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Sludge to Energy Enterprises in Kampala (SEEK)

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Business models for faecal sludge treatment end products in Kampala, Uganda

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Executive summary

The goal of the Sludge to Energy Enterprises in Kampala (SEEK) project is to work towards resource recovery based solutions for waste management becoming a reality and thereby:

- providing new business opportunities and increasing access to renewable energy
- improving public and environmental health in urban areas through the provision of sustainable sanitation service chains

The objective of this study was to develop business models for faecal sludge (FS) treatment end products in Uganda. The products assessed are:

- pellets
- crushed fuel
- char
- FS blended char briquettes

Each of these products was studied in detail because their composition, performance and applicability varies with customer segments. In general, the Ugandan market shows demand for FS end products. The study mainly focused on industries that require heat in their production processes producing non-edible products because unlike households, there's less issues over safety of the fuel with regard to human health. The findings from the research are summarized below.

Pellets

Focus was put on industries which are currently using biomass fuels for heating of non-edible products. Examples include clay, cement and tea companies which could use the pellets for heat generation in their production processes in the drying, pre-heating or firing phases. The major finding was that the pellets need to be adjusted to meet the requirements and conversion technologies of these factories, e.g. it has to be supplied in powdered/crushed form to suit the technologies used.

Crushed fuel

Many factories have installed heating systems that require the use of a crushed fuel. Crushed FS has to compare mainly with coffee husks that are currently being used. Katale Clays Limited completed a successful industrial trial with the crushed fuel. Poultry refuse as the closest substitute is bought at 21 USD/ton. Most potential companies have a heating need and will gladly welcome a fuel that is reliable, efficient and affordable as an alternative or supplement to the agricultural wastes whose availability and price fluctuate depending on the seasons.

Char

We explored the production of char from FS for commercial purposes through carbonisation in a kiln. The main customer segments would be the manufacturers of carbonised briquettes; char being a major input for their products. The price of char dust from charcoal vendors is becoming increasingly high because they no longer look at it as a waste but rather a resource. The major challenge here and the next section is with the acceptance of FS as the feedstock.

FS blended char briquettes

In this section we focused on two companies that are producing FS blended char briquettes in Uganda. These companies are currently selling the briquettes at the same price as the briquettes from agricultural waste.

During a business development workshop, which gathered representatives from 16 organisations, the possibility of manufacturing and selling FS briquettes was discussed. Concern was expressed towards the negative perception of FS.

Further efforts should be focused towards marketing the briquettes to the briquette manufacturers and the char dealers.

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List of Abbreviations

AC	Ash Content
cm	Centimeter
CAPIDA	Canaan Pioneering Innovations and Development Agency
CREEC	Centre for Research in Energy and Energy Conservation
CV	Calorific Value
CD	Charcoal Dust
Eawag	Swiss Federal Institute of Aquatic Science and Technology
ESIA	Environment and Social Impact Assessment
FaME	Faecal Management Enterprises
FS	Faecal Sludge
GVEP	Global Village Energy Partnership
ha	Hectare
kg	Kilogram
MJ	Mega Joule
MC	Moisture Content
M&E	Monitoring and Evaluation
NWSC	National Water & Sewerage Corporation
OM	Organic Matter
Sandec	Department of Sanitation, Water and Solid Waste for Development
SEEK	Sludge to Energy Enterprises in Kampala
SYF4DIN	Strong Youth Foundation for Development International
UBOS	Uganda Bureau of Statistics
UGX	Uganda Shillings
USD	United States Dollar

1. Introduction

In Uganda, the demand for electricity greatly outstrips production rates (REA, 2013). Large industries have to rely on fuel imports like heavy furnace oil. The energy assessment mission (WWF, 2012) noted that the increase in use of fuel wood is highly attributed to small scale industries (brick and tile production, agro and fish processing). Mutyaba (2014) mentions that Uganda depends heavily on conventional biomass in its small scale industries that wood fuel has continued to be the 'fuel of choice even with its scarcity all over the country'. In industries, wood fuel is mainly used for drying, baking, roasting, among others in kilns and furnaces and it accounts for about 4.8 million tonnes per year (MEMD, 2015). 90% of the Ugandan population uses charcoal or firewood-based cook stoves. Since charcoal is always high in demand, traders at Kampala's markets call it 'black gold' (UNDP, 2016). Over 7,000 ha of protected forest reserves are destroyed annually for timber and charcoal. For instance, Langele village, locally referred to as the charcoal factory in northern Uganda, known for its beautiful scenery and thick forests, is no more (Akena, 2012).

Concurrently, urban biowastes, such as Faecal Sludge (FS) from onsite sanitation technologies, are discharged directly to the environment jeopardizing public and environmental health, and large amounts of FS end up in landfills (Diener et al., 2014; Gold et al., 2014; Murray et al., 2013; Strande et al., 2015). Although wastewater sludge has been widely used as a fertilizer in many regions all over the world, it can also provide renewable energy. This study explores the marketability of four different FS end products as a source of fuel in industries.

2. Scope

The study area was mainly Kampala, the capital city of Uganda, and parts of its outskirts. Focus was put on four FS treatment end products namely:

- pellets
- crushed fuel
- char
- FS blended char briquettes

Table 1 gives an overview of the various customer target groups for the different FS treatment end products.

Table 1: Customer target groups for FS treatment end products

FS treatment end product	Customer target group
Pellets	Industries that require heat in their production processes
Crushed fuel	Industries that require a crushed fuel for heat in their production processes
Char	Industries that require a carbonised crushed fuel
FS blended char briquettes	Industries/institutions/households that required a carbonised fuel

3. Methodology

The research was conducted through interviews (mostly face-to-face) with potential customers of each of the FS treatment end products (pellets, crushed fuel, char and FS blended char briquettes).

