# Influence of feedstocks on bio-slurry quality in Kenya - (Inc7)

## African Biodigester Component

### Organic Fertiliser Valorisation Implementer

SEE – Clean Cooking

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# Acronyms

| | |
|---|---|
| ABC | African Biodigester Component |
| ABPL | Africa Bioenergy Programs Limited |
| BEC | Bio-slurry Enriched Compost |
| BSUL | Biogas Solutions Uganda Limited |
| NP | National Partner |
| OFVI | Organic Fertiliser Valorisation Implementer |
| OM | Organic Matter |
| PNB-BF | Programme National de Biodigesteurs - Burkina Faso |
| SNV | SNV Netherlands Development Organisation |

# Terminology

The consortium adopts the following organic fertiliser terminology.

- **Bio-slurry** is the product from bio-digesters, generated through anaerobic digestion of organic materials (often animal manure)
- **Compost** consists of composted biomass, this may or may not include bio-slurry. Under ABC, only Bio-slurry Enriched Compost (BEC) will be considered
- **Bio-slurry Enriched Compost** (BEC) is compost that has been generated using (amongst other inputs) bio-slurry
- **Organic fertiliser** is any bio-based fertiliser which may include both bio-slurry and compost, but also other organic fertilisers such as biochar and bokashi.
- **Other biomass** used in agriculture such as mulching with woodchips, straw etc is not included here as organic fertiliser, this is only indirect organic fertiliser once decay of this biomass starts.
- **End user**: person applying the bio-slurry and/or compost (BEC) on his or her own land

# Definitions

The following definitions will be used in the report.

**Volatile solids (VS)** represent that portion of the organic-material solids that can be digested, while the remainder of the solids is fixed.

**Organic loading rate (OLR)** is defined as the amount of organic waste fed to the biodigester per unit volume of the digester. It is an important parameter for management of biodigester, and used to evaluate the feed intensity. OLR is expressed as kg of Volatile Solids fed per cubic meter per day (kg VS / $m^3$ / day).

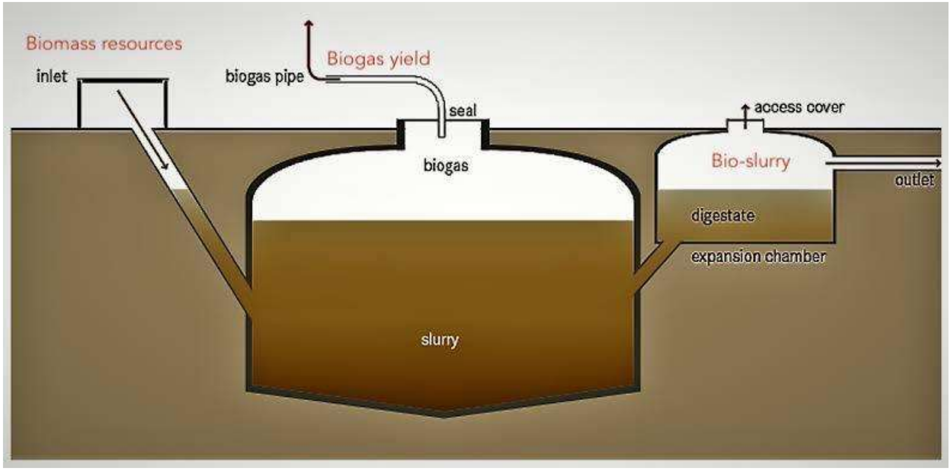
**The carbon to nitrogen (C/N) ratio** is significant in composting because microorganisms need a good balance of carbon and nitrogen (ranging from 25 to 35) in order to remain active. High C/N ratios can lead to prolonged composting duration and low C/N ratios enhance nitrogen loss.

**Hydraulic retention time (HRT)** is defined as the average time interval over which the substrate is kept inside the digester. It indicates the period of time at which the productivity could start to decline, while the organic fermentable substrate remains in the anaerobic digester.

