African Biodigester Component

Biodigester Market Assessment in Somalia

SEE – Clean Cooking

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This publication presents a market assessment of the biodigester potential in Somalia. This report was developed by Ahmed Giumale, an independent energy consultant for the African Biodigester Component in Kenya under the overall supervision of Florent Eveillé, African Biodigester Component Manager in Kenya. Among the colleagues who provided valuable inputs, the authors would like to thank Evelyne Munihu and Mark Rotich for their careful reading, editing and suggestions.

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

ABC has also explored options to implement cross-border activities with Somalia. The results from the assessment will facilitate a strategic discussion and decision-making by RVO (the Netherlands Enterprise Agency) on the type and scope of potential activities in Somalia, which will be translated into a strategy and implementation plan backed by a dedicated budget, should RVO decide to move ahead. The main objective of this study is to gather data and information on existing biodigester installed as well as analysing the different stakeholders involved in the biodigester sector in Somalia.

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Acronyms

Abbreviations	Description
€	Euro
°C	Degree Celsius
ABC	African Biodigester Component
ABPL	African Bioenergy Partnership Limited
AD	Anaerobic Digestion
AfDB	Africa Development Bank
BIO-NET	Biogas Network
BRA	Banadir Regional Administration
BVP	Biogas volume potential
CAPEX	Capital Expenditure
CN	Carbon Nitrogen Ratio
DFID	Department for International Development
DP	Dubai Ports
ESP	Electricity Service Providers
FAO	Food and Agriculture Organization
FGS	Federal Government of Somalia
FMS	Federal Member States
GEEL	Growth, Enterprise, Employment & Livelihoods
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HDPE	High-density polyethylene
IDP's	Internally Displaced Persons
IED	Improvised Explosive Devise
KSA	The Kingdom of Saudi Arabia
KWh	Kilo Watt hour
LPG	Liquefied Petroleum Gas
MoEWR	Ministry of Energy and Water Resources
MSW	Municipal Solid Waste
MW	Mega Watt
NDP	National Development Plan
OLR	Organic Loading Rate
PSAWENR	Puntland State Authority of Water, Energy and Natural Resources
RE	Renewable Energy
ROI	Return on Investment
SOGEA	Somalia Green Energy Association
Solar PV	Solar Photovoltaic
SOMINVEST	Investment Promotion Office in Somalia
SW	Solid Waste
TS	Total Solids
UAE	United Arab Emirates
VS	Volatile Solids
WFP	World Food Programme
WXKU	Wakaaladda Xoogga Korantada Ummaddab ENEE

Executive Summary

The Somali economy is mainly dependent on livestock as a source of livelihood. More than 80% of livestock husbandry in Somalia is in the form of pastoralism (a form of animal husbandry where domesticated animals are moved from one place to another in search of feeds and water). Somalia is one of the largest exporters of live animals mostly to the Middle East markets (Majid 2010). In the last three decades, the economy in general and the livestock sector in particular, suffered from the country's fragile institutions, insecurity and recurrent droughts. As a result, nomads have lost their traditional livelihoods and permanently settled to become Internally displaced persons (IDPs). Many more rural households have also migrated to the urban centres with their animals. This resulted in new ways of livestock husbandry in Somalia such as agro-pastoralism, urban animal husbandry, dairy farming and animal fattening businesses.

About 97% of urban Somali households depend on charcoal while rural households rely on firewood as their main source of energy for cooking (AfDB, 2013). This is putting massive pressure on scarce forest resources, contributing to desertification and the destruction of grazing and arable land. There is an urgent need to develop alternative sources of cooking fuel. As such biogas production from crop residues, food waste and animal waste represent an interesting source of higher tier clean cooking energy.

A biodigester is an enclosed vessel where organic material is digested in the absence of oxygen (anaerobic digestion) to produce biogas and bio-slurry. Biogas is a flammable gas which can be used for cooking, heat or electricity production (after cleaning) while bio-slurry can be used as a fertilizer, insect repellent or as food for certain animals.

Biogas plants could be installed in most parts of the country, particularly in the peri-urban centres with sufficient water sources. Sufficient biogas quantities to meet the household energy requirements of almost all villages and farming communities can be produced (AfDB, 2015).

Given the greater demand of energy for cooking and energy generation in Somalia, biogas is more suitable for use in these applications. The energy conversion efficiency of using biogas is 55% in cooking stoves and 30% in engines.

In Somalia, the available feedstock for biodigester is mainly animal manure which can be easily procured with no collection and transportation costs in some specific high potential areas where water is adequately available. These include:

- The animal quarantine centres in Berbera and Bossaso,
- Slaughterhouses in towns,
- Households with 5 – 10 animals and,
- Newly established medium scale dairy farms.

Municipal solid waste in Somalia has less than 10% of biodegradable content as kitchen waste is separated at source and fed to animals, whereas the commercial, market and agricultural wastes have rather informal market as an animal feed and may not be easily available as biodigester feedstock due to challenges related to collection, transport and separation of the non-biodegradable fraction of the waste.

Different sizes of biodigesters for different applications of biogas are suitable based on the feedstock available in various locations. For example, the quarantine centres in Bossaso hold over 1.6 million live animals for a period of at least 30 days before exporting them to Middle Eastern countries. This translates to over 4,000 tonnes of manure being produced per day over the 30 days period of quarantine. If this is to be used as a biodigester feedstock, the amount of biogas produced will be at

least 60,000 m^3, per day, enough to produce around 102 MWh of electricity per day. In Berbera, a similar number of live animals are exported yearly. For both Berbera and Bossaso quarantine centres, Electricity Service Providers (ESPs) can be encouraged to invest in biodigesters as a source of electricity generation.

In Somalia, the diet is based on cereal and meat. As a result, each town has at least one or two slaughterhouses. Major coastal towns from Kismayo in the south to Eyl along the Indian Ocean, Bossaso and Berbera on the Gulf of Aden, have slaughterhouses erected close to the shores of the Indian ocean and dump their untreated sludge directly into the ocean. The slaughterhouses in interior cities use self-made manholes for dumping waste while others along the Jubba and Shabelle rivers dump their biowaste directly into the rivers. Most recently, The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) supported the construction of a septic tank for the Jowhar slaughterhouse, which was dumping waste into the Shabelle river. The Department for International Development (DFID) funded the construction of Burco Slaughterhouse and erected a bio-septic tank for waste disposal.

Slaughterhouse waste is an environmental pollutant but at the same time a very good feedstock for a biodigester. Because of the nuisances (odour and smell) they produce, slaughterhouses are built away from residential areas. If a biodigester is to be installed next to the slaughterhouse, it may be necessary to pipe the biogas to the users or to pressurize and package the biogas in portable gas cylinders. A solar PV system or a biogas electricity generator can be used to run the biogas compressor affordably. The interviewed slaughterhouse managers have expressed interest to invest in biogas business with support from development partners.

Zero-grazing Dairy farming businesses are being established across the country and in particular in major towns. One such farm visited during the consultation stage keeps 40 cows supplying fresh milk to restaurants in Mogadishu. The farm owner realized the benefits of the technology and installed a $5m^3$ floating drum biodigester to provide biogas for cooking and bio-slurry for his farm located 20km outside of the city. He is currently planning to increase the capacity and to install a biodigester of $20m^3$.

Small scale farmers owning on average 5 to 10 animals represent most pastoralists in Somalia where animals are released for grazing during the day and confined in Kraals at night. Thousands of domestic biodigesters can be installed for these communities along the Jubba and Shabelle river in the south and Gibiley and Borame region in the north. The biogas here can be used directly for cooking by households.

This study has confirmed 6 installed biodigesters in Somalia in which 4 are active, and 2 are inactive whereas the potential is estimated at 62,000 biodigesters. Given the major difference between installed biodigesters and the technical potential, we recommend a phased approach working with the 2 existing biodigester companies, developing the capacities of local masons and incentivizing the participation of prefabricated biodigester companies from Ethiopia or Kenya to the Somali market through a phased approach with realistic targets per year e.g., 100 to 200 biodigesters in the first year.

To grow the biodigester market in Somalia, it is recommended that government institutions in charge of energy access, in collaboration with development partners initiate awareness creation in the target regions, provide policy support for the installation of large scale biodigester systems and support installation of standardized biodigester systems with operations and control systems in place. With a few pilot biodigester systems in Somalia, the market can pick-up as the benefits are realized.

In summary, the following strategies are recommended for the implementation of a market-based biodigester support programme by the political and development partners:

- Support governmental institutions such as in developing policies and institutional capacity.
- Initiate public awareness and setting up technical training centres for masons in Hargeysa, Garowe and Mogadishu.
- Develop the technical capacity of local masons to increase the number of biodigester technicians in Somalia.
- Support existing companies to increase their sales through Business Development Support.
- Develop adapted financing instruments with existing banks and (micro)finance institutions active in Somalia.
- Support market linkages between the Somali diaspora in Kenya and biodigester companies established in Kenya.
- Provide financial support for low-income households and access to finance for agro-pastoralists.
- Establish an incentive scheme such as a Result-Based Finance Facility for at least 10% of the market potential (6,200 units) through the three target regions for domestic biodigesters. This would require a phased approach with realistic targets per year (100 biodigesters per year initially).
- The slaughterhouses, medium scale dairy farms and the large-scale quarantine centres can be considered for a special financing mechanism, first through a few select pilots, for example 30 biodigester units for the medium scale dairy farms, 5 units for the abattoirs, and one unit for the quarantine centres, then onwards to gradual incremental on a rolling out basis.
- Engage one or both ESPs in port cities of Berbera and Bossaso and develop a feasibility study for biodigester project for each of them.

Country context in the target regions

Out of the five federal states of Somalia, three were selected for this market assessment study: South West, Hirshabelle and Puntland together with the Banadir Regional Administration and the territory of Somaliland. The South West and Hirshabelle regions have relatively significant agriculture and water resources due to the presence of the Shabelle and Juba rivers (FAO-SWALIM, 2022). The Puntland state and Somaliland represent interesting cases of agropastoralism and livestock export contexts. The Banadir Regional Administration (BRA) is the Headquarters of the capital city Mogadishu, the main economic and most populated city in Somalia.