As most of the end products are relatively new on the Ugandan market, the research focused on how to develop a business case for the end products and also to gather key information from the user perspective taking into account preferences and concerns raised. To analyse the market potential of the different FS treatment end products, business model canvases were developed.

The analysis was based on the Business Model Canvas, a strategic management and entrepreneurial tool, which allows entrepreneurs to describe, design, challenge, invent, and pivot their business model (https://strategyzer.com/canvas). The Business Model Canvas, see schematic representation below, consists of nine basic building blocks:

- Value Proposition
- Customer Segments
- Customer Relationships
- Channels
- Revenue Streams
- Key Activities
- Key Resources
- Key Partners
- Cost Structure

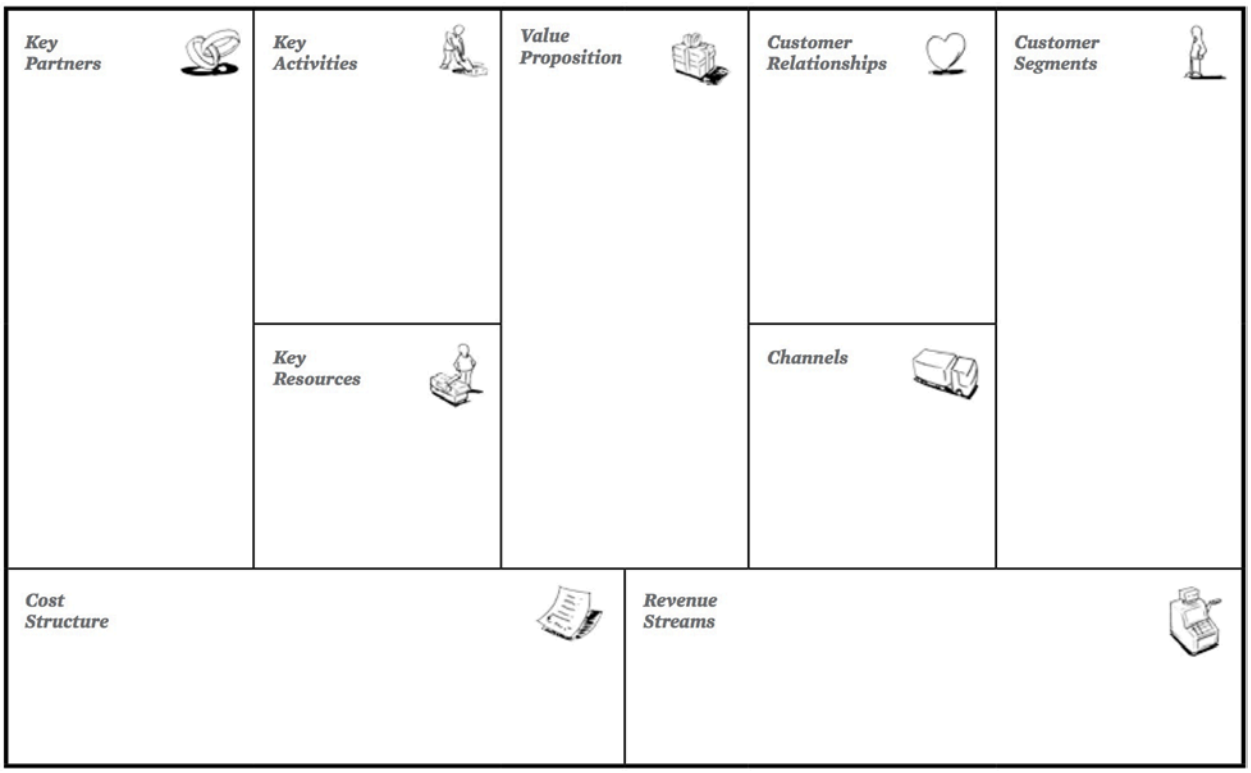

Figure 1: Business Model Canvas

A case study approach was used to collect the primary data. Secondary data collection was done from journals and research publications. The study units were companies, organisations and communities that were potential customers for the FS treatment end products. The study population was selected from 26 companies including fisheries, clay and cement companies.

4. Results and discussions

4.1 Pellets

4.1.1 Introduction

Dewatered FS can be processed into pellets using a Bioburn pelletizer (Englund et al., 2015). In order to improve the fuel quality and increase the fuel quantity, FS can also be co-processed with other bio wastes (Englund et al., 2015). Details on the fuel pellet characteristics are included in Byrne et al. (2015) and Englund et al. (2015).

Figure 2: Pellets in cookstove

4.1.2 Customer segments

Customer segmentation is reliant on what the customer considers as value. We have two customer segments whose needs justify different offers and they would be willing to pay for different aspects of the same product.

Customer segment 1	
Basic product:	Fuel pellets
Market:	
Value proposition:	Produce and deliver fuel pellets customized to meet your energy needs at an affordable price with good ecological reputation
Industry:	Manufacturing companies (such as clay and cement companies)
Size:	Medium enterprises
Location:	Uganda
User status:	Factories that require heat in their production process
Purchase criteria:	Efficient, readily available, quality, high heat emitting crushed fuel at an affordable price
Purchase procedure:	Contractual

Box 1: Customer segment 1 for fuel pellets

Customer segment 2	
Basic product:	Information
Market:	Interns, researchers
Value proposition:	Knowledge enrichment in co-processing FS as high energy fuel source
Industry:	Academia and research
Size:	Varies with extend of required information
Location:	Local and international
User status:	Have a knowledge gap
Purchase criteria:	Experience (duration) in the field, practicality (on ground existence), survival in the market
Purchase procedure:	Contractual

Box 2: Customer segment 2 for fuel pellets

Twenty-six companies, their industries ranging from breweries (2), briquetting (4), cement (2), clay (4), fisheries (4), institutions (1) and tea (7), were contacted during the market research for pellets. The figure below shows the relative distribution among the industries.