# 1. Introduction

The newest energy crisis is adding to the need to transform fossil energy systems into more sustainable alternatives in Kenya as well as elsewhere, where poor energy infrastructure and limited funding opportunities restrict investments in solar and wind energy. Anaerobic Digestion (AD) is a mature and established technology which can be used to generate biogas and methane for cooking, light and heating also in remote areas lacking an electricity grid or gas infrastructure. Current efforts to promoted the development of AD is focussing on small (3 to 8 cubic metre) household units almost exclusively fed with cattle or pig manure. Upscaling AD implementation and biogas production will require adoption of medium-scale (20 to 100 cubic metre) AD units, fed with a range of feedstocks including household waste and organic residues from food industries.
This report of Inc7 focuses on Kenya, where implementation and use of medium-scale units is currently taking off and where infrastructure for their implementation is relatively well developed. An inventory was done of the most common biomass resources available in the country, to feed the medium scale biodigesters. Based on this inventory multiple scenarios were worked out to achieve well-balanced feeding regimes for the biodigesters so that optimal biogas production and bio-slurry quality is assured.

Biodigesters can be fed with a range of biomass resources. The digesters essentially convert this biomass resources into biogas and bio-slurry (figure 1). This happens though a process called anaerobic digestion (oxygen-free environment), where the bacteria in the digester feed on the biomass resources. Biomass resources are defined as biological materials that get broken down by living organisms, such as bacteria's. There are three categories of biological materials: primary, secondary, and tertiary resources.




Primary resources are residues that have been taken directly from the land or stables (table 1). They consist of residues from agricultural crops, forest residues (leaves, wood) and manure from animals. Secondary biomass sources come from the processing of primary resources by industry (table 1). They consist of food (fruit, vegetable) & beverage processing, wood processing (chips and sawdust), dairy or slaughterhouse waste. Finally, tertiary resources are post-consumer residue streams (table 1). These include used vegetable oils, animal fats and greases, and municipal solid waste.

*Table 1: Feedstock categories*

| Residue Category | Source | Feedstocks |
|---|---|---|
| Primary residues | Land, stable | Manure, field residues (straw, stems, leaves, etc.), harvest remains |
| Secondary residues | Food processing, industry | Residues from food and beverage processing, from dairy and sugar industry, slaughterhouse waste, food processing waste, |
| Tertiary residues | Households, markets | Municipal Solid Waste (MSW), food remains (kitchen and table waste), cooking oil |

The mixtures of biomass resources that are fed to the digesters have a big impact on the process performance (e.g. Ojolo et al., 2007; FNR, 2010; Weiland, 2010; Ngumah et al., 2013; Battista et al., 2016; Langeveld and Peterson, 2018). It's therefore important to maintain a well-balanced feeding regime of the biodigesters, to ensure sufficient residue amount of biomass resources with a balanced nutrient composition are met. If this requirement is not met, the micro-organisms in the biodigester risk to be over- or underfed which will disrupt the digestion process leading to decreasing biogas production and poor-quality bio-slurry.

The report is organized as follows. An introduction to the methodology is given in Chapter 2. Results are presented in Chapter 3, which is followed by a brief discussion section in which some conclusions are drawn (Chapter 4).

# 2. Methodology

## 2.1 Availability

Literature research has been conducted to inventorised Kenya's primary, secondary and tertiary biomass resources (Annex 1). Availability of primary residues is calculated by combining crop outputs with key data on field residues. Data are taken from statistics (FAOSTAT data on crop and food production) and literature.

Definitions of waste streams are presented in Annex 1.

## 2.2 Biogas potential

Potential methane production is calculated, using data on availability of major residue and waste streams in Kenya. For each stream, composition (dry matter, amount of Volatile Solids (VS)), and specific methane yield are calculated using public reference data. Total potential is calculated for the entire country.

## 2.3 Bio-slurry composition and feedstock mixtures

Data are collected on the composition of feedstocks, especially dry matter, nitrogen and potassium concentration. Data are used in the calculation of the bio-slurry composition. A limited number of feedstock mixtures is defined, consisting of combinations of waste streams that can be used as feedstock at larger scales. Calculations refer to a medium-scale digester of 100 $m^3$, daily fec with a volume of 4 $m^3$, giving a retention time (HRT) of 25 days. Water may be added to the mixtures if viscosity is too high (dry matter is kept below 15% of the mixture).