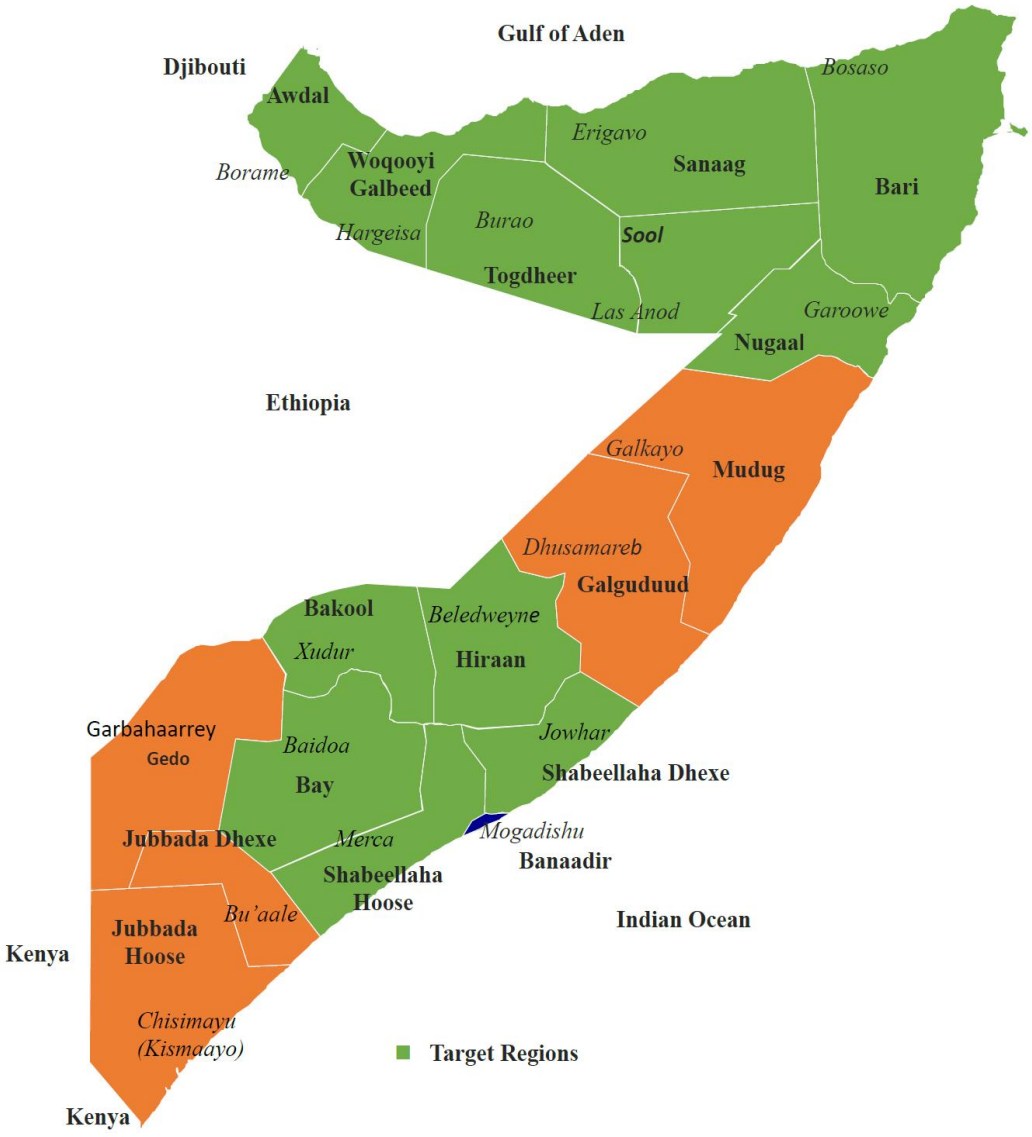

Figure 1 - Map of Somalia. Biodigester Assessment Target regions - © GIZ

Banadir Regional Administration (Mogadishu)

The Banadir Region is the capital city of the Somali Federal Government. The Region has 17 districts. The Banadir Regional Administration (BRA) and the Municipality of Mogadishu are headed by a Governor who is also the Mayor of Mogadishu. The person is directly appointed by the President of the Federal Government of Somalia. Each district is administrated by a district commissioner. The Population estimate survey conducted in 2014 indicated a population of about 1,650,227 persons. Mogadishu, which is a sandy port city without any agricultural or farming operations is situated on the coast of the Indian Ocean. Rich agricultural fields in the middle and lower Shabelle regions provide the city with agricultural produce. Dairy farming, drip irrigation, and greenhouse farming businesses have emerged in the Daynile peripherical district of Mogadishu because of the security concerns restricting the supply of agriculture products from inland and the increasing demand of the expanding urban population of the capital.

This area has plenty of water obtained from hand dug wells and boreholes. This is where most of Mogadishu's water suppliers are based to provide fresh water to the city. Due to over abstraction of groundwater, sea water intrusion in the coastal sandy aquifer has been experienced pushing freshwater abstraction 15 to 30 kilometres from the coast inland.

South West State

The South-West State of Somalia is a Federal Member State in southwestern Somalia. Barawe is the official capital of the South West state of Somalia although Baidoa is the main city where the government office is currently located. The population of the state is estimated to be 2.5 million. The major towns with a population of over half a million are Afgoi, Biadhabo, Marka, Bur-Hakaba and Barawe. The population of Bakool districts is getting smaller due to the prevailing insecurity and as a result, more than 50% of the population has migrated to Baidoa.

The Bay and Bakool Regions completely depend on livestock and rainwater for farming, whereas the Lower Shabelle region mostly rely on the river Shabelle to cultivate farmland. Various types of fruits and vegetables are grown such as tomatoes, onions, chili, pepper, carrots, lettuce, and cucumbers. The city of Mogadishu serves as the primary market for this farm products.

Hirshabelle State

The Hirshabelle State has two main regions. The Middle Shabelle region consists of the capital city Jowhar, and the districts of Balad, Mahaday, Warshiekh, Adale and Aden-Yabaal. The Hiran region consists of five districts: Beledweyne, Bulobarde, Jalalaqsi, Matabaan and Mahas. The river Shabelle flows through seven districts. The state is bordered by Banadir to the south, Bakool to the west, Galmudug to the north and Ethiopia to the West. According to Ministry of Planning, the population of the State is estimated by regions with the middle Shabelle comprising 516,036 people and the Hiran Region 520,685[1].

[1] www.nbs.gov.so/docs/PESS_Somal_population.pdf

The livelihood of the population in this state depends mainly on livestock and agriculture where they grow crops such as maize and sesame as well as fruits (tomato, onion, chili, mango, papaw and lime) and vegetables. The Hiran region is a hub connecting the North and southern part of the country, for Galmudug, Puntland and Somaliland (animals are transported from Beledwayn by trucks for export at Berbera and Bosaso ports. The Middle Shabelle market is Mogadishu. All livestock exports through the Bossaso port originate from the Hiran region of the Hirshabelle State, and the Bakool region of the South West State and transferred to Beledwayn.

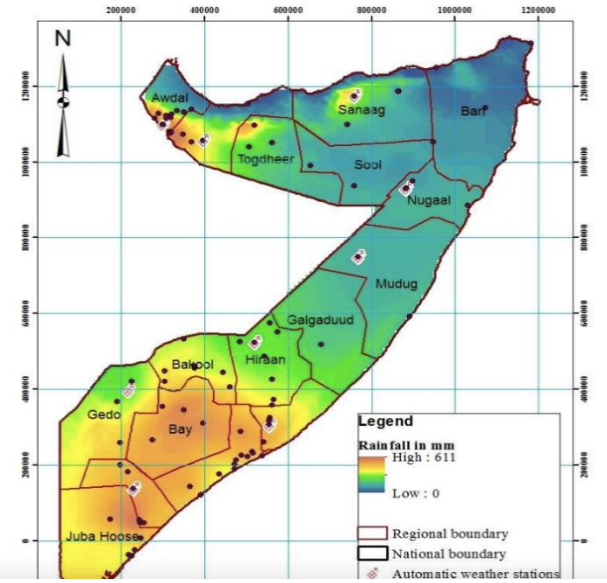

Figure 2 - Map of rain fall in Somalia. (Source: FAO)

Puntland State

Geographically, Puntland is in the north eastern part of Somalia and is a dry region. It shares boundaries with Ethiopia to the south west, the Gulf of Aden in the north, the Indian Ocean to the south east, the north west area in the west, and the central regions in the south. The State of Puntland covers 212,510 km^2, or nearly one-third of the total area of Somalia.

The seven following regions constitute the Puntland State: Baran, Nugal, Mudug, Sanaag, Sool, Ayn, and Karkaar. Garowe, the capital of the Puntland State of Somalia, is home to over 48,000 people. Bosaso is the principal port and the primary source of revenue of the Puntland State due to livestock exports and commodity imports. With a total population of close to 2 million, the state has no farmlands. As the name Puntland suggests, frankincense is the second source of income for the state. Underground water is available for human consumption, animals and biodigester development.

Somaliland

Somaliland currently has the administrative regions of Awdal, Woqooyi Galbeed, Togdheer, Sanaag, and Sool with a total population of just under 4 million. The economy of Somaliland is based on live animal exports to the Gulf States as well as some fruits and vegetables exports to Djibouti. Rainfed farming is mostly present in the mountainous regions around the towns of Borama, Gibiley, Burao, Sheikh and Erigavo. Pastoralism is present in arid areas. The main source of income for the administration is the custom revenues from the Berbera port and Wajale entry point at the border with Ethiopia. The main livestock found in the Eastern part of Somaliland are cows whereas camels, sheep and goats are herded in the west. During the dry season, water scarcity is reported in some regions such as Wajalle and the capital city of Hargeisa.

The energy sector

Somalia's energy sector is not sufficiently diverse: imported oil, firewood and charcoal are the main types of energy. Firewood and charcoal are utilised for cooking, whereas crude oil is used for transportation and electricity generation. The importation of oil depletes US dollars currency reserve, while the vast collection of firewood and charcoal production destroy forests. The need for energy grows as security improves, which causes greater deforestation and increased demand on oil imports. Renewable energy is a required alternative for the development of a sustainable energy system and can be used to address energy related issues. To reduce oil imports, electricity production can primarily be supplemented by Solar Photovoltaic (PV), wind turbines, hydroelectric systems and biogas from biodigester using the nation Renewable Energy (RE) potential.

The energy sector is facing tremendous challenges, which include:

- Lack of diversified energy sources
- High poverty rate and energy dependence on imported fossil resources
- Scarcity of energy supply and access due to the absence of essential energy and electricity infrastructure
- Limited legislative, institutional regulation, and framework.
- High electricity tariffs due to high investment costs and the inefficiency of energy companies
- Lack of incentives and unfavorable investment environment.
- Insecurity and political instability.

