2015

Market Assessment of RRR Business Models – Kampala City Report

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Executive Summary

Introduction

The feasibility studies conducted in Kampala are a core of the research project and sought to explore across different settings the applicability, adaptability and comprehensiveness of the proposed business models in real-life settings; resulting in the strengthening of the methods and procedures, but also in view of scalability and viability. A key component of the feasibility studies is the market assessment of the RRR business models as functioning markets, an enabling institutional environment and positive economic and financial conditions are essential for sustainable business activity in any sector including the waste reuse sector. This report thus presents the results of the market assessment as part of the feasibility testing for the implementation of waste reuse (resource recovery and reuse - RRR) business models in Kampala, Uganda.

The set-up of any RRR business and the commercialization of a new product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends among other factors particularly on market demand. Specifically, the question of whether a demand actually exists and the price end-users are willing to pay for this new product needs to be explored. "Demand, even among those with limited resources, is not automatic." (Phillip et al., 2003; page 194). For this reason, the market assessment set out to evaluate the current and potential market for the recovered resource and the effect of different factors (e.g. socio-cultural aspects and perceptions, price of substitute products, etc.) on market demand. Information on market segments, potential clients of the RRR product, their actual and potential number and resource absorption capacity and their willingness-to-pay (WTP) were assessed.

Additionally, the adoption of effective marketing and pricing strategies to ensure business sustainability require entrepreneurs to comprehensively understand the dynamics inherent in the relevant sub-sectors. This translates into the need for evaluating the structure (i.e. competition, differentiation of substitute products, barriers to market entry, among others) of the product market they operate in, i.e. how the behavior and performance of other businesses influence their decision making. Another important facet to the market assessment is demand forecasting – i.e. market outlook. Market forecasting is a crucial element for business owners in assessing future capacity requirements, evaluating their decisions in the implementation of new business strategies and pricing decisions. Businesses need to adopt different strategies ranging from establishing key partnerships and price markups to maintain a competitive advantage and ensure sustainability. An assessment of the above listed aspects provides entrepreneurs with a solid market information base crucial for business start-up and sustainability. In that regard, the specific objectives of the market assessment were:

1. To assess the market value of the RRR products under consideration –
    a. To assess consumers' willingness-to-pay (WTP) and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
    b. To estimate the potential market size for the RRR product;
2. To assess the extent and characteristics of the market structure;
3. To evaluate the market outlook of the RRR products and to what extent the RRR products would be viable over time in the market.

A total of 8 RRR business models was selected for the feasibility studies in Kampala. For the purposes of the market assessment, an end-use typology of the business models was employed as although the underlying concept of the business models were different, a number of the end-products were the same across different business models. Thus for some business models, the related customer segments and relevant actors along the value chain considered would be the same. In that regard, for the selected business models, the following 5 value-added products were considered: 1) briquettes, 2) electricity, 3) treated wastewater, 4) MSW-based compost and 5) faecal sludge-based compost. Untreated wastewater is not considered a marketable commodity as it is considered to increase human health risk and environmental pollution and thus potential users' valuation was not assessed.

Table A: List of RRR business models and related products

Business Model	Value-added product	Recovered resource
Model 1a: Dry fuel manufacturing: agro-waste to briquettes	Briquettes	Energy
Model 2a: Energy service companies (agro-waste to energy (electricity)	Electricity	
Model 4: Onsite energy generation by sanitation service providers		
Model 9: On cost savings and recovery (treated wastewater for irrigation)	Treated wastewater	Wastewater
Model 10: Informal to formal trajectory in wastewater irrigation	Untreated to partially treated wastewater	
Model 15: Large-scale composting for revenue generation (MSW to compost)	MSW-based compost	Nutrients
Model 17: High value fertilizer production for profit (faecal sludge to compost)	Faecal sludge-based compost	
Model 19: Compost production for sanitation service delivery (faecal sludge to compost)		