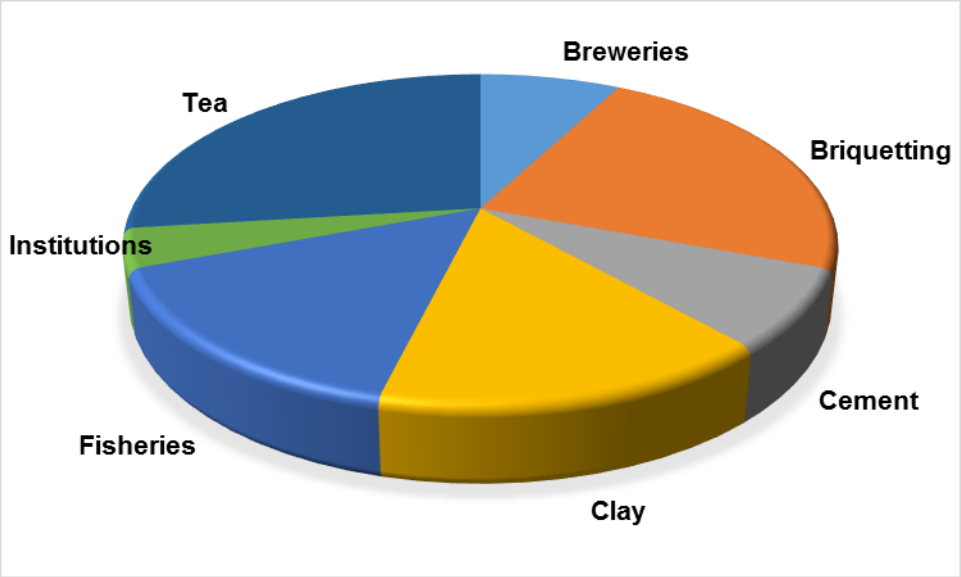

Figure 3: Distribution of industries visits for pellets

The visited companies that expressed interest and had a possibility of applicability in their technologies fall in three categories: clay, cement and tea. The administration of one government university, though willing to test the fuel, mentioned the technology and produced smoke as a limitation.

One tea company expressed interest in complimenting their current fuel (wood) with pellets. However, they wanted the pellets in a bigger size (the size of a briquette) if it were to be accommodated in their technology. Their cooking technology has widely spaced iron bars on which the wood is placed.

Tororo and Hima/Lafarge were the only cement companies contacted. Tororo is currently using coal so Hima was the only one that expressed interest in using the pellets. Hima had a high demand for fuel due to inadequacy of supply for their production process and expressed interest in investment in fuel development on the market (Kanda, A., personal communication). CREEC provided sample pellets for testing at Hima lab however results were never shared. They got an opportunity to try crushed fuel with Kenlon Industries, a fuel supplier, with positive results, (Rubaramira, D., Kenlon Industries).

Uganda Clays and Katale clays are the two clay companies interested in the pellets. Main reasons for this are the unreliability of the agricultural based fuels and associated high prices. Table 2 summarizes the particular fuel requirements of the potential clients.

Table 2: Fuel requirements for potential clients

Organisation	Current fuel type	Fuel use (tons/day)	Costs of fuel (USD/ton)	Fuel requirements
Katale clays	Saw dust	15.3	~ 40	Fuel qualities: interested in charcoal-like glow effect Size: 1 cm by 1 cm Guaranteed supply Temperature range: 850-900 °C
Uganda Clays	Bagasse Coffee husks Saw dust	10-20	Information not provided	Fuel qualities: crushed Size: 4 mm Moisture Content: 17% Calorific Value: 17 MJ/kg Density: 230-250 kg/m3 Ash Content: 10% Test run quantity: 10 bags
Hima cement	Coffee husks Saw dust Rice husks Milled bagasse	400	Information not provided	Fuel qualities: crushed Test run quantity: 100 tonnes Compare pellet variables to coffee husks because it is the ideal fuel Size: 5 mm Moisture Content: 17% Calorific Value: 17 MJ/kg Ash Content: < 30%
Eagle Investments Limited	Firewood and electricity	3-4	1970 per month	Size: larger (briquette size) Temperature ranges: 100-120 °C for 8 hours daily

4.1.3 Key activities

The key activities for pellets are:

- collection of feedstock
- treatment
- mixing
- pelletizing
- drying
- quality control
- packaging and branding
- delivery

4.1.4 Key resources

The key resources for pellets are:

- Raw material suppliers, such as NWSC providing FS, which is dried on their sand beds; supply of other biomass waste streams, like coffee, rice husks, spent grain, banana peels and saw dust, is done on contractual basis depending on the different mixture percentages required.
- Sack suppliers. The sacks are used for packing the pellets for storage and transport. This arrangement is on contract basis.
- Equipment suppliers. Bioburn is the manufacturer of the pelletiser which doubles as an automated mixer and pelletiser. The solar drier was designed, manufactured and assembled on ground by Esmouc Construction, a local company in Uganda.
- Protective gear, including jumpsuits, boots, gloves, nose masks, first aid box and fire extinguishers, are provided by a supplier on contractual basis.
- Additionally, IT technology is required in the form of software for the website (to attract and inform potential customers), accounting (to track sales and profits) and production (to track production capacity progress)

4.1.5 Customer relationships

Established channels include direct contact through email, website/blog, social media, telephone (landline/mobile) and shop front for prompt feedback.