Biodigester Technology

Bio-digestion Process

Anaerobic Digestion (AD) or simply known as biodigestion is a microbiological process whereby organic matter is decomposed in the absence of oxygen. This process is common to many natural environments such as swamps or digestive system of ruminants. Using an engineered approach and controlled design, an airproof reactor tank is used to process the organic biodegradable matter to generate two main products: energy-rich biogas and a nutritious digestate also known as bio-slurry which is a natural fertiliser.

Benefits of Biodigesters

The use of a biodigester for organic waste processing provides many benefits. This includes the generation of renewable energy, a reduction of greenhouse gases, a reduced dependency on fossil fuels, job creation, and closing of the nutrient cycle. It transforms organic waste material into valuable resources while at the same time reducing solid waste volumes and thus waste disposal nuisance and costs. Biogas as a renewable energy source not only improves the energy balance of a country but also contributes to the preservation of natural resources by reducing deforestation, and to environmental protection by reducing pollution from waste and use of fossil fuels.

Biogas applications

Depending on the biogas source's characteristics and the local energy demand, biogas can be used for a variety of energy purposes. Given the greater demand for cooking and energy generation in Somalia, biogas is an ideal addition to the energy mix for these applications.
According to (Kossmann, 2011), the energy conversion efficiency of using biogas is 55% in cookstoves and 30% in engines for electricity production. The most efficient way of using biogas is in combined heat and power (CHP) where 88% efficiency can be reached. However, this is only possible for larger installations where the exhaust heat is re-used in the process.

Table 1 - Typical utilisation rates of biogas (Source: Lo and al. 2010)

Biogas Application	Consumption Rate (L/h)
Household cooking stove	200 – 450
Biogas / diesel engine per brake horsepower (746 watts)	420
Generation of 1 kWh of electricity with biogas / diesel mixture	700

Direct combustion and heat utilization

The simplest way for households to utilise biogas is by directly burning it in stoves, which supplements, minimizes or eliminates the need for conventional cooking fuels like wood, charcoal, kerosene or liquefied petroleum gas (LPG). For this purpose, hydrogen sulphide (H_2S) or carbon dioxide (CO_2) are not entirely removed from the gas. Since H_2S is corrosive it is recommended to clean the gas, as well as use non-corrosive material (HDPE pipes for gas piping and aluminium metal for the stove).

Electricity generation

In general, each cubic meter (m^3) of biogas contains the energy equivalent of 6 kWh or 21.6MJ calorific value (FNR, 2009). However, due to conversion losses in a combined heat power engine, $1m^3$ of biogas can be converted to about 2kWh and the remaining biogas is converted into 4KWh heat which can then be used for heating applications. 2 kWh is enough to power 200 light bulbs of 10W each, which is about 50 homes or a 500 W food blender for four hours.

Nutrients / Fertiliser (Bio-slurry)

Given its chemical composition, bio-slurry is a good organic fertiliser. The substrate contains every plant nutrient needed for plant growth, including nitrogen (N), phosphorus (P), and potassium (K), as well as trace elements. The nutrients N, P, and K are crucial for plant growth, and their relative ratios are particularly significant for improving soil. The main advantage of biodigestion is that the nutrients, in particular Nitrogen become more easily accessible to the plants. A universal optimal ratio of these nutrients cannot be generally established because each kind of soil and each plant species have unique needs for N, P, and K. However, their presence in bioslurry is not as concentrated as in chemical fertilisers. The second advantage of biodigester is its water content. Needed for plant growth.

Available Biodigester feedstock in Somalia

The available feedstock for biodigestion in Somalia is limited to animal manure as agricultural waste is normally recycled as animal feed. Kitchen waste is also separated at the source and fed to animals limiting the biodegradable municipal solid waste content.

Livestock Manure

Livestock manure can be used as a feedstock for small (0 to 50m^3), medium (50 to 500m^3) and large (more than 500m^3) sized biodigester. It can be found in most parts of the country, particularly in the peri-urban and urban centres. Sufficient biogas quantities to supplement the household energy requirements of almost all villages and farming communities can be produced.

In Somalia, livestock is estimated to be around 36 million in 2020 according to the Food and Agriculture Organization (FAO) and with a human population of 16 million, there are 2.3 animals per inhabitant. This means there is enough feedstock available for biodigester technology to provide clean energy as well as fertilizer for farming activities. In Somalia, the main livestock comprise camel, cattle, sheep and goats, with numbers of livestock estimated at 7.1 million for camel, 4.9 million for cattle, 12.3 million for sheep, and 11.6 million for goat (FAOSTAT, 2020)

A cow is estimated to produce a minimum of 40kg of dung per day. A camel, 10kg, a sheep, 2kg and a goat, 1kg. Under pastoralist or semi-confined state as it is the case in Somalia, the collectable dung from the night stabling is about half of the total dung per day per animal. Other factors such as droughts and limited improved animal feed could possibly further reduce available manure. However, in the absence of specific literature on the topic, we have only discarded half of the theoretical amount of manure production per animal. Therefore, in theory, the average total amount of cow dung available daily for biodigestion in Somalia is 151,600 tonnes. The Table below shows the estimated calculation of dung production and total collectable dung per day available for biodigestion.

Table 2 - Livestock Population and Manure Production per day.

Animal Type	Numbers (Millions)	Average Daily Dung Per Animal (Kgs)	Total Daily Dung (Million Kgs)	Daily Collectable Dung Per Animal (Kgs)	Total Available Dung (Million Kgs)
Cow	4.9	40	196	20	98
Camel	7.1	10	71	5	35.5
Sheep	12.3	2	24.6	1	12.3
Goat	11.6	1	11.6	0.5	5.8
Total	35.9	53	303.2	26.5	151.6

Collection, transport of animal manure and water scarcity in some regions e.g., Gibiley, are the main challenges in Somalia as pastoral farming is a common practice. Civil war, insecurity and climate change have forced massive migration from rural to urban centres in the past three decades. In Mogadishu, there are more than one million IDPs (IOM, 2013) and twice as much have migrated from the countryside and settled in the outskirts of the city. Similar phenomena can be observed in all other major cities including Hargeysa, Borame, Burco, Garowe, Bosaso, Beledwayne and Baidoa. Most of the migrants who are not registered as IDPs come to cities with their livestock and this is the reason that livestock roam in cities during the day.

The available livestock waste which can be used as feedstock for biodigester in Somalia can be found at export ports, small and medium size semi-pastoral households in urban, peri-urban areas and slaughterhouses.

Export ports

Bossaso Port

Located on the southern coast of the Gulf of Aden, the municipality serves as the commercial capital of the region and is a major seaport within the autonomous Puntland state. In Bossaso, the summers are long, hot, arid, and partly cloudy. The winters are warm, humid, dry, and mostly clear. It is windy year-round. Over the course of the year, the temperature typically varies from 22°C to 37°C and is rarely below 19°C or above 39°C[2].

In Bossaso, there are three livestock quarantine centres, two located in the outskirts of the city. Livestock come from Galmudug, Hirshabelle and Southwest states as Bosaso port became the only port for livestock exportation in Somalia, excluding Somaliland. The Kingdom of Saudi Arabia (KSA), Yemen, Oman and the United Arab Emirates (UAE) are the main destinations for Somaliland livestock exports. Saudi Arabia is the main destination for most sheep and goat exports as 70% of the export takes place during the Muslim Hajj season. The total number of livestock animals exported from Bossaso in 2021 was 1,653,782.

Figure 3 - Animal quarantine centre in Bossaso - © GIZ

Table 3 - Exported livestock from Bossaso Port (2021) (Source: Bossaso animal health and welfare office).

Month	Sheep and Goats	Cattle	Camel
Jan	86,756	2,596	268
Feb	125,331	3,139	2,556
Mar	132,553	4,583	2,578
Apr	140,193	1,730	63
May	158,053	1,284	38
Jun	249,850	4,763	1,165
Jul	299,113	3,939	1,308
Aug	88,144	1,582	941
Sep	70,033	2,596	476
Oct	81,170	171	0
Nov	115,078	2,345	470
Dec	67,157	1,289	471
Total	1,613,431	30,017	10,334

[2] https://weatherspark.com/y/104781/Average-Weather-in-Bosaso-Somalia-Year-Round

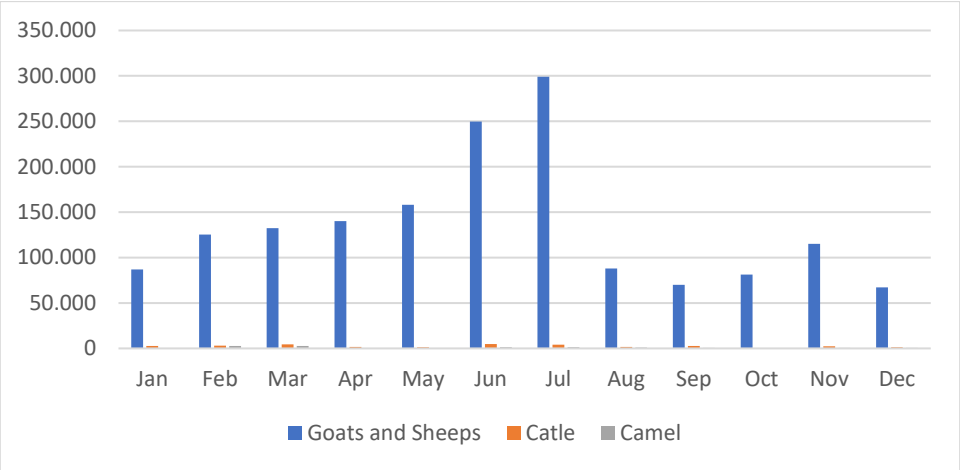

Figure 4 - Live animals exports from Bossaso port in 2021 (Source: Bossaso port)

According to the graph above, the exportation peaks in July corresponding to the *Hajj* pilgrimage of 2021 and the June peak shows that exportations start one month earlier that the Hajj. The graph also demonstrates a monthly average of 10,000 animals exported throughout the year. This was observed during the site visit in one of the quarantines centres in Bossaso where livestock animals were quarantined in September before shipment to Yemen.

