures by actor are quite similar: male workers are the main actors for all three activities, followed by male adults, female adults and female workers. The participation of children in all activities is limited. It appears that the three activities are somehow linked as the actor who stores/processes may also be the one who transports and applies.

3.9 Barriers for improved usage of bio-slurry and BEC

The BUS reports do mention only one barrier for improved usage of bio-slurry and BEC by households, being the lack of training of households. The report on a national bio-slurry extension conference in 2017 is providing a broad overview of general constraints (Kenya Biogas Program, 2017). To compose a more comprehensive overview, all workshop participants were individually requested to write down maximum five main barriers faced by the households. A total of 79 barriers were submitted as classified by OFVI, see Table 19.

Table 19: Barriers for improved usage of bio-slurry and BEC

Type of barrier	Barrier
Storage	-No space for storage (2x) -Lack of knowledge/technical know-how (2x) -Lack of compost pits -Lack of knowledge on storage time and management to maintain quality -Lack of collection vessels -Volatility of the minerals (N)
Processing	-Lack of knowledge/technical know-how (3x) -Lack of machines/mechanisation (2x) -Difficulty in handling bio-slurry -Lack of right tools to handle bio-slurry and BEC -Lack of easier means -Lack of information on the nutrient values -Lack of access to finance
Transport	-Lack of appropriate/easy means (2x) -High costs as the product is bulky (2x) -Bulkiness (2x) -Need to have containers -Lack of technologies -Lack of information on the best equipment -Difficulty on packaging and movement
Application	-Lack of knowledge on application rates and times (5x) -Lack of knowledge/technical know-how (2x) -Lack of clarity on 'how, when, how much and where' -Lack of information on crop application -Limited training -Labour intensive -Handling of bio-slurry is messy -Lack of certainty that bio-slurry/BEC will work on the crops
Trade	-Limited demand compared to inorganic fertiliser/limited demand (2x) -Difficulty in packaging (2x) -Lack of customers -Lack of marketing -Lack of information on nutrient composition

Type of barrier	Barrier
	-Bulkiness -Lack of standardisation -Lack of branding/value addition -Limited know-how
General	-Lack of knowledge on the benefits/advantages of bio-slurry and BEC (3x) -Bulkiness of the product (3x) -Insufficient/lack of training (2x) -Labour-intensive work (2x) -Identification and classification of various feedstocks resulting in different quantities and qualities of bio-slurry -Lack of knowledge on importance of biodigesters -Lack of knowledge among farmers on the composition/quality of the bio-slurry based on the feedstock to the digester and how to apply it -Lack of perception on home-grown organic fertilisers including compost -Wrong perception -Lack of information to create confidence among farmers (how, when, what) -Lack of awareness of decomposition processes -High maintenance and labour needs -Lack of clarity on the product value -Lack of promotion, also because inorganic fertiliser is the social norm -Lack of quality on inherent nutrients -Lack of packaging -Sticking to habitual practices -Lack of regulatory standards governing sale, storage, transport and application of bio-slurry -Lack of differentiation of bio-slurry for market niches, e.g., hydro-phonics, soil remediation, soil fertility and weed control -Lack of capacity building -Lack of sensitisation of the farming community

The barriers to the use of bio-slurry and/or BEC by households are manifold, but looking at those being mentioned most often, the following may need the attention of OFVI in the implementation phase:
-storage: limited space.
-processing: lack of tools & equipment.
-transport: lack of tools & equipment and high cost.
-application: lack of knowledge, in particular on application rates.
-trading: limited demand and difficulty in packaging.
-storage/processing, transport and application in general: lack of knowledge and labour-intensive.

4 Conclusions

The main conclusions on the baseline usage of bio-slurry and BEC by biodigester households in Kenya are the following:

Installation and functionality rate of biodigesters:
From 2009 up to 2021, over 26,000 biodigesters have been installed in Kenya. The functionality rate of these digesters is estimated to be 79-88%. This rate means that about 22,000 households with a biodigester in Kenya produce bio-slurry on a regular (daily) basis. Digesters with a capacity of 8 m3 are in the majority.

Feeding of the biodigesters:
Most biodigesters are fed with manure from dairy and other cattle; some with swine manure. Households do not feed all manure to the digester, mainly because they avail more manure than the digester requires to produce gas for cooking. Other reasons included inability to collect all dung (e.g., when animals are free ranging) and alternative use of manure. Most households feed their

digester every day (54-66%) but feeding about 3 times per week is also widely practiced (34-46%). Toilet attachment is estimated to be maximum 5%.