For each of the mixtures, methane yield and bio-slurry composition is calculated.

# 3. Results

## 3.1 Availability

Calculation of residue availability is presented in Annex 1. A total of 3.2 million tonnes of field crop residues are estimated to be generated each year. Most (1.9 million tonne) is maize stover, cobs and roots. Other important crops are plantain banana (0.7 million tonne), vegetables and sorghum. Annual manure production amounts to 300 million tonnes; two thirds of this (189 million tonne) is cattle manure. Assuming one quart of cattle manure and half of poultry manure can be collected for treatment in biodigesters, 80 million tonnes of manure is available for digestion. More than half of this is cattle manure. (for details, see Annex 1).

Availability of main secondary residue streams is calculated in the Annex; results are presented in Table A.3. Total availability is one million tonnes per year; more than half of this is sisal pulp. Food waste has been estimated at eight million tonnes (Table A.4). One quarter of this is waste from cereals (maize, rice, etc.). Other important sources are root crops (cassava, sweet potato), fruits and vegetables. Part of food waste is recovered as urban waste (Municipal Solid Waste, or MSW). Availability for Nairobi has been estimated at 1 million tonnes per year (GTZ, 2010).

An overview of the most important primary, secondary and tertiary residues is presented in Table 2. Fourteen waste streams have been selected, covering major field crop residues (maize, banana), manure, food industry waste (sisal, coffee, slaughterhouses, sugar cane) and household waste. There are major differences in composition. Dry matter contents varies between 2% for sisal pulp and 88-90% (sugar filter cake). In total, 112 million tonnes of residues are available. Over 30 million tonnes of this is of dry matter. Two thirds of this can be recovered from chicken manure. Other relevant streams include cattle manure, cereal food waste and maize stover.

*Table 2: Main organic residue streams in Kenya*

| Resource | Supply (million tons) | Dry matter (% of fresh) | Dry matter (million tons) |
|---|---|---|---|
| **Primary** | | | |
| Maize stover | 3,8 | 29 | 1,1 |
| Banana stems | 19 | 5 | 0,1 |
| Cattle manure | 47 | 8 | 3.8 |
| Chicken manure | 42 | 55 | 22.8 |
| Pig manure | 11 | 4 | 0,4 |
| **Secondary** | | | |
| Sisal pulp | 0,6 | 2 | 0,01 |
| Coffee pulp | 0,6 | 29 | 0,2 |
| Slaughterhouse waste | 0,06 | 21 | 0,01 |
| Sugar filter cake | 0,2 | 90 | 0,17 |
| **Tertiary** | | | |
| Fruit waste | 1.5 | 12 | 0,2 |
| Cereal food waste | 2.2 | 88 | 1,9 |
| Vegetables, oils | 1.4 | 29 | 0,4 |
| MSW (Nairobi) | 1,0 | 30 | 0,3 |

[1] = excluding beer

## 3.2 Biogas potential

Most common waste streams are high (over 80%) to very high in Volatile Solids. Main exceptions are banana stems and vegetables. Biogas potential of the feedstocks varies between 13 (banana) and 560 $m^3$ methane per ton of Volatile Solids (VS). The share of Volatile Solids in dry matter varies between 4% for banana stems to 97% for maize stover. Combining this information with dry matter contents gives VS contents ranging from 0.2% for banana to 91% for cereal food waste.

*Table 3: Biogas potential of selected biomass resources*

| Resource | Volatile Solids (VS) | | Methane yield | Methane yield | Methane yield |
|---|---|---|---|---|---|
| | (% of dry matter) | (% of fresh) | ($m^3$/tonne of VS) | ($m^3$/tonne fresh) | (million $m^3$/year) |
| **Primary** | | | | | |
| Maize stover | 97 | 90 | 288 | 260 | 982 |
| Banana stems | 4 | 0,2 | 13 | 0,03 | 0.05 |
| Cattle manure | 82 | 9 | 192 | 17 | 595 |
| Chicken manure | 75 | 19 | 277 | 52 | 2.184 |
| Pig manure | 86 | 20 | 355 | 66 | 781 |
| **Secondary** | | | | | |
| Sisal pulp | 82 | 10 | 330 | 33 | 20 |
| Coffee pulp | 91 | 50 | 244 | 122 | 67 |
| Slaughterhouse waste | 80 | 12 | 560 | 67 | 4 |
| Sugar filter cake | 97 | 24 | 262 | 64 | 12 |
| **Tertiary** | | | | | |
| Fruit waste | 80 | 51 | 516 | 264 | 403 |
| Cereal waste | 93 | 91 | 265 | 242 | 526 |
| Vegetables, oils | 78 | 10 | 425 | 43 | 59 |
| MSW (Nairobi) | 92 | 18 | 260 | 48 | 47 |
| Total | | | | | 5.708 |