Table 4 - Available manure at Bossaso port (Source: Bossaso port)

Month	Kg/day
Jan	112,298
Feb	179,481
Mar	219,522
Apr	114,292
May	111,697
Jun	261,475
Jul	267,652
Aug	97,737
Sep	107,057
Oct	44,860
Nov	123,214
Dec	72,869

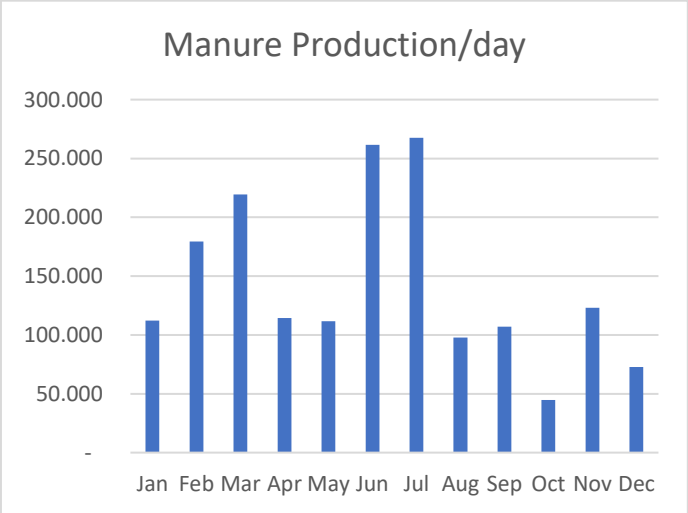

Figure 5 - Available animal manure from quarantine centres in Bossaso – (Source: Bossaso port).

The average daily manure production from a beef cow is estimated at 25 – 30Kg per day where the dairy cows produce 45 – 50Kg per day[3], goats produce 0.5Kg/day and the Somali camel – which is very similar to the UAE camel, for which information is available, produces 15 – 25Kg per day. Taking the lower values of the manure production per animal, the total available manure for biodigester feedstock from Bossaso port per day can be calculated and is shown in the table below.

[3] http:/web.worldbank.org

The average manure production from livestock quarantine centres in Bossaso is 142,679 Kg/day and as the animals remain in the quarantine for an occupational period of 30 days before exporting, the weight of manure is increased to 4,280,376.25 Kg per month. The local city council is currently struggling to manage and dispose this large amount of biowaste. The manure is also mixed with urine and large quantity of grass from animal feed which increases the amount of waste. This is shuffled on site, transported with trucks, and dumped 20 km outside the city with considerable cost for waste disposal and large amount of methane released directly to the atmosphere from the decomposing manure.

Biogas and electricity production estimates from Bossaso Port

The animal waste at the port provides an easily accessible and economically viable waste for energy utilisation, production of digestate for use as an organic fertilizer as well as waste management. As a rule of thumb, 10kg of manure (wet waste) produces 0.4m^3 of biogas per day this means the available manure from Bossaso port per day could theoretically produce 1198m^3 of biogas/day. One of the most convenient ways to use this energy is to convert it into both heat and electrical energy. for consumption at the quarantine centre as described in the calculation below.

Figure 6 - Dried up animal manure in the quarantine centre - © GIZ

Biogas production potential capacity estimates at Bossaso could be estimated using the following calculation (S. Hidayati et al 2019):

Available cow manure per day = 142,679 kg
Percentage of Total solids (TS) and Volatile Solids (VS)
%TS = 21%*142,679 kg/day = 29,962 kg/day
%VS = 19%*142,679 kg/day = 27,109 kg/day

Biogas volume potential (BVP) = 0.04m^3/kg * 29,962kg per day = 1198m^3/day

The methane gas volume is calculated as 65.7%*1198m^3/day = 787m^3/day.

The potential of electrical energy production from the above biogas is obtained using the conversion factor (FK) of 4.7:

E = Methane volume * FK = 787*4.7 = 3,700KWh

Power is calculated as E/24h = 3700/24 = 154KW, enough power to supply the quarantine centre and an equivalent of 15 average homes.

Besides the adequate availability of the feedstock, the availability of fresh water for mixing the feedstock is also a key consideration. When the floor is well constructed and finished, the quarantine centre can also enable collection of both animal dung and urine. A more detailed process shall be engaged during sizing and choice of the ideal biodigester model, by the rule of thumb, about two biodigester units of 1200m^3 could be constructed. The investment cost will put into consideration other support structures such as cow dung collection, feeding mechanisms and trucks, tankers for distribution of bioslurry of about 100 tonnes daily to different destinations such as farms around the

quarantine centre. The bioslurry produced from these biodigesters will be useful as an additional source of income for the quarantine centres when sold to farms around Bossaso. A similar situation applies for the quarantine centre and the port of Berbera.

Electricity and Electrical Service Provider (ESP) in Bosaso

In Bossaso, electricity is provided by a private and public partnership company known as Wakaaladda Xoogga Korantada Ummaddab ENEE (WXKU). It has a capacity of 7MW diesel generation, and the United Arab Emirates (UAE) are planning investment in a 6MW solar energy power plant with the aim of supplying clean power to the port, which is managed by DP world, an UAE based company.

As the cost of diesel-based electricity generation has increased all over the world due to the war in Ukraine, the cost of electricity in Bossaso went up from 0.56 to 0.9€/kWh. There is an opportunity for ENEE to invest in the biodigester technology. Although the three quarantine centres are in three different locations, three different suitable biodigester sizes and generators can be installed and power fed to the grid.

Berbera Port

Located in the Gulf of Aden, Berbera is a major livestock export port and the main source of income for Somaliland. In 2019, 1.89 million livestock animals were exported from Berbera most of them sheep and goats to Saudi Arabia during the Hajj pilgrimage. Many of these animals come from Sool and Sanaag as well as the Somali Ethiopian region as far as Dire Dawa (500 km from Berbera). The figure 6 below, shows the livestock exports published by the Somaliland Chamber of Commerce, Industry and Agriculture in 2020.

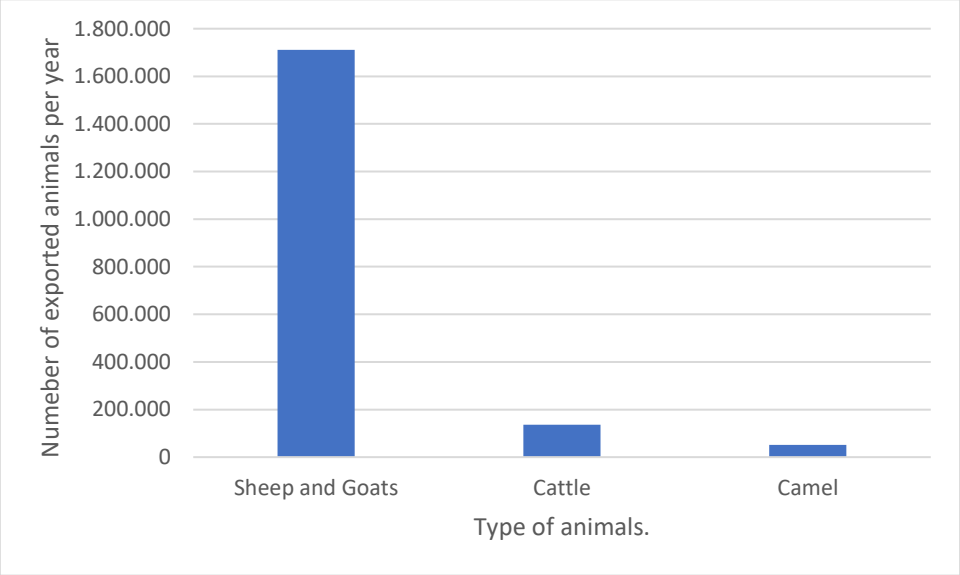

Figure 7 - Exported live animals from Berbera port 2019 (Source: Somaliland Chamber of Commerce, Industry and Agriculture (2020))

Berbera has two animal quarantine centres of approximately the same capacity as Bossaso. The centre that was visited during the assessment is situated on the city's eastern edge close to the power plant. The table above illustrates the number of animals exported from Berbera port which is comparable to figures from Bossaso. There is sufficient availability of water in Berbera for biodigester development.

The quarantine facility management expressed interest in the biodigestion technology of waste conversion to biogas to reduce expenses in collecting, transportation, and disposal of manure. The power company is keen on the concept of generating electricity from biogas produced by the livestock quarantine in the facility.

Figure 8 - Dried animal manure – © GIZ

Slaughterhouse waste

In Somalia, meat and cereals constitutes the main diet and thousands of animals are slaughtered yearly. The consumption of meat and in particular camel meat has increased in main cities along with population increase due to rural urban migration. In Mogadishu, for example, there was only one slaughterhouse in 1990's (Kawan Bari). Currently, there are five main slaughterhouses three of which dump the waste straight to the Indian Ocean as they are located alongside the coast. The total number of livestock slaughtered daily is estimated to be around 180-250 animals, mostly camels.

One slaughterhouse visited during the assessment is Jazira, located next to Mogadishu International Airport. It is the second largest slaughterhouse with the capacity of 20 camels per day. It should be noted that sheep and goats are slaughtered at homes and in animal markets slaughtering slabs and the waste is easily disposable.

Figure 9 - Visited slaughterhouse in Jazira, Mogadishu – © GIZ

Across the country, every city has at least two slaughterhouses. In Somaliland, the meat consumption is even higher than in the rest of Somalia.

Waste management at slaughterhouses

All the major coastal cities from Kismayo in the south to Eyl along the Indian Ocean and the two main cities of Bossaso and Berbera on the Gulf of Aden have slaughterhouses built close to the coast. The sludge is dumped into the Indian Ocean. The inland city slaughterhouses dump waste into excavated pits and rivers in the locality. Most recently, DFID funded the construction of Burco Slaughterhouse and built a bio-septic tank for waste disposal. GIZ funded the construction of a septic tank for Jowar slaughterhouse that previously dumped waste to the Shabelle river.

Slaughterhouse waste for bioenergy and waste management

The slaughterhouse waste consists of animal dung, guts and blood, and is richer in carbon nitrogen energy content than animal dung. Due to the high lipid and protein content, these types of waste fractions have high methane potential (Jhosané Pagés Díaz) For this reason, a considerable amount of biogas and bio-slurry can be produced from slaughterhouse waste while avoiding rivers and ocean water contamination.

Slaughterhouse waste as biodigester feedstock

Fixed dome biodigester can be built with locally available materials such as mortar and brick by trained masons. The main challenge here would be the use of the product (biogas and bio-slurry). A tanker truck can be used to transport the slurry to nearby farming regions or gardens if any. Most of the slaughterhouses are in the outskirts of Somali cities with no nearby residential or commercial centres, the direct use of biogas for cooking will not be practical. However, biogas can be used for water heating for staff showers and cleaning of the facility. The biogas can also be transformed into electricity through a generator for own consumption.