Storage and processing of bio-slurry produced by biodigesters:
Most households (between 41 and 79%) use bio-slurry directly (on a daily basis) on crops. Between 17-57% of the households first store the bio-slurry. Households first storing bio-slurry said that they mainly kept the slurry in an uncovered lagoon (7-20%), in liquid form (30-43%), solid form (5-18%), sun-dried (24-27%) or composted it (8-12%), with (1-9%) or without (4-11%) roof. They often practiced different storage methods at the same time. An estimated 20% of the households are keeping double compost pits.

Transport of bio-slurry and/or BEC:
Bio-slurry is mainly transported through pipes, channels and with cans, and tanks. BEC is transported by wheelbarrows, bags, containers and pick-ups.

Application of bio-slurry and/or BEC:
The majority of the households reported that bio-slurry was mainly applied as fertiliser (94-98%), while others reported use as animal feed (0-1%) or insecticide/pesticide (0-1%). Trading of bio-slurry or BEC was hardly practiced, assumingly 3%. Most households (41-68%) directly applied the liquid slurry while others first collected it in a tank and applied it progressively on crops (7-31%). Other modes included drying (14-34%) and composting (1-7%). Households often combined different application modes.

Crops:
Bio-slurry and/or BEC is mainly applied to the following crops: maize (10-28%), Napier grass (8-18%), vegetables (21-31%), bananas (12-17%), coffee (5-15%) and tea (2-21%). OFVI may consider fruit trees and Irish potatoes as potential crops in near future. Households predominantly noted that the quality of their crops has improved (97-100%) while 1-3% said that the crop quality remained the same.

Other fertilisers:
Prior to the installation of biodigesters, 63 to 89% of the households were using other types of fertilizers while 11-37% applied no fertilizers at all. The main types of fertilizers used by then were chemical fertilisers (53-62%), farm-yard manure (25-34%) and compost manure (9-15%). After the installation of the biodigester, 67% of the households were still using other types of fertilizers because bio-slurry was insufficient to achieve higher yields and/or to meet different plant needs. The other fertilizers used were chemical fertiliser (64%) and organic fertiliser (36%). Expenditure on chemical fertilizers for households who continued to use them after the installation of the biodigester reduced for most households (79-99%), while this expenditure remained the same for 1-20% of the households.

Bio-slurry training:
A minority of the households (13-35%) received training on slurry handling and application. No information was gathered on which household members (female/male) were trained. The trainings were conducted by organisations or companies including KBP/ABPL (0-63%), masons or technicians (9-72%), others (17-39%) and family or friends (0-3%). Likely more training has been provided, as the surveyed respondents may be different from the household members being trained. ABPL reports that over 10,000 bio-slurry usage and management trainings have been provided since 2016, with 46% of the trainees being female.

Appreciation of bio-slurry:
Almost all household with a functioning biodigester would recommend the technology to others. Bio-slurry as a source of fertiliser is however recommended by 3-11% of these households only. Possible explanation for this discrepancy may be that households carry a low perception about bio-slurry & BEC, despite the benefits, as their application requires more efforts compared to chemical fertiliser.

Gender:
In Kenya, 60% of the biodigesters are owned by men; 39% by women; and 1% by institutions. After the installation of the biodigester, both female (93-99%) and male (94-100%) household members reported time savings. The saved time was mainly spent on income generation activities, social activities and recreation/leisure. Male workers are identified as the main actors for storage/processing, transport and on-field application, followed by male adults, female adults and female workers. The participation of children in all bio-slurry and BEC related activities is limited. It appears that the three distinguished activities are somehow linked, as the actor who stores/processes may also be the one who transports and applies.

Main barriers for improved usage of bio-slurry and BEC:
The barriers to the (improved) use of bio-slurry and/or BEC by households are manifold, but the following may need the attention of OFVI in the implementation phase:
-storage: limited space.
-processing: lack of tools & equipment.
-transport: lack of tools & equipment and high cost.
-application: lack of knowledge, in particular on application rates.
-trading: limited demand and difficulty in packaging.
-storage/processing, transport and application in general: lack of knowledge and labour-intensive.