Table 3: Advertising and promotional strategies

Promotion / advertising type	Expected improvement
Workshop day; creating awareness on energy from FS pellets	This promotion type will enlighten potential users on the use of FS pellets.
One-on-one client meetings	This mode of awareness creation promotes consumer confidence as the client's particular needs are met.
Print media advertising Press release Photography	Customers have the information availed in print whenever they need it. Being a new product, the visuals are advantageous in attracting attention.
Social media campaign Facebook, Twitter, google+, watsapp	Creating awareness to a global audience would attract wider customer base due to the wider coverage and potential funding.
Customer incentives Free samples Discounts Branded promo gifts	Customers get a feel of how the service/product is. This leverages your customer base as a sales force i.e. guaranteed referrals.
Follow-up phonecalls	Communication to the client through a phone call is very useful when conducting a follow-up on user experience of the fuel/product.
Exhibitions	Through exhibitions, we take advantage of the exposure since exhibitions attract masses, there's coverage for the product all at a go.
Market research	This helps to find out the competing factors on the market and strategize on how best to take advantage.
Website & direct mail	This provides a two-way avenue for the client to get a quick response, place orders or make inquiries while we get instant feedback on the product.

4.1.6 Distribution channels

From the research, direct channels are encouraged for example company owned stores, sales force and the internet because they are convenient but also allow room for fast feedback much as there are high fixed costs.

4.1.7 Cost structure

Among the fixed and variable costs that will be incurred during the production and marketing of the FS end products include; rent, land, truck, machinery, laboratory, protective gear, labour, utilities, infrastructure, technology (software packages), marketing, purchase of raw materials, licensing fees, fuel, packaging, storage costs, security, taxes, office supplies, maintenance, salaries, etc.

4.1.8 Revenue streams

This section seeks to illustrate the revenue avenues and the pricing mechanisms that the business would use to generate income from the two customer segments.

Table 4: Revenue models for different customer segments

Customer segment	Revenue model	Mode of implementation
Factories that use heat in their production processes	Asset sale	USD per ton of pellets
Interns, scientific and social researchers	Consultant / internship fee	Service charge per unit hours

Payment types accepted: Acceptable payment terms could include cash, cheque and credit for established clients.

Credit policy: the business would establish a credit policy/terms for customers and suppliers detailing duration of the credit period, collection procedures.

4.1.9 Business model canvas

Below is a business model canvas outlining how the bio-pellets would be produced and distributed into the market for the two customer segments.

<table>
<tr>
<td rowspan="2">Key partners

University
NEMA
UNBS
Sack suppliers
Bioburn KCCA
Raw material suppliers

WASH Alliance</td>
<td>Key activities

Research
Administration
Marketing
Storage
Packaging
Drying
Pelletising
Quality control
Pre-treatment
Mixing
Delivery</td>
<td rowspan="2">Value proposition

Produce and deliver high quality bio-pellets of high heat content
Readily available in small cylindrical shape at an affordable price with good ecological values.

Knowledge enrichment in FS processing of pellets as a high energy fuel source</td>
<td>Customer relationship

Dedicated personal assistance

Personal contact</td>
<td rowspan="2">Customer segments

Factories located in Uganda that require heat in their production processes;
Cement
Tea
Clay
Plastics manufacturing
Soap manufacturers
Steel and iron
Paper mills

Research; Academic institutions
Interns
Market researchers worldwide</td>
</tr>
<tr>
<td>Key resources

Warehouse
Lab
Pelletiser
Truck
Solar drier
Protective gear
Mixer
Workers
Tarpaulin
Geotextile
Wheelbarrow
Software

Website</td>
<td>Channels

Sales force
Company stores

Internet</td>
</tr>
<tr>
<td colspan="3">Cost structure

UMA membership
Maintenance
Welfare
Rent
Office supplies
Utilities
Machinery
Sacks
Security
Marketing
Taxes
Research
Licences
Salaries
Truck
Fuel

Website developer</td>
<td colspan="3">Revenue streams

Asset sale

Consultation
Internship</td>
</tr>
</table>

Note: the highlighted wording are applicable to customer segment 2, the non-highlighted to customer segment 1

The major finding was that even though the demand for biomass fuels for productive use keeps increasing, pellets have not had wide application in Uganda yet pellets have a wide potential. Among the biggest limitations to the use of pellets as an energy source is the incompatibility of the technology that is currently being used. Most companies are either using heavy furnace oil or other biomass in either crushed or big sizes.

4.1.10 SWOT, PESTLE and risk analyses

In addition to developing the business model canvas, three other analyses were made:

- SWOT analysis
- PESTLE analysis
- Risk analysis

Each analysis will be explained and addressed below.

SWOT analysis

A SWOT analysis, showing internal factors (in form of strengths and weaknesses) and external factors (in form of opportunities and threats), was performed. The results are displayed in the table below.

Table 5: SWOT analysis for pellets

Strengths	**Weaknesses**
• Solution to sanitation • Burns equally efficiently at an affordable price • Promotes waste management in Kampala through resource recovery. • With a university as a partner, there's access to the latest renewable technologies, thus, the business is able to research and develop innovations • Unlike agricultural residues, pellets aren't limited by seasonal variations	• Currently existing technology require the fuel in a crushed form • There are still research and development gaps • Lengthy drying period
Opportunities	**Threats**
• High need for heat in industries • Unreliable fuel supply • Environmental pressure on wood usage • In the cement factory, klinkers formed are not a very big limitation • Seasonal fuels-coffee husks • Expensive costs of fuel alternatives • Environmental pressure on wood usage	• Competing fuels on the market • Negative perception about FS • Competing fuels • Buyers bargaining power is high as they have a range of suppliers they can receive fuel from. • Supply for FS comes from one waste management site which means that any dysfunction in the operations of that site could affect the whole production cycle • Potential users require a crushed fuel • Health risks to those that come in contact are high

PESTLE analysis

A PESTLE analysis provides an overview of various factors impacting a business. These factors cover various area, as shown in the table below: political, economic, social, technological, legal and environmental, thus yielding the acronym.