Figure 10 - Slaughterhouse waste being dumped to the sea – © GIZ

Considering not all the biogas generated can be utilized at the slaughterhouse, the additional biogas could potentially be compressed into portable cylinders or in biogas bags for distribution to consumers around the area of generation. Slaughterhouse owners and managers will be interested in commercializing the biogas if they can be bottled or transported for sale as cooking gas.

This is an income generating opportunity as the prices of LPG has dramatically increased in the last few months from €17.8 to €26.23 between January and November 2022 for a 13kg cylinder.

The sizing of biodigesters for slaughterhouses will take into consideration the consistency and number of animals slaughtered and the frequency and consequently the sludge quantities generated from the daily animal slaughtering. Should the number of daily slaughtering be projected to increase in the near future, a second and even third biodigester can be installed when the need arises, with consideration of the business opportunity and the Return on Investment in the generation of more biogas and bioslurry. A case example is the Keekonyoike and Nyongara slaughterhouses biodigesters in Kenya. Each slaughterhouse slaughters over 150 animals per day. Keekonyoike built two biodigesters of 124 m^3 each at an estimate cost of 5,000 Euros each. The gas produced is used for water heating at the abattoir. The excess gas is planned for commercial bottling in the near future. This approach can be easily replicated in most of the slaughterhouses in the four target regions.

Zero grazing agro-pastoral waste

In Mogadishu, a few dairy farms have been established recently. One of the farmers visited during the study keeps 40 dairy cows and sells the milk to a local restaurant. The farmer owns another farm outside the city where he grows animal fodder.

The farmer, having been in the dairy business for at least five years now, experienced a challenge in the management and disposal of animal waste in the city as well as the need for fertilizing his fields: the import of chemical fertilisers in Somalia is severely restricted due to their costs and potential dual use. In 2021, the total value of imported chemical fertiliser in Somalia was 0,5% of the total value of imported fertilisers in Kenya (Source: ITC, 2021). This led the Somali dairy farmer to invest in a biodigester at an estimate cost of 700 Euros.

The farmer installed a 5m^3 floating drum biodigester in 2021 currently operational. The biogas is used in kitchen for cooking and the bio-slurry is transported to his farm with a 1,000L wheeled tank at a frequency of ten days.

Figure 11 - Installed biodigester by one of the dairy farmers in Mogadishu – © GIZ

About 20 similar dairy farmers exist in Mogadishu and other major cities such as Baidoa, Beledwayn, Borame, Hargeysa and Garowe. Although none of these farmers have installed biodigesters, they are most definitely facing the same challenges of managing the manure and therefore the need for biogas and bio fertilizer.

Dairy farms of these sizes will find investment in medium scale biodigesters economically attractive in management of the fresh manure, generation of biogas for heating and other productive uses such as powering generators and chaffcutters. The bioslurry produced will also be used to fertilize animal fodders, food for human consumption or even for sale.

Small Scale livestock holders

With the rural urban migration in the past three decades, many households in urban centres have at least 5 – 10 animals for their own subsistence. In Somaliland, the country is divided into two in terms of livestock animal distribution. The western part has a high cow population including in Wajale, Gibiley and Borame regions whereas in the eastern part households keep sheep and goats as well as camel. In south central Somalia, communities along the Shabelle rivers are small scale livestock holders from Hiran region to the lower Shabelle region. Household biodigesters would be suitable for all the above regions apart from Wajale which has been reported to have water scarcity during the dry season. Water is available in Gibiley, Borame and cities along the Shabelle river.

Table 5 - Household Biodigester Potential

Target region		Type and number of animals	Number of households	Size of biodigester	Estimated cost (Euros)
Somaliland	Wajale, Gibiley Borame	7 cows/HH in stables at night	12,000	6-12m^3	800 - 1200
Puntland	Godlogob, Garowe, Ayl	20 – 50 sheep and goats/HH	5,000	6-12m^3	800 - 1200
Hirshabelle	Beledwayn , Bulobarde, Jowhar, Balad	5 - 10 cows/HH in stables at night plus goats	25,000	6-12m^3	800 - 1200
Southwest	Afgoi, Qoryoley, Marka	5 - 10 cows/HH in stables at night plus goats	20,000	6-12m^3	800 - 1200
		Total:	62,000		

Residential Waste and Municipal Solid Waste (MSW)

Traditionally, household waste is simply disposed outside houses and the practice continues in small villages and peri-urban centres. Recently, solid waste management systems have been established in major cities across the county. Berbera town has an efficient solid waste management system compared to the rest of the country. In Somalia, the largest share of household waste consists of plastic waste, more so in the south and southcentral regions of Somalia.

Figure 12 - Urban animals feeding from kitchen waste – © GIZ

Currently the kitchen waste is separated at source and fed to livestock animals. This practice is common for two reasons: organic waste will decompose and smell as waste is collected once a week and feeding animals is a religious and cultural gesture. This means municipal waste have less than 10% organic waste content. In the south-central Somalia, 80% of the solid waste is plastic according to the CEO of African Solutions, the only recycling company in Somalia, who is also interested in starting biodigester business. On the other hand, in Somaliland, there is less plastic waste as plastic bags are banned.

Figure 13 - Urban animals feeding from kitchen waste – © GIZ

As such there is currently minimal opportunity to collect and treat municipal solid waste for anaerobic digestion.

Agricultural, Commercial and Market waste

Agricultural waste across Somalia and Somaliland is entirely reused as animal feed as well as the commercial and market waste. There is an informal market for some of the above waste and redirecting these as biodigester feedstock for energy production may have an indirect effect such us increasing the cost of animal feed. Using kitchen waste from restaurants as a biodigester feedstock is feasible for cooking partially or entirely produced biogas.
Jiko Biogas, which is one of the existing biodigester companies in Mogadishu that has successfully installed five of biodigesters is currently negotiating with a local restaurant to build a biodigester to convert their kitchen waste to biogas for cooking.

The need for the biodigester value chain in Somalia

The output of a biodigester includes nutrient-rich digestate known as bio-slurry, an organic fertiliser, and energy-rich biogas for cooking and electricity generation. Due to the following two factors, the value chain of biodigester is urgently needed in both Somalia and Somaliland.

Table 6 - Summary of biodigestion potential in the regions initial target markets

Target region **Somaliland** **Puntland** **Hirshabelle** **Southwest**	**Type and number of animals**	**Number of Clients (Biodigesters)**	**Size of biodigester**	**Estimated cost Euros**
Small Scale/Household Biodigesters	5 – 10 cows, enclosed at night. 20 – 50 sheep	Total potential of 62,000 HH biodigesters	6-12m^3	€ 800 - 1200
Slaughterhouses	Total of between 10 to 250 animals slaughtered per day (Cows, Camels, Sheep & Goats)	At least: 2 slaughterhouses per town * 13 major towns = 26 Medium scale biodigesters potential	50-500m^3	€ 8,000 – 20,000
Dairy Farms	20 and above Dairy Cows	20 per town*13 major towns = 260 medium scale biodigesters potential	50-500m^3	€ 8,000 – 20,000
Quarantine Centres (Export Ports) Bossaso & Berbera	1,65 million for Bossaso & 1.89 million for Berbera port in Total per year of Cows, Camels, Sheep & Goats	3 quarantine centres for Bossaso, 2 quarantine centres for Berbera. Total potential of 5 Large scale biodigesters of 500 m^3 to 2400 m^3	500 m^3 - 2,400 m^3	€ 50,000 - 200,000
Total Biodigesters Potential: Household: 62,000 (6-12m^3) Medium Scale: 286 (50-500m^3) Large Scale: 5 (500m^3 -2400m^3)		Total investment (EUR): Household: 49.6M to 68.2M Medium Scale: 2.288M to 5.72M Large Scale: 250,000 to 1,000,000 Total Investment: 52 to 75 Million Euros		

Biogas for clean cooking and electricity generation

The use of liquified petroleum gas (LPG) for cooking has been adopted in Somalia from 2010 as the price of charcoal has increased particularly in the arid regions of the country. In Somaliland and Puntland LPG is widely used for cooking although charcoal is still used by most low-income families. In Mogadishu, the use of LPG for cooking has recently been increased as the cost of charcoal has also risen. Firewood and charcoal come from Lower Shabelle and Lower Juba regions, both of which are controlled by jihadist groups preventing the charcoal supply to Mogadishu. As the LPG market is still self-developing, the increased demand created shortages and the prices increased.

Figure 14 - Biodigester system installed in Mogadishu by JIKO Biogas – © GIZ

Unfortunately, the price of standard LPG 13 kg gas cylinder in Somalia has been increased from €17.8 to €26.23 between January and November 2022 consequently the use of charcoal has risen considerably. The cost of imported diesel for power generation has also gone up from 0.66 €/L to 0.89€/L (WFP, 2022) reflecting a rise in the electricity tariffs across the country. This opens a potential market for biodigester technology as biogas can be used both for cooking and for electricity generation.

As a rule of thumb, an average family of 5 can use up a 13kg LPG cylinder costing €26.23 in 30 days, which translates to about €0.87 per day. For the same size family, with a household stove of 55% calorific efficiency on animal manure-based biogas, the biogas consumed would be 0.6 to 1.35 m^3 per day of biogas consumed. On the higher side, it costs €0.37 to produce 1 metre cubic of biogas. Therefore, to produce the highest household daily demand of 1.35 cubic metres of biogas would cost €0.5. This is €0.37 cheaper than LPG. There are other additional benefits from biodigesters, most of which do not come with the use of LPG or charcoal such as the bioslurry for own use as fertilizer or for sale, saving time, trees, and reduced indoor air pollution.

Bio-slurry for fertilization

There is an increasing demand for organic fertilizer. The import of chemical fertiliser is currently banned in Somalia as the improvised explosive devices (IED's) used by extremist groups can be made from chemical fertiliser. This is an opportunity for biodigester technology as local farmers are struggling to find fertiliser. The demand for fertiliser is further increased as agro-pastoral practices adoption increases. Currently in Mogadishu, 20L of bio-slurry from one of the installed biodigesters by JIKO biogas is being sold for €14.05 to local farmers. A communal biodigester installed by Jiko Biogas in the IDP camp of Jowhar is maintained through daily feeding by nearly 100 women, the biogas produced is utilized in a shared communal kitchen. The bioslurry obtained is spread out to dry, crushed into powder, packed and sold to local farmers as fertilizers at €30 per bag of 90kg resulting in improvement in food crops yields. (Abdirahman Hussein, 2022)

Existing biodigester companies and potential entrants

Existing Companies

Currently there are only two biodigester companies both based in Mogadishu, Somalia. Jiko Biogas which is a more established company and Som Biogas and Energy Solutions who is expanding in the sector as it is originally an LPG company.