# 3.3 Bio-slurry composition

The composition of major feedstocks is presented in Table 4. Nitrogen concentration varies between 0.3% (cattle manure) to 2.7% for slaughterhouse waste. Phosphorus concentration is low in MSW, but also for maize stover and fruit waste, while MSW, animal manure and cereal waste are low in potassium. Slaughterhouse waste and banana stems are high in potassium.

Total supply of macro nutrients (nitrogen, phosphorus and potassium) is calculated at 5.1 million tonnes, most of which is found in cattle manure. Secondary residual stream (derived from food industry) and tertiary streams (kitchen, restaurant and household waste) provide very small amounts of nutrients.

*Table 4: Nutrient contents of selected biomass resources*

| Resource | **Supply** (million tonne fresh) | **Nitrogen** (N, % of fresh) | **Phosphorus** (P, % of fresh) | **Potassium** (K, % of fresh) | **Total macro nutrients** (million tonnes) |
|---|---|---|---|---|---|
| **Primary** | | | | | |
| Cattle manure | 189 | 0.3 | 0.2 | 0.5 | 2.5 |
| Chicken manure | 83 | 2.0 | 0.3 | 0.5 | 1.1 |
| Pig manure | 11 | 0.5 | 0.8 | 0.5 | 0.3 |
| Maize stover | 3.8 | 0.4 | 0.1 | 2.8 | 0.1 |
| Banana stems | 19 | 1.5 | 0.2 | 3.1 | 0.9 |
| **Secondary** | | | | | |
| Sisal pulp | 0.6 | 0.9 | | 2.0 | 0.02 |
| Coffee pulp | 0.6 | 1.9 | 0.3 | 3.6 | 0.03 |
| Slaughterhouse waste | 0.06 | 0.6 | 1.0 | 0.3 | 0.001 |
| Sugar filter cake | 0.2 | 2.7 | 4.2 | 6.9 | 0.03 |
| **Tertiary** | | | | | |
| Fruit waste | 1.5 | 1.6 | 0.1 | 1.1 | 0.04 |
| Cereal waste | 2.2 | 2.0 | | 0.6 | 0.1 |
| Vegetables, oils | 1.4 | 2.8 | 0.4 | 0.6 | 0.1 |
| MSW (Nairobi) | 1.0 | 1.4 | 0.05 | 0.3 | 0.02 |
| **Total** | 310 | | | | 5.1 |

## 3.4 Feedstock mixtures

Many mixtures with combinations of the various available feedstocks can be used to feed biodigesters of medium or large scale. Combinations may be based on animal manure, kitchen or restaurant waste, food industry residues or urban waste streams including market refuse or MSW.

A series of options are provided to feed a medium large scale biodigester (100 cubic metre). The options include a range of feedstocks that have been described above. Various combinations of primary, secondary and tertiary feedstocks is evaluated. Average time feedstocks are staying in the biodigester (Hydraulic Retention Time, HRT) is 25-35 days to ensure optimum digestion. If needed, the feedstock is diluted with water.

Each option includes a combination of a minimum of two feedstocks, in many cases including at least one primary feedstock (manure). The following is considered: combinations of cattle, pig or chicken manure, banana stems, or maize stover (primary feedstocks), coffee pulp, slaughterhouse waste, sugar filter cake or sisal pulp (secondary feedstocks) and organic urban waste (Municipal Solid Waste or MSW), cereal food waste, fruit waste, vegetable waste, and meat and fish waste (tertiary waste). Details of ten selected options are given in Table 5.