5 Baseline data of ABC/OFVI result indicators

Based on the findings of this inception activity 2, the following baseline data can be presumed for related OFVI result indicators in Kenya, see Table 20.

Table 20: Baseline data for OFVI in Kenya

ABC/OFVI result indicator	Baseline	Notes
% of households applying bio-slurry and/or BEC	90%	Note 1: Though almost all households apply bio-slurry and/or BEC, there is room for improvements Note 2: The IVA will verify data submitted by biodigester enterprises at second verification (use of bio-slurry (yes/no/unclear); amount of bio-slurry produced; amount of BEC produced; and trading of bio-slurry (yes/no/unclear)
% of households with double compost pit installed	20%	Note 1: It will be important to distinguish bio-slurry pits from compost pits in the case of Uganda, as bio-slurry is often applied in liquid form Note 2: The IVA will verify data submitted by biodigester enterprises at first verification (number of bio-slurry pits; number of double compost pits). It would be good to have this last number verified at second verification as well
Tons of (excess) bio-slurry and/or BEC traded	TBD	Note 1: Bio-slurry and/or BEC is traded by 1-5% of the households, but the amount is not documented. An estimate could be made assuming the most popular size of the digesters (8 m3) and stipulated feeding rate. Alternatively, the share of households (%) trading bio-slurry and/or BEC could be considered as an alternative result indicator Note 2: The IVA will verify data submitted by biodigester enterprises at second verification (use of bio-slurry (yes/no/unclear); amount of bio-slurry produced; amount of BEC produced; and trading of bio-slurry (yes/no/unclear)

Annex 1 References

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Annex 2 BUS 2016 questionnaire (questions 6 and 8)

QUESTION 6 | *Parameter 'Bio'*

i. What do you do with the slurry from your biogas plant?	***(Circle all those that apply)*** a) Nothing b) Use it directly as fertilizer c) Make compost as fertilizer d) Use in fish pond e) Give away for free as fertilizer f) Sell as fertilizer g) Other (*specify*)……

ii. If you use Bio-slurry for fertiliser (if you select B) what type of crop do you apply it to?

iii. If you use Bio-slurry for fertiliser (if you select B) how long have you applied it

iv. How do you apply the Bio-slurry as fertiliser on your crops?

	Yes No
v. Have you received any training on the management and use of bio-slurry?	

If v is No, skip to question 7.
vi. If yes, who trained you?

QUESTION 8| *GS-03 Soil Condition*

	Yes No
i. Were you using any other type of fertilizer before bio-slurry?	
ii. If you apply slurry as fertilizer, how do you feel the quality of your crops has changed since you started applying slurry?	a) I don't apply slurry as fertilizer b) Crops have improved c) Crops have stayed the same d) Crops have worsened

Annex 3 BUS 2018 questionnaire (questions 6 and 8)

QUESTION 6 | *Parameter 'Bio'*
iii. What do you do with the slurry from your biogas plant?
***(Circle all those that apply*)**
a) **Uncovered lagoon** (*Slurry is collected into a specific storage lagoon, which is large enough and deep enough to hold manure for a period of 1 year or longer. Although the tank is not covered, the slurry inside is hardly mixed.)*
b) **Liquid slurry** *(as above, but for periods less than one year).*
c) **Daily spread** *(slurry is applied to cropland as fertiliser)*
d) **Other** (please specify) .....

iv. If you use Bio-slurry for fertiliser (if you select C) what type of crop do you apply it to?
Crop type bio-slurry is applied to……

v. If you use Bio-slurry for fertiliser (if you select C) how long have you applied it (months)?
Number of months……

vi. How do you apply the Bio-slurry as fertiliser on your crops?
***(Circle all those that apply*)**
e) Dried then applied to crops
f) Composting first then applied to crops
g) Applied directly in liquid form to crops
h) Collected in slurry tank then applied progressively
i) Other (specify).....

vii. Have you received any training on the management and use of bio slurry?
Yes No

viii. If yes, who trained you? *Person who trained respondent……*

QUESTION 8| *GS-03 Soil Condition*
i. Were you using any other type of fertilizer before bio-slurry?
Yes No

ii. If Yes, what kind of fertilizer were you using before bio-slurry? (***tick all that apply***)
d) Chemical fertilizer
e) Compost manure
f) Farm yard manure
g) Other Bio-slurry
h) Other fertilizer

iii. If you apply slurry as fertilizer, how do you feel the quality of your crops has changed since you started applying slurry?
d) I don't apply slurry as fertilizer
e) Crops have improved
f) Crops have stayed the same
g) Crops have worsened

Annex 4 BUS 2019 questionnaire (questions 4, 5, 6 and 8)

QUESTION 4 | Number of animals NT

How many of the following animals do you own?	*Dairy cattle ……*
	Other cattle ……
	Market swine (Pigs) (for market) ……
	Breeding swine (Sows and boars) (for breeding) ……
	Poultry ……
	Sheep ……
	Goats ……
	Other (specify) ……..