Jiko Biogas

Established in 2016 by a renewable energy enthusiast Somali American entrepreneur who has also established a solar PV company in Somalia. JIKO Biogas have installed five biodigesters. Three of these Biodigesters are installed in Mogadishu and two in Jowhar. According to the operations manager, four of the biodigesters are currently operational. One of the Jiko biogas biodigester was visited during the data collection for this study. The biodigester is made from a fibreglass water tank and provides enough biogas for a family of five. JIKO Biogas company profile is in the annex 10.2.

Som Biogas and Energy Solutions

Som Biogas and energy solutions was launched by local entrepreneurs in 2017 with the objective of encouraging the use of Somalia's available renewable resources and provide energy in the form of electricity and cooking fuel. Although the company currently provides LPG for cooking in Mogadishu and the Southwest state in Somalia, they have expressed interest to expand to the biodigester technology to provide biogas and bio-slurry to their target regions. They have acquired prefabricated biodigesters from Kenya and successfully demonstrated the system in Baidoa to create awareness to the local farmers. SOM Biogas company profile is in the annex 10.3.

Figure 15 - Biodigester system demonstrated by SOM Biogas - © GIZ

Potential New Entrants

Potential new entrants in the biodigester market in Somalia include current active renewable energy companies as confirmed by the chairman of Somali Green Energy Association (SOGEA) where 12 local renewable energy companies are members, biodigester companies active in Kenya or Ethiopia and electricity service providers (ESPs). ESPs are looking for cheaper sources to generate electricity. These potential entrants are profit businesses. ESPs and Somali energy companies have enough capital to invest.

One of the main challenges, is the absence of technical expertise and the potential for even considering biodigester technology as a workable commercial investment. If the ESPs are convinced about the biodigester technology, the suitable target for the biodigester installation would be in the ports and the slaughterhouses where the feedstock and water are available in sufficient and stable quantities.

Biodigestion Technologies Export/Import Scheme

The two biogas companies currently active in Somalia, Jiko biogas and Som Biogas as well as the 12 local Renewable Energy Companies under the umbrella of SOGEA require capacity building, support and linkage to venture into the biodigesters market in Somalia. Capacity building areas could include

technical training, support in enabling environment, awareness creation, business development and incentivising installations, sustainability and bioslurry use through Results Based Financing.

The Renewable energy companies will also be exposed to opportunities in biodigesters business through linkages to established prefabs companies in Kenya such as HomeBiogas, Biogas International, Sistema among others who could liaise to export biodigesters across the border from Kenya to Somalia for installation by the locals and staff from these companies who will be equipped with the requisite technical knowhow. Established associations in Kenya such as ABPL and BIO-NET could also collaborate with SOGEA and the RE companies to train fixed dome masons in Somalia who will be able to install biodigesters using the locally available brick and mortar.

Opportunities and Challenges for biodigester adoption in Somalia

Opportunities

- Enough feedstock and available water in target regions

The livestock population for feedstock supply and perennial availability of water in the target regions are the two key important elements in the assessment of the market potential. This will ensure optimum functionality of the biodigesters once installed.

- Presence of two biodigester companies operating in Somalia and many others in neighbouring Countries (Kenya & Ethiopia)

Jiko Biogas, Som Biogas and Igad Sheikh Technical Veterinary College have set a positive precedence to the biodigester adoption in Somalia. In addition, the biodigester market has developed much better in the neighbouring countries such as Ethiopia and Kenya. This acts as a convenient launch pad for the growth of biodigester market in Somalia. Established structures in both Kenya and Ethiopia could serve as the source of the biodigestion technology such as fixed dome and prefabricated models, capacity building, supply and demand financing models and awareness creation from experienced sector players such as the government, development partners, learning institutions, research institutions and biogas associations.

- Potential for Medium scale enterprises to fund installation of biodigesters

The commercial medium scale enterprises such as the dairy farms and slaughterhouses make substantial profits in their business activities. Thus, it is assumed they have the capacity to acquire and pay for medium scale biodigesters and with the savings from using biogas, use and sale of bioslurry, they can recoup their capital expenditure (CAPEX) in an economically reasonable return on investment period.

- Attractive benefits of biogas and bioslurry

Availability of biogas and bioslurry to the households, dairy farms, slaughterhouses and quarantine centres comes with valuable multisectoral benefits crosscutting in environmental conservation, economic savings, health, food security and job creation

Challenges

- Lack of locally available skilled labour

Somalia is still new to the biodigester market and will require robust efforts to develop skilled technical expertise in biogas. Before this step is well established the trainings will take a financial toll on the companies venturing into the sector. Capacity building initiatives and technical trainings to offer installation and after sales services will be a key activity to bridge the gap in the introduction of biogas to the country.

- Lack of financing opportunities particularly for low-income families

Due to the many years of political instability, the economy in Somalia has experienced slow growth leading to less disposable income by the households. In this case the households lacking the capacity to purchase the biodigesters upfront will require flexible financing mechanisms that blends well with the average purchasing power.

- Enabling environment

Introduction of biodigestion technology and business in Somalia will spur economic growth and this will require acceptance and support from the government and all other sector stakeholders. these key sector players shall be sensitized and encouraged to collaborate to create and a conducive enabling environment for the companies involved.

- Low awareness raising and marketing activities on biodigesters

Considering the low number of biodigesters installed in Somalia (6 with 4 functioning and 2 inactive), the level of awareness both in theory and in person experience is still very minimal. Awareness creation and marketing will be a major inception activity in the introduction of biodigester business and technology in country.

Government institutions

The Ministry of Energy and Water Resources (MoEWR) was established by the Federal Government of Somalia (FGS) in Mogadishu to formulate and carry out comprehensive energy sector policies and to steer the energy industry. The government intends to create a National Regulatory Authority by 2021, to carry out market reform, and boost electricity access both off-grid and on-grid from 10% to 45% by 2024, according to the 2020-2024 National Development Plan 9 (NDP). To encourage foreign direct investment, the Ministry of Planning, Investment, and International Cooperation formed the Investment Promotion Office (SOMINVEST) in 2015. One of the industries this office focuses on is energy investment.

SOMINVEST currently deals only with foreign companies, and helps with legal issues, registration, certifications, visa and work permit as well as tax exemption on energy projects. Examples of such a company is Kube energy, a Norwegian company who are in the process of installing a 4MW solar plant in Baidoa. SOMINVEST is the gateway for both local and foreign investments.

Apart from Puntland, all other Federal Member States (FMS) have similar Ministries for the energy sector policies and regulations. These Ministries are nascent with no sufficient budget and no international cooperation or support to develop regional energy policies, strategies, plans and regulate the sector.

The Puntland administration has no Ministry of Energy, Water or Natural Resources. Instead, there is the Puntland State Authority of Water, Energy and Natural Resources (PSAWEN), which is an autonomous agency, mandated to oversee and regulate the electric power industry. PSAWEN reports directly to the office of the President of Puntland.

In Somaliland, the Ministry of Energy, Water and Mineral Resources has responsibility for the energy sector policy and oversight. The Somaliland government launched the National Energy Policy (2010) as a result of the EU-supported Somaliland Energy Policy Dialogue and Somaliland Energy and Livelihoods Programme, as well as its National Development Plan (NDP) II which targets specific goals. Most recently, the Somaliland investment forum headed by the president focused on the development of clean, reliable and affordable energy.

Institutional and Local Capacity in the biodigester technology

Institutional capacity

None of the government institutions consulted have ideas or plans for biodigester technology. Although most have welcomed the idea during the discussions, it has become apparent that no governmental organisation within Somalia or Somaliland have sections, offices or mandated departments for biodigester development. consequently, there is no strategy concerning biodigestion in Somalia. No regulations, policy or guidelines in place, no incentives and finally, no institutional capacity. A possible action point includes the development of a biodigester unit or department in the federal ministry of energy in Somalia and one in Somaliland with capacity building being supported by development partners.

Local capacity

One of the reasons that currently installed biodigesters are underperforming or even not functioning is the lack of operation and maintenance of the systems due to the lack of technical knowledge. Only three of the installed biodigesters in Mogadishu by JIKO Biogas seems to have sustainable biogas and bio-slurry production during the assessment. The fixed dome biodigester installed in Sheikh Veterinary School was not operational when visited and this is mainly due to unregulated Organic Loading Rate (OLR). It seems that only one person is trained to operate the system and he was not available during the data collection. Hence, capacity for installation, maintenance and operation of biodigesters in the country is limited to less than 10 persons.

Recommendations

There is enough feedstock and water available for biodigester technology in Somalia in the form of animal manure. The other feedstocks such as market waste and crop residues are currently used as animal feed. Somalia has a high demand for biodigester end products in the form of biogas for cooking and electricity generation as well as bio-slurry for fertiliser.

Utilizing this massive amount of animal manure would not only provide the vitally important energy and fertilisation, but it will also help the concerned municipalities manage waste, particularly in ports and slaughterhouses, while lowering greenhouse gas emissions.

In order to realize this technical potential, the following points should be addressed:

- The assessment has found two companies having difficulties to make new sales and develop their business while there is potential and interested clients. It is recommended to support these two existing companies to increase their sales through Business Development Support.
- It has been demonstrated that the government does not have any capacity, nor strategy dedicated to biodigester support. Reinforcing their capacity will enable the government to initiate public awareness activities to raise sales and develop policies to support the enabling environment.
- The number of biodigester masons in Somalia is very limited. Setting up technical training centres for masons in Hargeysa, Garowe and Mogadishu will increase their number and the biodigester offer for potential clients. It can also create a new livelihood source for existing masons and develop the offer of vocational training centres.
- The ability to pay in Somalia remain low, especially for renewable energy products not familiar to Somali households. Developing adapted financing instruments with existing banks and (micro)finance institutions will support the development of new offers by biodigester companies.
- The Somali diaspora has the capacity to invest, support the import of products to the Somali market and to establish a solid client based for biodigester companies. Establishing linkages between prefabricated biodigester companies established in Kenya and the Somali diaspora in Kenya would support market activation in Somalia.
- Biodigester companies are in a very infant stage in Somalia, they need demand activation, a supportive enabling environment, BDS as well as an attractive incentive product such as a Result-based Finance Facility to increase their sales. We assume that 10% of the market potential (about 6,200 biodigesters) throughout the three target regions for domestic biodigestion potential could be realistically targeted. The slaughterhouses, medium scale dairy farms and the large-scale quarantine centres can be considered for a special financing mechanism, first through a few selected pilots, for example 30 biodigester units for the medium scale dairy farms, 5 units for the abattoirs, and one unit for the quarantine centres, then onwards to gradual incremental on a rolling out basis.
- The quarantine centres in Berbera and Bossaso are vital for the economy of Somalia and the livelihoods of the Somali. However, they are also a source of nuisance and high costs. Engaging one or both ESPs in port cities of Berbera and Bossaso to develop a feasibility study for biodigestion could trigger a reflexion to develop industrial biodigesters as a source of both electricity, heat and fertiliser for local use.