Table 6: PESTLE analysis for pellets

Political	**Economic**
• Policy on FS handling • Policy on health and safety	• Taxes on products • Taxes on equipment • Resources used are regarded as waste products hence the cost of acquiring them is very low. • fuel price changes can affect transport
Social	**Technological**
• Lack of knowledge about pellet usage by potential implementers • Increased awareness of environmental issues • To lower the cost of production, companies have to purchase the cheapest form of energy	• Guarantee on fuel availability • Appliances in current usage • No spare parts for the pelletiser • Pellet storage: should address affinity for water during storage • Technological developments • Innovations in the drying applications will quicken production
Legal	**Environmental**
• Certification for operation in FS by NEMA, • Authorisation permits by KCCA • Quality Control and Standards by UNBS	• Disposal of remains

Risk analysis

Lastly, a risk analysis was done revealing market risks and ways of mitigation these risks. Market risks exist in three categories namely; customer risk, competitor risk and supplier risk. However, in this analysis, we used the risk assessment matrix to identify risks of highest priority down to the lowest ones. This enables us to assess the impact of the risks on the business start-up.

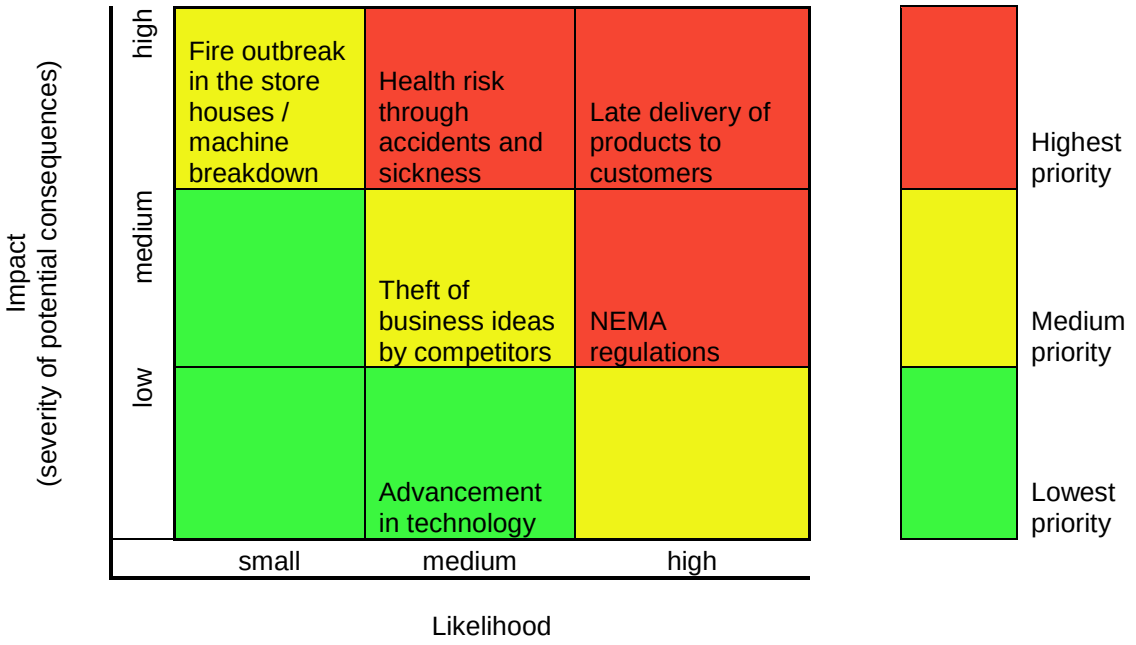

Figure 4: Market risk assessment matrix

A risk management plan was developed to help recognize and rationally respond to both the most obvious risks and the unanticipated occurrences irrespective of the magnitude in a cost effective manner. The risk management plan is shown in the table below.

Table 7: Risk management plan for pellets

Priority	Risk factor	Type	Likelihood	Severity of potential impact	Mitigation tactics
1	Late delivery of products to customers	Operational	High	Large	- Increase production capacity - Increase drying rate
2	Health risk	Operational	Medium	Large	- Health Insurance - Visible signs - Protective gear - Mandatory regular check ups
3	Machine breakdown	Technology	small	Large	- Maintenance - Insurance of machine - Train local engineers - Local fabrications of machine parts to avoid importing spare parts
4	NEMA regulations	Legal Government	High	Medium	- Environmental and Social Impact Assessment - Monitoring & Evaluation
5	Fire outbreak in store houses	Operational	Small	Large	- Install first aid kit - Install fire extinguisher - Fire drill staff training - Emergency exit points
6	Theft of business ideas	Competition	Medium	Medium	- Protect measurements and ingredients during presentations
7	Advancement in technology	Technology	Medium	Low	- Upgrade for particular machine parts

A health and safety plan, as shown in the table below, was also developed.