QUESTION 5 | Parameters MST,S,k / MSP,S,k

What fraction of different animal's manure would you estimate is:

Fed into the bio digester? (%) **Not fed into the bio digester? (%)** **Reason if 100% not fed**

Dairy cows / Other cattle / Market swine (pigs) / Breeding swine (pigs) / Poultry / Sheep / Goats / Other animals (if specified in Q4 above)

QUESTION 6 | Parameter 'Bio'

What do you do with the slurry from your biogas plant and what percentage is involved? *(select all that apply)*	Used as fertilizer (Daily Spread)……%
	Used as an insecticide/pesticide……%
	Bioslurry is stored……..%
	Bioslurry is sold……..%
	Discarded……..%
	Other……%
If Bioslurry is stored, how do you store bio slurry and what percentage do you store? *(select all that apply)*	Uncovered lagoon (black watery mass.)…….%
	Liquid slurry (brown porridge type)……%
	Solid storage……..%
	Sun drying……%
	Composting with roof……..%
	Composting without roof……..%
If you use Bio-slurry for fertiliser ***(if you select a*** in ***6(a)*** above) what type of crop(s) do you **mainly** apply it to?	Crop type bio-slurry is applied to ……
If you use Bio-slurry for fertiliser ***(if you select a*** in ***6(a)*** above***)***, how long have you applied it (months).	Number of months……
How do you apply the Bio-slurry as fertiliser on your crops? ***(Circle all those that apply*)**	Dried then applied to crops
	Composting first then applied to crops
	Applied directly in liquid or solid form to crops
	Collected in slurry tank then applied progressively
	Other (specify)……
Have you received any training on the management and use of bio slurry?	Yes
	No
If yes, who trained you?	*Person/company/entity who trained respondent……*

QUESTION 8| *GS-03 Soil Condition*

Were you using any other type of fertilizer before bio-slurry?	*Yes*
	No
If Yes, what kind of fertilizer were you using before bio-slurry? (tick all that apply)	Chemical fertilizer
	Compost manure
	Farm yard manure
	Other Bio-slurry
	Other fertilizer
If you use bio slurry as fertilizer, how do you feel the quality of your crops has changed since you started applying slurry?	Crops have improved
	Crops have stayed the same
	Crops have worsened

Annex 5 BUS 2020 questionnaire (questions 4, 5, 6 and 8)