In summary, the private sector can be supported to promote installation of biodigesters in all the target regions while the institutional capacity is being developed.

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Annexes

Stakeholder consultation list

#	Date	Name	Organization
1	10/09/22	Bashiir Mohamud - Chairman	Somali Green Energy Association (SOGEA)
2	12/09/22	Abdi Hirsi Ali Founder and CEO	Africa Solutions
3	13/09/22	Abdifarah Ibrahim Director of energy	Ministry of Energy and Water Resources
4	13/09/22	Mahad Ahmed Manager	Jazira Slaughterhouse
5	14/09/22	Emily Addonizio Resilience Specialist	FAO Somalia
6	14/09/22	David Monticelli, Ir., Dr. Programme Manager Resilience, infrastructure and productive sectors section	Delegation of the European Union to the Federal Republic of Somalia
7	17/09/22	Ahmed Husein Ibrahim (Biogas)	Sheikh Veterinary School
8	17/09/22	Mohamoud Osman. Director	Berbera Livestock Quarantine
9	18/09/22	Martin Jäger, Advisor for DRM	GIZ
10	19/09/22	Sharmarke Director of Energy	Ministry of Energy and Mineral Resources
11	27/09/22	Abdulrazak Mohmed CEO	SOM Biogas
12	29/09/22	Profesor Alasow Dean of the Faculty of Engineering	Somali National University
13	01/10/22	Sahal Abdulle Owner	Cattle farm
14	02/10/22	Abdi Barre Operations Manager	JIKO Biogas

JIKO BIOGAS

Providing Nature's Cooking Fuel

Company Profile

Figure 1: Women who live near Jowhar in HirShabelle walk 30Km just to collect firewood for cooking

In 2018, according to IEA, only 5.8% of Somalians had a primary access to clean cooking facilities. The main source of cooking fuels in Somali is firewood and charcoal. **Somali is semi-arid and predominantly scrubland and desert.** Firewood and charcoal pose a great danger to the health of the users by exposing them to toxic smoke and their safety through precarious trips made to source firewood from forests. They further threaten the health of the environment through forest degradation and deforestation, threatening the remaining forest of this semi-arid land, and black carbon emissions from burning solid fuels such as charcoal. No forgetting the loss in productivity through time lost in sourcing for firewood and the cost implication of the ever-increasing prices of charcoal in Somalia. Women and children, more so young girls, are disproportionally affected by these challenges. Cooking should be fun not torturous and that's what we are making it at JikoBiogas.

Our Journey

Our journey started off when we envisioned and believed in a different reality for Somalia, then we saw the opportunities spread all over Somalia's pastoralist society, which in some cases is a menace to the owners, **Animal dung.** To bring our vision to reality, we carried out research and after successful feasibility and preliminary studies, JikoBioGas was officially registered in April 2018 by Hirshabelle State.

Contact: +14805163323 Email: jikobiogas@gmail.com
Website: https://jikobiogas.com/
Twitter: @Jikobiogas

Providing Nature's Cooking Fuel

JikoBioGas was established in Jowhar to provide Biogas energy, a clean, accessible, and an alternative source of cooking fuel in Somalia. We too believe, that if it is not affordable, it is not accessible. In addition to providing biogas, we also provide a natural fertilizer, the by-product of biogas, as an alternative to the inorganic fertilizer.

Figure 2: Biogas testing and prototyping

Our Vision

To help rural villages move out of poverty and become self-sustaining using clean renewable energy, while digesting urban organic waste for energy and organic fertilizer production.

Our Objectives

i. Utilize cow dung which is a menace and health hazard to farmers as fuel and fertilizer.
ii. Create employment for around 200 residents to elevate living standard of the villagers by employing workforce for collecting cow dung daily.
iii. Generate income for the investors and the local municipal county
iv. To create awareness of the utilisation of biogas as cooking fuel and reduce deforestation.
v. To develop Jowhar as Technology Center for biogas and fertilizer production.
vi. To create a conscious and healthy society that cares for the environment and their health by using biogas and fight charcoal burning and deforestation
vii. To rejuvenate Jowhar rice fields by providing high nutrient fertilizers
viii. To provide biogas as a cooking fuel for 5000 families and produce 7000 tons of natural fertilizer per year at the price of 55 per 50 kg sack.

Providing Nature's Cooking Fuel

Our Projects

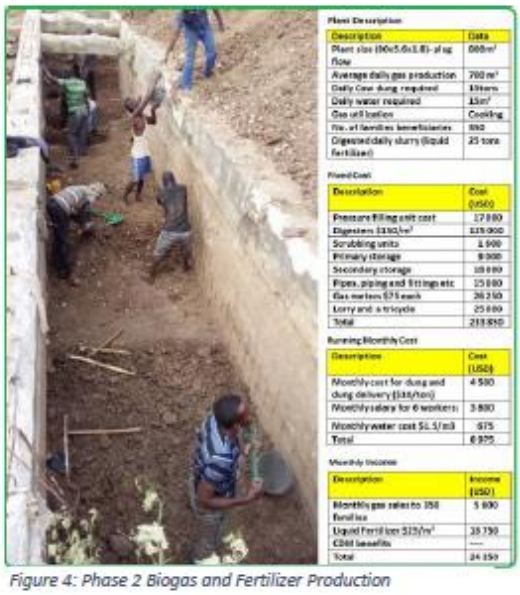
1. Biogas Plant- Phase 1 completed

A pilot project of biogas and fertilizer production is now completed and is serving 20 families and providing natural fertilizer to farmers in Jowhar. The project was financed through P3 agreement with HirShabelle State. The 48m3 digester is using feedstock from 160 cows out of the 60,000 available in Jowhar.

Figure 3: Pilot plant set up in an old sugar factory in Jowhar

2. Commercial Biogas for Cooking

A process is now underway to build a commercial biogas in Jowhar to provide cooking fuel for 350 families. The gas will be piped to houses with gas meters installed.



Plant Description

Description	Data
Plant size (06x5.6x1.8)- plug flow	060m³
Average daily gas production	700 m³
Daily Cow dung required	10tons
Daily water required	15m³
Gas usfl loation	Cooking
No. of families benefitiaries	350
Digested daily slurry (liquid fertiliser)	25 tons

Plant Cost

Description	Cost (US$)
Pressure filling unit cost	17 000
Digesters $350/m³	525 000
Scrubbing units	1 500
Primary storage	9 000
Secondary storage	18 000
Pipes, piping and fittings etc	15 000
Gas meters $75 each	26 250
Lorry and a tricycle	25 000
Total	213 850

Running Monthly Cost

Description	Cost (US$)
Monthly cost for dung and dung delivery ($10/ton)	4 500
Monthly salary for 6 workers	1 800
Monthly water cost $1.5/m3	675
Total	6 975

Monthly Income

Description	Income (US$)
Monthly gas sales to 350 families	5 400
Liquid Fertilizer $15/m³	18 750
CDM benefits	---
Total	24 150

Figure 4: Phase 2 Biogas and Fertilizer Production

Providing Nature's Cooking Fuel

3. Mini Biogas Digesters for Restaurants in Mogadishu

The biogas initiative for Mogadishu restaurants will save not only the restaurants' disposal cost but also reduce the amount of waste thrown into the sea. JikoBiogas is now building biogas systems for restaurants to reduce their waste and costs as they will use the biogas produced for cooking.

Through a joint public awareness drive dubbed ***"Wasted Food = Wasted Resource"*** undertaken jointly by JikoBiogas team and Power Off-Grid team, we have managed to sign agreements of building subsidised biogas plants for more than 50 restaurants. The subsidy is exchanged with CDM rights.

4. Biogas Plants for Animal Farms in Mogadishu

There are many dairy farms in and around Mogadishu who needed solutions to their cow dung waste. Building of biogas facilities for dairy farmers is now in place. SomMilk Dairy Farm, the largest dairy farm in Somalia is among the dairy farms that have signed an agreement with JikoBiogas to construct a biogas plant. Most of these plant bee operating on and off since March 2019.

5. Biogas Plants for Electricity in Jowhar

Jowhar has more biogas potential than any other district in Somalia. Farmers are well organised in cooperatives and therefore JikoBiogas has signed joint agreement with them for the construction of biogas plants for electricity generation and fertilizer

The first plant for the joint venture between JikoBiogas and Bula Sheikh Farmers Cooperative will be in full production at the end of March 2019 to produce 65MWh of electricity annually with 2000 tons of organic fertilizer

Providing Nature's Cooking Fuel

Plant Description

Description	Data
Plant size (8x5.6x1.8)- 4 plug flow digesters	150m³
Average daily gas production	120 m³
Daily Cow dung required	4 tons
Daily water required	4 m³
Gas utilization	Electricity
Daily Power Production (running at 50% efficiency)	180kWh
Digested daily slurry (liquid fertilizer)	6 tons

Figure 5: Biogas design for Bula Sheikh Farmers' Cooperative

6. Youth Empowerment

We invest in the future and ensure longetivity of our impact by training the youth on the theoretical and practical aspects of biogas to enable employment opportunities and job creation. So far we have trained youth through such programmes as the Demand Based Youth Training program funded by USAID-Somalia who have found employment in Mogadishu.

Providing Nature's Cooking Fuel

Our Impact

❖ *Social Impacts*

- Healthy cooking environment for families without smoke and soot
- The Commercial Biogas plant in Jowhar will create jobs for women; 6 employed for phase1, targeting 25 women for phase2 and 220 for phase 3.
- Improving livelihood of women in rural areas by reducing their workload and saving them time enabling them to be involved in other social activities

❖ *Environmental Impact*

- According to FAO, livestock are responsible for 18% of greenhouse gas emission. This is mainly in the form of methane.
- Biogas plants will save tons of greenhouse gases from entering the atmosphere.
- Biogas fuel is alternative to firewood and charcoal thus preserving the environment by stopping deforestation.
- Cattle dung is collected everyday thus making the paddock clean and healthier for the environment, livestock, and the villages.