Cattle manure is the dominant feedstock used in options 1, 2, 3 and 8 while option 5 and 10 contains considerable shares of pig and chicken manure. Field residues have been included in option 2 (banana stems) and 8 (maize stover). Food industry residues include coffee pulp (option 3), sisal pulp (option 10) and slaughterhouse waste (option 6). Other waste streams include cereal food waste, fruit and vegetable waste, meat and MSW.

Most option require dilution of the mixtures with water. In the calculations, equal amounts of water are added to options 1, 5, 6 and 7. Options 2,3 and 8 require less water. Option 9 (containing sugar filter cake and fruit waste) requires a dilution of 4:1 (four volumes of water added to one volume of feedstock).

*Table 5: Feeding scenarios for medium scale biodigesters*

| **Option** | **Primary feedstocks** (%) | **Secondary feedstocks** (%) | **Tertiary feedstocks** (%) | **Water added** |
|---|---|---|---|---|
| Option1: Cattle manure | Cattle manure (100%) | | | 1:1 |
| Option2: Cattle manure, banana stems | Cattle manure (80%)<br>Banana stems (20%) | | | 0.5:1 |
| Option3: Cattle manure, coffee pulp | Cattle manure (80%) | Coffee pulp (20%) | | 0.5:1 |
| Option4: Chicken manure, MSW | Chicken manure (80%) | | MSW (20%) | 3:1 |
| Option5: Pig manure, cereal food waste | Pig manure (90%) | | Cereal waste (10%) | 1:1 |
| Option6: Cattle manure, slaughterhouse waste, MSW | Cattle manure (30%) | Slaughterhouse waste (40%) | MSW (30%) | 1:1 |
| Option7: Market waste | | | Fruit waste (40%)<br>Vegetables, oils (40%)<br>Meat and fish (20%) | 1:1 |
| Option8: Cattle manure, maize stover | Cattle manure (90%)<br>Maize stover (10%) | | | 1:1 |
| Option9: Sugar filter cake, fruit waste, vegetables, oils | | Sugar filter cake (40%) | Fruit waste (40%)<br>Vegetables, oils (20%) | 4:1 |
| Option10: Chicken manure, sisal pulp | Chicken manure (20%) | Sisal pulp (80%) | | 0 |

Theoretical methane production varies between 20 and 300 cubic metre per day. Highest yields are generated by mixtures containing kitchen waste (fruits, vegetables, oil and cereal food waste), sugar filter cake and maize stover. Pure cattle manure is the least productive option (Figure 1).