<table>
<tr><td colspan="4">QUESTION 4| Number of animals NT</td></tr>
<tr><td colspan="2">How many of the following animals do you own?</td><td colspan="2">1. Dairy cattle ……
2. Other cattle ……
3. Market swine (Pigs) (for market) ……
4. Breeding swine (Sows and boars) (for breeding) ……
5. Poultry ……
6. Sheep ……
7. Goats ……
8. Other (specify) ……..</td></tr>
<tr><td colspan="4">QUESTION 5 | Parameters MST,S,k / MSP,S,k</td></tr>
<tr><td colspan="4">What fraction of different animal's manure would you estimate is: (Fill for each animal type that is reported owned in 4(a). The total of manure fed and manure not fed must be equal to 100%)</td></tr>
<tr><td>Fed into the bio digester? (%)</td><td colspan="2">Not fed into the bio digester? (%)</td><td>Reason if 100% not fed</td></tr>
<tr><td colspan="4">Dairy cows / Other cattle / Market swine (pigs) / Breeding swine (pigs) / Poultry / Sheep / Goats / Other animals (if specified in Q4 above)</td></tr>
<tr><td colspan="4">QUESTION 6 | Parameter ‘Bio’</td></tr>
<tr><td colspan="2">a. What do you do with the slurry from your biogas plant and what percentage is involved? (select all that apply) (Total should equal 100 %)</td><td colspan="2">a. Use directly for various purposes ……%
b. Store it first……%
c. I don’t use it / discarded……%
d. Other (specify)_____ ……%</td></tr>
<tr><td colspan="2">b. If you use bio slurry directly for various purposes, what do you do with it and what percentage is involved?</td><td colspan="2">a. Used as fertilizer……%
b. Used as an insecticide/pesticide……%
c. Used as animal feed……%
d. Bio slurry is sold……%
e. Other (Specify)……%</td></tr>
<tr><td colspan="2">c. If Bio slurry is stored, how do you store bio slurry and what percentage do you store? (select all that apply) (Total should equal 100 %)</td><td colspan="2">a. Uncovered lagoon (black watery mass.) ……%
b. Liquid slurry (brown porridge type) ……%
c. Solid storage……%
d. Sun drying……%
e. Composting with roof……%
f. Composting without roof……%</td></tr>
<tr><td colspan="2">d. How do you apply the Bio-slurry as fertiliser on your crops? (Circle all those that apply)</td><td colspan="2">a. Dried then applied to crops
b. Composting first then applied to crops
c. Daily applied directly in liquid form to crops
d. Collected in slurry tank then applied progressively
e. Other (specify)……</td></tr>
<tr><td colspan="2">e. To which crops do you apply bio slurry</td><td colspan="2">Crop type bio-slurry is applied to……</td></tr>
<tr><td colspan="2">f. If you use Bio-slurry for fertiliser , how long have you applied it (months).</td><td colspan="2">Number of months……</td></tr>
<tr><td colspan="2">g. Have you received any training on the management and use of bio slurry?</td><td colspan="2">1. Yes
2. No</td></tr>
<tr><td colspan="2">h. If yes, who trained you?</td><td colspan="2">Person/company/entity who trained respondent……</td></tr>
<tr><td colspan="4">QUESTION 8| GS-03 Soil Condition</td></tr>
<tr><td colspan="2">a. Were you using any other type of fertilizer before bio-slurry?</td><td colspan="2">1. Yes
2. No</td></tr>
<tr><td colspan="2">b. If Yes, what kind of fertilizer were you using before bio-slurry? (tick all that apply)</td><td colspan="2">1. Chemical fertilizer
2. Compost manure
3. Farm yard manure
4. Other Bio-slurry
5. Other fertilizer</td></tr>
<tr><td colspan="2">c. If you use bio slurry as fertilizer, how do you feel the quality of your crops has changed since you started applying slurry?</td><td colspan="2">1. Crops have improved
2. Crops have stayed the same
3. Crops have worsened</td></tr>
</table>

Annex 6 Baseline 2021 questionnaire (questions 48-57)

D. Animal Waste Handling

Note that the livestock categories and methods of manure handling must be phrased exactly as below. The enumerator/surveyor should possess sufficient knowledge of the different animal types and manure handling techniques to identify the manure handling technique, if the householddemonstrates their typical activities, but is perhaps not able to name the activity.

48. How many animals of different types do you own and how much manure is produced per day?		
Animal Type	**Number owned on average**	**Amount of dung(KG/day)**
Dairy cows		
Other cattle		
Market swine (pigs)		
Breeding swine (pigs)		
Poultry		
Other (*specify*)		

49. When do the rainy months occur?		
50. For how long does WET/RAINY season last? *(Number of days/month)*		
51. Under what conditions are you keeping your animals during the DRY season?		
Type of animal	Conditions under which they are kept	*Number of hours per day (total is by definition 24h)*
Dairy cows	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Other cattle	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Market swine (pigs)	1= Walk freely in field	*1=.....hrs/day*

	2 = Confined/stabled	*2= .....hrs/day*
Breeding swine (pigs)	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Poultry	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Other (specify)	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*

52. Under what conditions are you keeping your animals during the WET season?		
Type of animal	Conditions under which they are kept	*Number of hours per day (total is by definition 24h)*
Dairy cows	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Other cattle	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Market swine (pigs)	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Breeding swine (pigs)	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Poultry	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*
Other (specify)	1= Walk freely in field 2 = Confined/stabled	*1=.....hrs/day* *2= .....hrs/day*

53. When the animals walk freely in the field, what do you do with the manure of the animals that is left in the field?		
	Dry Season	**Wet Season**
Leave it there	.....%	.....%
Collect it	.....%	.....%