❖ *Economic Impact*

- Generation of income for the investors and the local municipal county
- Development of Jowhar as Technology Center for Biogas and fertilizer.
- Rejuvenate Jowhar rice fields by providing high nutrient natural fertilizers
- Creation of employment opportunities
- Invention of new local breed of biogas cookstoves

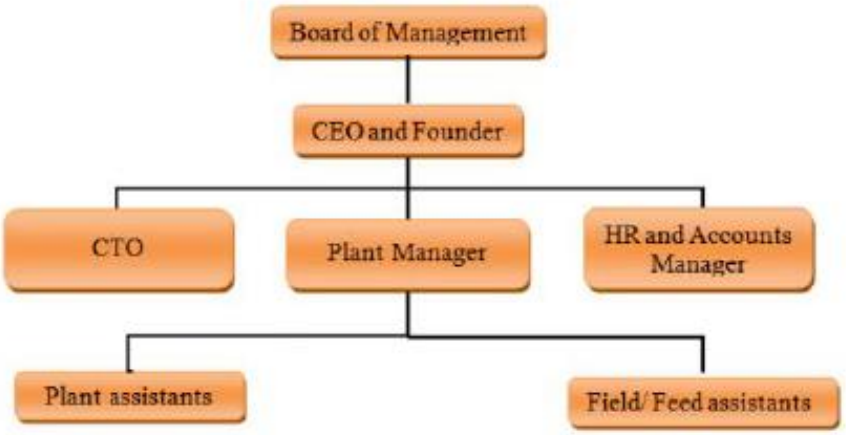
Figure 6:Fertilizer and Cook stove Production Lines

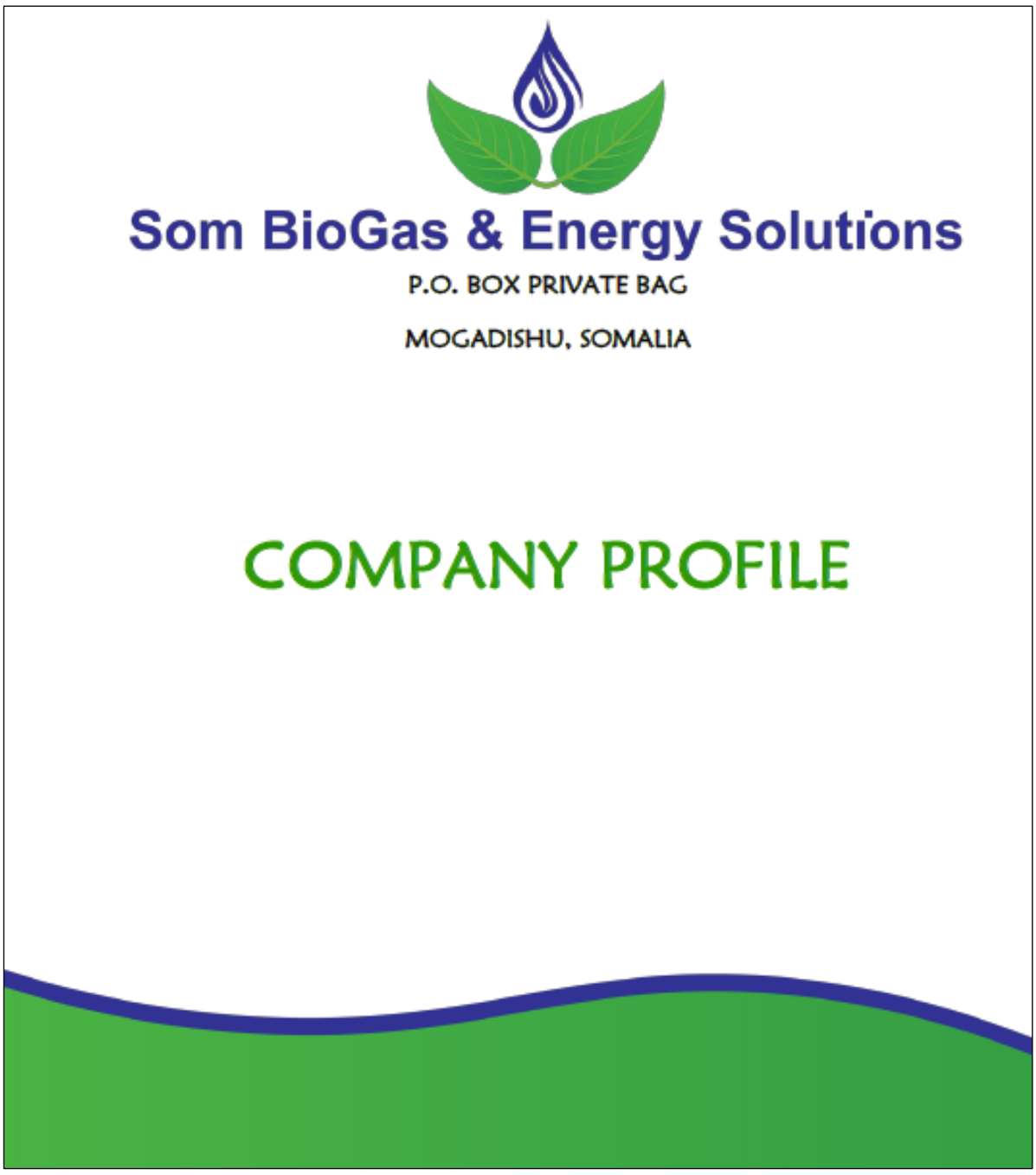
Providing Nature's Cooking Fuel

Our Team

JikoBiogas team is built on a foundation of enthusiastic people who share a common goal of renewable energy, better health and wealth for their community.

Organizational Structure for JikoBiogas in Jowhar




Som BioGas & Energy Solutions
P.O. BOX PRIVATE BAG
MOGADISHU, SOMALIA
COMPANY PROFILE

INTRODUCTION

Som Biogas & Energy Solutions is a modern, progressive and forward-looking Company, environmentally and socially responsible, with ambition to become the market leader in the field of recovery of biodegradable waste in Somalia to create cooking gas.

The Company identifies its development opportunities in new ways of applying the existing technology and opportunities in the area of:

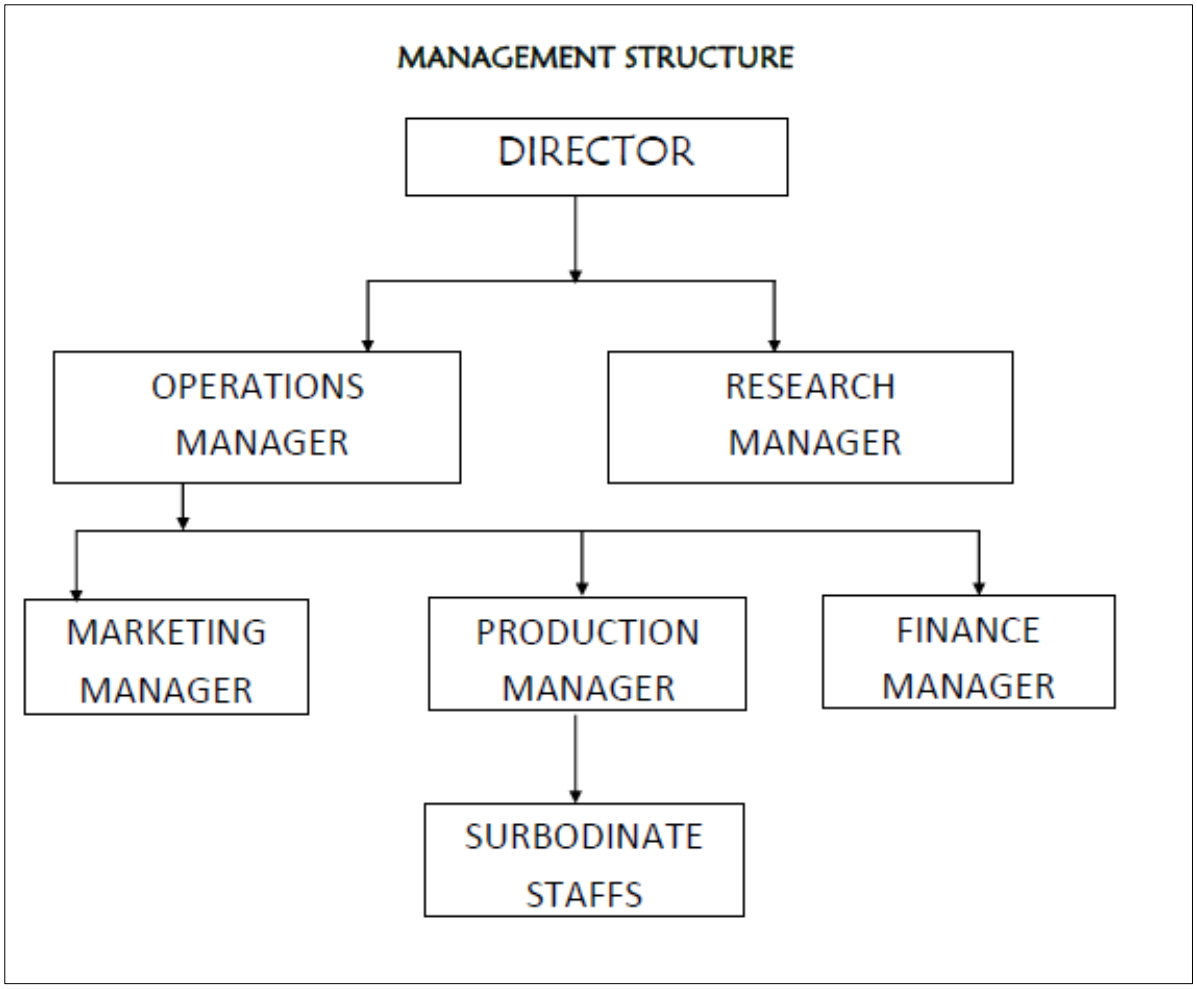
i. Production of electricity and natural gas from renewable energy sources.
ii. Processing of biodegradable waste to generate cooking gas.
iii. Material and energy recovery of sludge solid.

Currently, there is no biogas plant In Somalia, which allows recovery of kitchen, animal, and catering waste in accordance with applicable legislation except Som Biogas & Energy solutions.

It is the Company's ambition to change the passive method of sludge disposal, which generate costs into the active way, which generate income.

MISSION

To encourage the use of Somali's available renewable resources and provide renewable energy in the form of electricity and cooking fuel, sustainably and cost effectively


MANAGEMENT STRUCTURE
DIRECTOR
OPERATIONS MANAGER
RESEARCH MANAGER
MARKETING MANAGER
PRODUCTION MANAGER
FINANCE MANAGER
SURBODINATE STAFFS