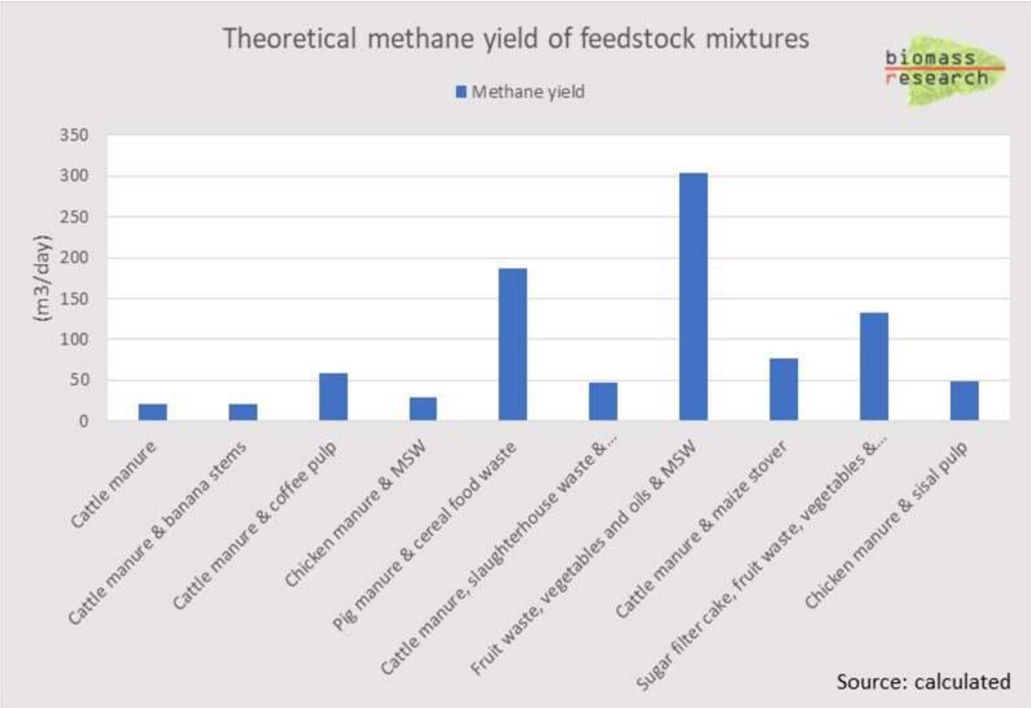



*Figure 1: Theoretical methane yield of feedstock mixtures*
Note: Order of mixtures in the figure is following the order presented in Table 5

Figure 2 depicts nutrient concentrations of bio-slurry generated by feedstock mixtures. Highest nitrogen concentrations are found in mixtures with vegetables, fruit waste and chicken manure. Bio-slurry made from anaerobic digestion of pure cattle manure contains the lowest nitrogen concentration (less than 2 kg/m$^3$). Potassium concentrations are high in feedstock mixtures containing fruit waste, banana stems and coffee pulp.

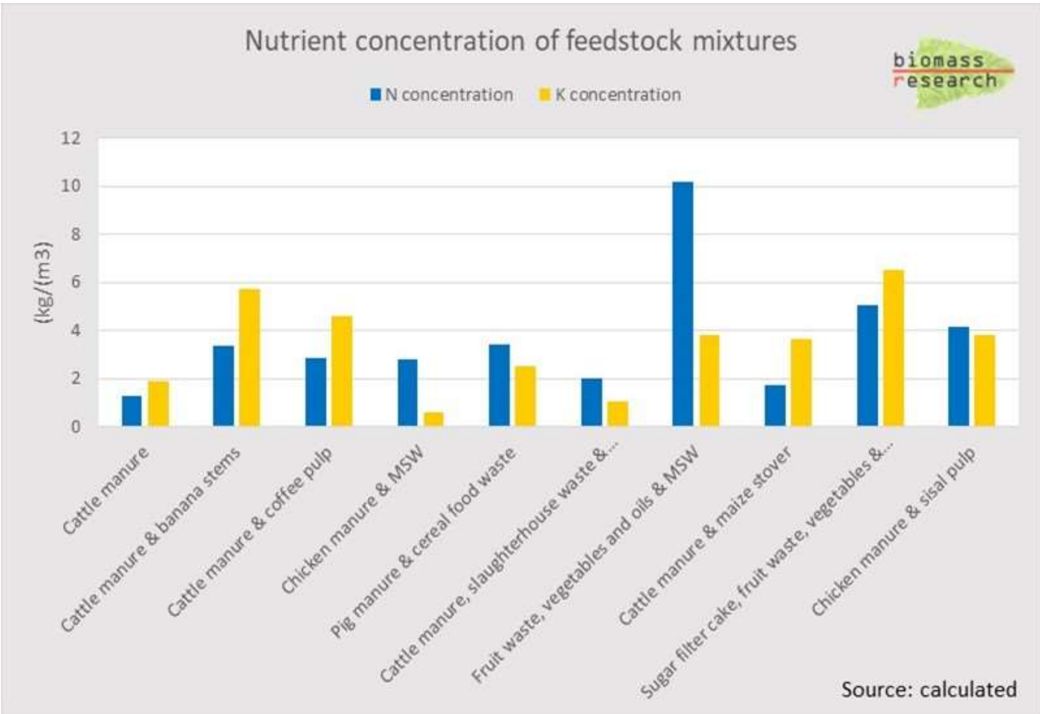



*Figure 2: Bio-slurry ntrogen and potassium concentration*
Note: Order of mixtures in the figure is following the order presented in Table 5

# 4. Discussion and conclusion

The newest energy crisis is adding to the need to transform fossil energy systems into more sustainable alternatives in Europe as well as elsewhere including Africa, where poor energy infrastructure and limited funding opportunities restrict investments in solar and wind energy. Anaerobic Digestion (AD) is a mature and established technology which can be used to generate biogas and methane for cooking, light and heating also in remote areas lacking an electricity grid or gas infrastructure. Current efforts to promote the development of AD is focussing on small (3 to 8 cubic metre) household units almost exclusively fed with cattle or pig manure. Upscaling AD implementation and biogas production will require adoption of larger AD units and mobilisation of a range of feedstocks including household waste and organic residues from food industries.