Table 8: Health and safety plan for pellets

Exposure Group	Process step	Health risk	Exposure route	Mitigation measures
Workers in treatment plant	Pre-treatment of FS	Contamination with faecal pathogens due to handling it before it is completely treated	- Vector borne with flies and maggots - Dermal contact	- Put FS on drying beds to remove pathogens - Restrict access to operations - Insect vector and rodent control
		Foul smell	- Inhalation	- Use of masks
	Mixing	Contamination with faecal pathogens (crushed fuel/pellets)	- Dermal contact	- Wear protective attire
	Pelletizing	Accident		- Maintenance of machines - Instructions
	Drying	Contamination with pathogens (crushed fuel/pellets)	- Ingestion	- Educate workers about hazards - Protective gear
	Quality Control	Contamination with pathogens (crushed fuel/pellets)	- Ingestion	- Place clearly visible signs - Protective gear
	Packing	Contamination with pathogens (crushed fuel/pellets)	- Ingestion - Inhalation - Dermal	- Place clearly visible signs - Wear appropriate protective gear
Marketer	Marketing	Contamination with pathogens (crushed fuel/pellets)	- Dermal contact - Ingestion	- Place clearly visible signs on packaging - Implement a worker well-being programme
Transporter	Delivery to customer	Dusty dry material Foul smell Accident Contamination during on and off loading	- Dermal contact - Inhalation - Contamination - Vector spread	- Training on handling waste during transportation - Place clearly visible signs - Ensure the drivers have authentic driving permits - Protective gear
Customer	Storage	Dust	- Inhalation	- Ensure good ventilation
		Getting damp	- Rain	- Visible signs on packaging
		Contamination with pathogens (crushed fuel/pellets)	- Ingestion	- Insect-vector and rodent control
	Heating	Dust	- Inhalation of aerosols	- Visible signs on packaging
		Foul smell	- Ingestion	- Protective attire
		Contamination	- Dermal contact - Ingestion	- Visible signs on packaging
		Heavy metal disposal		- Ash should be compliant with heavy metal thresholds if it might be reused

4.2 Crushed fuel

Customer base	
Basic product:	Crushed fuel
Market:	
Value proposition:	Produce and deliver crushed fuel customized to meet your energy needs at an affordable price with good ecological reputation
Industry:	Manufacturing companies (such as clay and cement companies)
Size:	Medium enterprises
Location:	Uganda
User status:	Factories that require heat in their production process
Purchase criteria:	Efficient, readily available, quality, high heat emitting crushed fuel at an affordable price
Purchase procedure:	Contractual

Box 3: Customer segment for crushed fuel

Case study: Katale Clays

Katale Clays is among the companies that have been part of the SEEK market study from the early stages. Mr. Kasujja, the production manager at the factory first expressed interest in using the new fuel when approached about pellets in early 2015.

Interest was derived from their search for cheaper alternatives and particularly the ability of the crushed fuel to hold some charcoal properties (glowing without wasting away). With the current fuels being used (sawdust), the clay products at the bottom of the kiln would not get burnt because the sawdust would burn out mid-air. So the crushed fuel was of major interest because the particles get to the bottom when they are still glowing, hence enabling the products at the bottom to get burnt as well.

On 23 May 2016, the company was given four bags of a blended crushed fuel. The mixture was composed of 70% FS and 30% coffee husks. From their observation, except for the blower going off during the firing (which affected movement of heat in the kiln), the company was able to achieve the desired temperatures of 850-900 °C. Also, the produced clay product had a similar quality as those fired with saw dust.

A second test was conducted with 5 bags of 100% FS and the performance was monitored by the technical team from the SEEK project together with Katale Clays staff. Initially the crushed fuel was fed into the kiln after the fire had built up. Observations were heat build-up at the bottom of the kiln but the flames were not getting high enough to burn the clay products at the top of the kiln so saw dust was introduced and then it was a perfect blend as all products were catered for and required temperatures attained.

The variables to be tested for include: replacement rate and savings accumulated, existence of bad smell, temperature variables, ease of use, quality of final product

Table 9: Parameters assessed during product testing at Katale Clays

Parameter	Observation
Replacement rate	More bags of saw dust were used because the moisture content was high in some of the crushed fuel sacks so there was a need to mix a higher proportion of sawdust.
Existence of foul smell	None (the workers were sniffing hard to try and guess the ingredients).
Temperature variables	Took a while to be attained but increased when mixed with the sawdust. The crushed fuel wasn't completely dry.
Ease of use	Less labor intensive; unlike the sawdust that is sometimes delivered with unwanted materials in the sacks, the crushed fuel does not require sorting before being fed into the kiln.
Quality of final product	Same as with saw dust.
Willingness to pay	Willing to pay the same or lower cost than the current fuel substitute (poultry waste).
Performance	Good, because it generates the required heat and enables the products at the bottom of the kiln to get burnt as well.

On 20 July 2016 bricks were removed from the kiln at Katale Clays Limited to witness the unpacking of the kiln and examine the products. Overall, the clay products from the course in which SEEK fuel was used came out just as fine as the rest of the products from other parts. However, since the heat was concentrated in the lower layers, some products at the top most layers were not properly burnt hence a whitish discoloration which implies it can easily develop cracks. The products from the very bottom were overly burnt hence turning black. Katale Clays staff were impressed with the performance [firepower] of the fuel, but expressed two concerns:

- The bulk density of the fuel since it was settling at the bottom. They however attributed it to the high moisture content. With further drying, the fuel should be able to fire well from the top to bottom.
- The ability to supply in bulk vis-a-vis cost of fuel. In that regard some computations of the currently used fuels were done for comparison purposes when the product is finally on the market.

The main fuels being used include fine saw dust and wood shavings. Poultry refuse is used as a supplementary fuel in times of scarcity.