54. If a share in 53 is collected, what do you do with the collected manure during DRY season? *(total adds up to 100% of manure deposited in the field)*

	Uncovered Lagoon	Liquid/ slurry	Solid storage	Dry lot	Daily Spread	Burned for fuel	Composting	Other(specify)	Total
Dairy cows	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other cattle	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Market swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Breeding swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Sheep	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Goats	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Poultry	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other (*specify*)	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%

55. If a share in 53 is collected, what do you do with the collected manure during WET season ?*(total adds up to 100% of manure deposited in the field)*

	Uncovered Lagoon	Liquid/ slurry	Solid storage	Dry lot	Daily Spread	Burned for fuel	Composting	Other(specify)	Total

Dairy cows	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other cattle	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Market swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Breeding swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Sheep	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Goats	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Poultry	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other (*specify*)	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%

56. For manure from stabled/confined areas, specify the fraction of animal x´s manure handled in this way during DRY season

	Uncovered Lagoon	Liquid/ slurry	Solid storage	Dry lot	Daily Spread	Burned for fuel	Composting	Other(specify)	Total
Dairy cows	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other cattle	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Market swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Breeding swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Sheep	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Goats	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Poultry	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other (*specify*)	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%

57. For manure from stabled/confined areas, specify the fraction of animal x´s manure handled in this way during WET season

	Uncovered Lagoon	Liquid/ slurry	Solid storage	Dry lot	Daily Spread	Burned for fuel	Composting	Other	Total
Dairy cows	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other cattle	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Market swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Breeding swine	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Sheep	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Goats	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Poultry	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%
Other (*specify*)	....%	....%	....%	....%	....%	....%	....%	....%	Check if 100%

Below an explanation of the different methods of manure handling:

Uncovered anaerobic lagoon*: A type of liquid storage system designed and operated to combine waste stabilization and storage. Manure is collected into a specific storage lagoon, which is large and deep enough to hold manure for a period of at least 1 year. Although the tank is not covered, the manure inside is hardly mixed. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields. (black watery system)*

Liquid/slurry: *Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year. (Looks like brown porridge)*

Solid storage: *The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.*

Dry lot*: A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.*

Pasture/Range/Paddock: *The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.*

Daily spread: *Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.*

Burned for fuel: *The dung and urine are excreted on the fields. The sun-dried dung cakes are burned for fuel.*

Composting: *composting in piles, an enclosed channel or windrows with either daily or no mixing.*

Annex 7 Functionality assessment questionnaire (questions 11, 16, 38-42, 45)

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)

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

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)

45. During feeding, what volume (in m3) is usually added into the digester? (Wakati wakulisha, nikiasigani (katika m3) kinaongezwa kwenye digester?)

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?

Annex 8 Actors in the Kenyan biodigester household taking care of storage, processing, transport and application of bio-slurry and/or BEC

Percentages (%) put in for each of the six groups with workshop participants, totalling to 100% for each row. Average of all six groups for each activity is provided in **bold**.

Activity/ Actor	Female Adults	Female Children	Male Adults	Male Children	Workers
Storage/ processing	**28%** (30,40,0,40,50,10)	**4%** (10,5,0,1,5,5)	**17%** (20,10,5,40,10,15)	**8%** (10,5,0,4,5,25)	**41%** (30,30,95,15,30,45)
Transport (to field)	**18%** (0,20,40,0,40,10)	**2%** (0,5,1,0,0,5)	**32%** (0,40,40,50,20,30)	**6%** (20,5,4,0,0,5)	**43%** (70,30,15,50,40,50)
Application (on field)	**32%** (40,50,5,50,10,35)	**5%** (5,0,0,1,5,18)	**15%** (10,10,5,30,30,2)	**4%** (5,0,0,4,5,10)	**45%** (40,40,90,15,50,35)

Conclusions/way forward:
-Big differences in scoring, which may be explained by the very different background of the participants in the groups.
-Mostly workers take care of all activities. It would have been better to also distinguish between female and male workers.
-Female adults spend more time on storage/processing and on-field application compared to male adults, but the latter are more engaged in transport.
-Participation of children in all activities is limited.
-On the way forward, it was agreed with ABPL to redo this exercise (with workers divided between female and male) among their field officers as they are very close to the practices of the biodigester households.