Main organic waste streams in Kenya include primary (agricultural), secondary (food industry) and tertiary (kitchens, restaurants) streams. An inventory suggest over 110 million tons of organic waste are available, containing 31 million tons of dry matter most of which originates in animal manure. The amount of residues is much more than generally is assumed, but their use can only be realised through massive investments in biodigester infrastructure and waste collection chains. While it is not likely that this is realised in the short or medium term, but the outcomes clearly show the potential for enhanced production of biogas, a clean, safe, and cheap source of energy which generates valuable organic fertilizers.

Animal (mainly cattle and chicken) manure consists two thirds of the available residues, but their methane potential and nutrient concentrations are relatively low. An evaluation of ten possible feedstock mixtures that can be used in medium scale biodigesters shows options containing kitchen waste (fruits, vegtables, oil and cereal food waste) and chicken manure can be relevant sources of nitrogen. Potassium (an important nutrient for crops like coffee and banana) can be sourced from mixtures containing fruit waste, banana stems and coffee pulp.

More work is needed to evaluate feedstock and mixture performance. It is recommended to develop a test program for medium scale biodigesters in practice, which can provide valuable information for the development of the biogas and bio-slurry) markets in Kenya and beyond. Current developments abroad (especially India and Brazil) provide interesting examples that can be used as point of reference.

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# Annex 1: Biomass resources Kenya

## Primary residues

Availability of primary residues was calculated from crop statistics combined with literature data and expert knowledge on residue availability. Two indicators have been used to calculate availability of field residues. Their definition is given below.

> **Residue-to-Produce Ratio** (RPR) = ratio between weight of residues and weight of economic product
>
> **Harvest Index** (HI) = ratio of economic product to total biomass generated

Both indicators are expressed as kg per kg. Values were derived from literature.

Fischer et al. (2019) provide detailed values for the Residue-to-Produce Ratios. Reported RPR values at low to average yield levels are 2.0 for maize, 3.0 for sorghum and 4.0 for millet, indicating that the majority of the biomass is in the form of residues (stover, cobs, roots). Values for soybeans, rapeseed and sunflower is 3.5. Lower RPR values are expected at higher yield levels (Fischer et al.; 2019). According to Asefa (2019), HI for maize is ranging between 0.2 and 0.56 (equivlant to RPR 4.0 and 0.8). Rice HI varies between 0.31 and 0.51 (RPR 2.3 to 0.3). For both crops, lower boundaries of estimates presented by Fischer et al. have been used. In the case RPR values could not be obatained, HI values were retrieved from alternative literature sources.

RPR and HI were used to estimate amounts of field crop residues. The findings are summarised in Table A.1. A total of 3.2 million ton residues are generated each year. Maize is the most important crop, generating an estimated 1.9 million tonne each year. Other important crops are plantain banana (0.7 million tonne), vegetables and sorghum.

*Table A 1: Crop area, production and primary residues for major crop groups (2020)*