Table 10: Fuels, amount and costs per fueling cycle

Fuel type	Unit costs (USD/ton)	Amount	Total costs (USD)
Poultry refuse	~ 21	8	~ 170
Wood shavings	~ 20-40	5	~ 600
Fine saw dust	~ 40	5	~ 530

Note:
The costs of wood shavings and fine sawdust were reported in USD/truck (121 USD/truck for wood shavings and USD 106/truck for fine sawdust). For sake of uniformity and comparison, these have been transferred into USD/ton using the following assumptions:

- Wood shavings weigh between 250 to 500 kg per cubic metre, depending on moisture content (http://arbtalk.co.uk/forum/general-chat/14505-whats-weight-wood-chip.html and http://www.simetric.co.uk/si_materials.htm)
- Fine saw dust weighs 210 kg per cubic metre (http://www.aqua-calc.com/calculate/volume-to-weight and http://www.simetric.co.uk/si_materials.htm)
- A truck load is approximately 12.5 m3 (2.5 m wide x 5 m long x 1 m high)

4.3 Char

Case study: Strong Youth Foundation International

Water for People together with private partners are in the process of planning to construct an institutional kiln to carbonize FS. In this section a business model canvas was used to derive how they plan to make char production from FS potential business.

<table>
<tr>
<td rowspan="2">Key partners

KCCA
Private emptier companies
NWSC
Transport company
Kitezi landfill
Waste collectors
Supporting companies like; GVEP, REBI, Living Earth Uganda
WASH Alliance
Water for people

University</td>
<td>Key activities

Marketing/sales
Networking
Transportation
Awareness creation
Collection of raw materials
Sorting
Drying
Carbonising
Branding and packaging
Distribution</td>
<td rowspan="2">Value proposition

Efficiently performing char from organic waste materials available in bulk at subsidised prices
Minimum risks
User friendly
Safe</td>
<td>Customer relationship

Automated communication
Aftersales services
Free delivery services within Kampala
Bonuses for bulk purchases
Contractual basis</td>
<td rowspan="2">Customer segments

Carbonised briquette manufacturers as a major raw material

UMEME for earthing purposes</td>
</tr>
<tr>
<td>Key resources

Retort Kiln
Wood
FS
Protective gear
Licences
Solar drier
Human resource
Trucks
Laboratory
Engineering experts</td>
<td>Channels

Internet

Use of agents</td>
</tr>
<tr>
<td colspan="3">Cost structure

Kiln Maintenance
Rent
Office supplies
Website
Utilities
Kiln
Sacks
Security
Marketing
Taxes
Research
Licences
Salaries
Truck
Fuel</td>
<td colspan="3">Revenue streams

Asset sale
Supporting organisations, e.g. which supports start-up businesses related to renewable energy</td>
</tr>
</table>

Table 11: SWOT analysis for char

Strengths	Weaknesses
• Partnering with NWSC guarantees supply of FS • Safe product when carbonised • Offer free delivery with bulk purchases • Use of efficient drying technologies • Partnerships with char vendors	• There's a need for expertise skills like engineers to build large kiln for FS carbonising
Opportunities	**Threats**
• Availability of bulk buyers • Supporting organisations have access to numerous briquette producers • Seasonality of organic waste • REBI supports innovations in renewable energy • Increasing prices of charcoal dust	• Inadequate funding • NWSC will construct a biogas system at its Bugolobi plant; although this may not affect availability of FS from Lubigi, the impact is unknown (e.g. more FS may be delivered to Bugolobi instead of Lubigi) • Overall price of FS char is higher than the market price of competitor (char dust) • Users are scared of touching it

This char will be competing with the charcoal dust that is currently being used in addition to organic matter. The charcoal dust is currently being sold on average at around USD 21 per ton (Nakitende, C. & Tumwesige, V., personal communication). Among the costs that will be incurred while setting up a char production business will ne; FS, kiln, labour, fuel, marketing and possibly a truck for distribution. Being a new product on the market, there is need to concentrate efforts on awareness creation to convince buyers to make the new decision.

4.4 Faecal sludge blended char briquettes

Most producers deal in carbonised briquettes producing mainly stick, pillow and honeycomb briquettes using charcoal dust and organic matter. They are majorly small-scale producers supplying households, poultry farmers and a few institutional consumers.

The process of carbonised briquette production requires heating the dried biomass (FS and other organic waste) in the absence of oxygen to produce char which is mixed with binders (e.g. starch to prevent the briquette from disintegrating) before it is briquetted.

As shown in Table 12, in this section we present companies that have ventured into the production of FS blended char briquettes and though still in the early stages, were operational at the point of writing. Among them is Sanivation, a company based in Naivasha, Kenya. They are currently producing pillow shaped briquettes at 30% FS to 70% charcoal dust. Being sold at the same price as wood based charcoal in households and restaurants within Naivasha province.

In Uganda, three companies produce FS blended briquettes namely CAPIDA, Strong Youth Foundation for Development International (SYF4DIN) (Namagembe, 2016) and a youth group from Kole district working closely with Water For People (Kasozi, 2016). However for this report we shall focus on SYF4DIN based in Nansana, Uganda.

Table 12: Briquette composition and price per company

Company	Composition	Price (USD/kg)
CAPIDA	FS = 40%	0.39
SY4DIN	FS = 50%	0.77
Kole residents	FS = Information not provided	0.21
Green Bio Energy / Briketi	Organic Matter + Charcoal Dust	0.24
Green Heat Uganda	Organic Matter + Charcoal Dust	0.77
Sanivation (Naivasha, Kenya)	FS = 30% (solar treated, uncarbonized)	2.40

From the business development workshop held 18 June 2016, the briquette companies that were represented came up with three models for selling FS blended briquettes. The business model canvas below summarized all the three into one canvas.