| Crop | Area (million ha) | Yield (ton per ha) | Output (million ton) | Residues (mln ton) | Remarks |
|---|---|---|---|---|---|
| Maize | 2.19 | 1.7 | 3.79 | 1.90 | RPR 2.0 |
| Sorghum | 0.22 | 1.4 | 0.32 | 0.15 | |
| Millet | 0.12 | 1.3 | 0.15 | 0.048 | |
| Rice | 0.03 | 6.4 | 0.18 | 0.01 | 0.005 to 0.10 |
| Cowpea | 0.24 | 1.1 | 0.26 | 0.12 | |
| Pigeon pea | 0.13 | 0.9 | 0.12 | 0.03 | |
| Sisal plants | | | | 0.12 | |
| Common bean | 0.004 | 1.08 | 0.043 | 0.02 | 0.012 to 0.023 |
| Groundnut, sesame | 0.043 | 1.42 | 0.027 | 0.01 | |
| Cassava, yam | 0.063 | 24.11 | 0.091 | 0.036 | |
| Vegetables | 0.087 | 13.73 | 0.66 | 0.24 | |
| Cotton | 0.014 | o.44 | 0.006 | 0.002 | |
| Plantain banana | 0.072 | 25.74 | 1.85 | 0.70 | |
| Coffee | 0.12 | 0.31 | 0.04 | 0.012 | 0.0010 to 0.014 |
| Total | | | | 3.25 | |

[1]: numbers for 2019

Source: calculated from FAOSTAT (2022), Fischer et al. (2019), Unkovich et al. (2009), Asefa (2019), Kimutai et al. (2014), Maheswarapp, et al. (2011).

Annual manure production was calculated using animal number statistics and manure production per head. Results are presented in Table A.2. Total annual manure production is some 300 million tonnes, two thirds of which is cattle manure.

*Table A 2: Manure production*

| Animal type | **Number of animals** (million) [1] | **Fresh manure** (million ton) | **Remarks** |
|---|---|---|---|
| Cattle | 17.8 | 189 | Only dairy cattle |
| Chicken | 42.4 | 82 | Half of the heads in Kenya |
| Pigs | 0.4 | 11 | 20% of all heads |

[1]: numbers for 2014

Source: Chávez-Fuentes et al. (2017) and GTZ (2010)

# Secondary residues

Availability of secondary residues was calculated by combining literature data (GTZ, 2010) and food and crop processing information. Main results are given in Table A.3. Total availability is one million tonnes per year; more than half of this is sisal pulp.

*Table A 3: Availability and characterof secondary residues*

| **Source and type of residue** | **Amount of fresh waste** (million ton per year) | **Dry matter** (million ton per year) | **Remarks** |
|---|---|---|---|
| Sisal pulp | 0.62 | 0.01 | Sisal drying facilities |
| Sugar filter cake cake | 0.19 | 0.17 | Sugar plants |
| Coffee pulp and processing waste | 0.11 | 0.2 | Large number of plants |
| Pineapple solid waste | 0.08 | | Large number of plants |
| Slaughterhouse waste | | 0.01 | Houses vary in size |
| Total | | | |

Source: adjusted from GTZ (2010)

# Tertiary residues

Total annual food supply amounts to 23.6 million tonnes. Reported waste shares vary between 20% for pulses, meat and animal products and 45% for fruits and root crops. Food waste is estimated at 8 million tonnes per year. One quarter of this is waste from cereals (maize, rice, etc.). Other important sources are root crops (cassava, sweet potato), fruits and vegetables.

*Table A 4: Availability of tertiary residues*

| Residue type | **Food supply** (million tonne) | **Waste** (%) | **Food waste** (million tonne) | **Remarks** |
|---|---|---|---|---|
| Cereals (excluding beer) | 7,28 | 30 | 2,18 | Mostly maize |
| Starchy roots | 3,47 | 45 | 1,56 | Cassava, irish potato |
| Pulses | 0,84 | 20 | 0,17 | |
| Oil crops | 0,14 | 20 | 0,03 | Mainly groundnut, soya |
| Vegetable oils & vegetables | 3,06 | 45 | 1,38 | |
| Fruits (excluding wine) | 3,40 | 45 | 1,53 | |
| Animal fats | 0,78 | 20 | 0,16 | Cooking oil, skins |
| Meat | 0,06 | 20 | 0,01 | |
| Eggs | 0,08 | 20 | 0,02 | |
| Milk | 4,35 | 20 | 0,87 | Excluding butter |
| Fish, seafood | 0,16 | 35 | 0,06 | |
| Total | 23.6 | 34 | 8.0 | |

[1]: based on a number of 5.24 million inhabitants (2019)
Source: calculated from Secondi and PrincipTO (2022) AND Gustavsson et al. (2011)