<table>
<tr>
<td rowspan="2">Key partners

Suppliers (such as NWSC and pit emptiers)
Financial institutions
Distributors
Licensing and standards bodies
Local and global associations
Academia
Development partners
(Inter)national NGOs
Stove manufacturers
Local leaders</td>
<td>Key activities

Collection
Production
Packaging
Distribution
Marketing
Sensitisation
Training</td>
<td rowspan="2">Value proposition

Training on usage
Delivery
Long lasting
High intensity for heat
Converting waste to wealth
Reliable and sustainable cooking/energy solution through high quality carbonized FS briquettes
Emptying pit latrines and give briquettes in return
Clean and healthy and smokeless cooking
Sustainable fuel supply
Cost saving</td>
<td>Customer relationship

Functional website
Social media
Relationship desk
Networking
Local media
Political and peer educators
Client visits
Workshops/trainings
After sales services
Printed materials</td>
<td rowspan="2">Customer segments

Households
Educational institutions
Prisons
Poultry farms
Restaurants
Other industrial customers like chapatti stalls, saunas, bakeries, blacksmiths</td>
</tr>
<tr>
<td>Key resources

Personnel
Briquette making knowledge
Equipment
Trucks
Outlets
Infrastructure
Finances</td>
<td>Channels

Outlets and stalls
Supermarkets
Markets
Door to door
Exhibitions
Worship places</td>
</tr>
<tr>
<td colspan="3">Cost structure

Human resource
Technology
Raw materials
Utilities
Rent
Maintenance of equipment
Distribution and transport
Marketing
Licences
Taxes</td>
<td colspan="3">Revenue streams

Sale of briquettes and stoves
Consultancy and trainings
Grants and Equity investment
Supporting organisations like REBI (Supports start-up businesses related to renewable energy)
Payment methods may include; cash, credit, bank and mobile money</td>
</tr>
</table>

Two of the ten represented companies are currently producing FS blended briquettes. For the success of this business intervention, the following points should be considered as raised by the briquette manufacturers;

- Follow up on customer satisfaction
- Regular monitoring visits and surveys
- Provide after sales services
- Sensitization is very important, but there is a need for bigger platforms to sensitize the masses
- Psychological change of attitudes towards FS, be it elite (well educated) or non-elite (non-educated) users
- The local language used to translate the word FS may have a negative impact on uptake
- Focus groups (for example in churches and markets) can be used to teach people that briquettes from treated FS have no negative health impacts
- Ensuring high-quality and reliable products
- Think of certification of briquettes
- Cleaner product than current solutions
- Long lasting
- Easy to use
- Think of complimentary goods, such as stoves, to bind customers to your product
- Conserving the environment can be a factor in decision making
- Provide incentives for people to use FS briquettes, such as low price but also free samples to try the product
- Maintain a stable price
- Customers are willing to pay for better alternative fuels
- Provide alternatives for paying, e.g. cash or credit
- Reliable supply of products, currently the production rates of briquettes are low
- There are few briquette compatible stoves available on the market
- Record keeping and documentation of business numbers and impact is very important, for example when applying for grants and when talking to investors
- Think of signing Memoranda of Understanding with key partners (such as distributors, but also other notable briquette suppliers) to secure working and solid relationships to strengthen business
- Establish fixed routes instead of driving around haphazardly to reduce distribution costs

5. Conclusions and recommendations

Having discussed the findings about the different market based approaches to apply the FS treatment end products, we recommend the following:

With regard to the negative perceptions towards FS, we recommend making deliberate efforts towards the positive marketing of these products. During client visits, particular attention should be paid to the translations used because that affects perception of the products. Sensitization efforts should be organized in such a way as to target wide coverage and increase adoption rates.

There should be long term price consideration so that once the products are on the market, the sales are not affected by fluctuating prices yet the product is still in its initial stages of adoption on the market. Once tested, the product should be sold at the same price as the products on the market with improvements in the value proposition like packaging, delivery or aftersales services.

There should be development of a database for better data collection so that conclusions made are based upon comprehensive research so that businesses are in a better position to inform policy makers. For instance, about standards for carbonized briquettes since there's no clear policy guidelines.

Further research is required in the following areas; safety of pellets for handling, emissions from pellets, research on availability, durability and usability of FS, more research on the smell and social acceptance.

Being an important step of the sanitation chain; that is, maximizing value through the use of waste treatment products, more investment is required in the creation of awareness about how use of these resources/end products which will in turn help to achieve better sanitation in the environment/community.

The following factors should be taken into consideration when promoting FS briquettes (Essien, J., personal communication);

- Behavioural aspect of the users
- Consumers require more information
- Requires testing of the product to provide information about; time spent cooking, starting time, burning rate, ash content, moisture content, environmental factors and also address concerns about the smoke and smell

The latter has been addressed in Kiwana et al. (2016).

Pellets

Even though potential clients are particularly impressed with the possibility of blending the fuel with other co-processed agricultural wastes to achieve the desired fuel properties, fuel applicability is limited by the incompatibility of the fuel with the technology they currently use. A crushed form of the fuel would be ideal for the conversion technologies of these factories.

Crushed fuel

Many companies use technologies that require a crushed fuel to generate heat thus providing excellent opportunities for selling the crushed fuel. The heat produced meets the client's requirements as it can be blended with any other fuel.

Char

The assessments show that there is demand for char from the briquette manufacturers who need it as a raw material. The efforts of the support organisations is an opportunity to take advantage of using partnerships so that it is easier for the entrepreneurs to get access to clients and get financial support.

FS blended char briquettes

Production and sale of FS blended char briquettes is a marketable venture as shown by the existing FS briquette producers; SY4FDIN and CAPIDA. Sanivation also provides another reference point for the success story. As long as the briquettes perform equally efficiently, they can compete favourably on the market. The SEEK project demonstrated that FS briquettes perform similar to regular charcoal from wood and briquettes from biomass (Kiwana et al., 2016).

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