Methodology

▪ Overview of Methodology

The successful development of any RRR business depends on the effective workings of different facets of the respective value chain including: (a) market linkages between related subsector markets; (b) business dynamics between relevant economic actors and (c) consumers' responsiveness to newly developed and available products. When introducing a new product into the market, businesses are particularly interested in three factors: current and future consumer demand, competition and production costs. Though cost estimations are simple and straightforward, the assessment of consumer demand (as measured by willingness-to-pay (WTP)) and competition are comparatively more complicated and not a straight forward calculation as historical data of consumer purchase patterns are guidelines at best (Lusk and Hudson, 2004). Specific methods were developed and used for the evaluation of the consumers' WTP, the assessment of market structure and outlook. The choice of methods for evaluating the different research questions were dependent on the context, the related RRR product, access to data and analytical tools to be employed. The WTP and market outlook analysis viewed the business models from an end-product perspective, whilst the market structure was conducted from a sector perspective; i.e. (a) alternative fuel market, b) electricity market, c) water market and d) fertilizer market.

- **Study Area and Data**

The primary survey covered five key districts in Kampala. For the WTP and market size assessment, primary data on price offers from market experiments, information on demographics and socio-economic factors were collected from different groups of respondents depending on the RRR product. Data on price of substitute products, macro-economic factors, amongst others were collected from secondary sources. WTP measures were derived directly from the purchase price and additional econometric analysis. For the market structure, both primary and mostly secondary data were collected and used for the supply chain analysis, although this was dependent on the RRR product. Data on the number and size of key players, players' characteristics (e.g. economies of scale, access to financing, marketing and distribution costs, and level of integration and nature of contractual agreements) were collected from primary sources. For the market outlook assessment, data on market demand and market share were obtained from the WTP and market structure assessment components. Additional secondary data on alternative products, prices and quantity of sales of existing competing products in the market was collected from relevant institutions (e.g. marketing boards and departments).

Results of the Market Assessment

- ***Model 1: Dry fuel manufacturing: Agro-waste to briquette***

The results indicate that there is a growing and substantial market demand for briquettes in Kampala. Most of respondents were found to be aware of the benefits and costs of briquettes and were willing to pay over and above the current market price of 1000 UGX (Ugandan shillings)/kg. The WTP estimates for businesses and households were 1.5 – 2 and 2 – 3 times higher than the current market price of competitive products, respectively. Subsequent scenario analyses to assess the impact of trade-offs associated with the implementation of different government policies on consumers' WTP for briquettes indicated that households, in particular, were willing to pay 3 times higher than the current price of substitute products with the institution of an enforceable law which prohibits the use of non-renewable energy sources with a fine equivalent to the current market price. A similar effect on WTP estimates was observed for businesses although the marginal price increase was lower than that of the households.

The potential total market demand was estimated under the following assumptions: a) under 2 scenarios - S1 (status quo - no change in legislation regarding use of non-renewable energy sources) and S4 (an enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price of the prohibited fuel when caught); b) adoption rate for households of (78.5% under S1 scenario, 82% under S4 scenario) and businesses (63% under S1 scenario, 93% under S4)[1]; c)surrounding districts considered to be notable potential markets - Luwelo, Mpigi, Mukono, Wakiso and Kampala. The potential market demand for briquette is significant and estimated at 55,400 tons/year and 240,000 tons/year for households and businesses, respectively. The difference in market demand with the implementation of an enforceable law (S4) is notable but not significant.

[1]Based on the assumption that adopters are considered to have a WTP $\geq$ 1000 UGX/kg. Percentages were derived from cumulative demand curves.

Table B: Mean Willingness-to-Pay of Briquettes with and without cheap talk method

Scenario	Households		Businesses	
	Without cheap talk	With cheap talk	Without cheap talk	With cheap talk
No change in current legal environment	1913.2 (6558.34)	1660.38 (4431.59)	866.67 (296.34)	826.67 (283.98)
Government institutes a law that prohibits the use of non-renewable energy sources but you are unsure if it is enforceable yet	1839.2[a] (5787.45)	2517.02[a] (6656.48)	1083.33[b] (512.66)	1226.67[b] (635.14)
An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine when caught of an unknown amount *(could be lower or higher than* market price of fuel)	2755.1 (8466.45)	2716.73 (7110.73)	1350.00[c] (543.77)	1483.33[c] (662.85)
An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price of the prohibited fuel when caught	2678.6 (7784.09)	2806.92 (6886.65)	1516.67[d] (885.55)	1633.33 [d] (937.10)

[a, b, c, d] Differences in estimates are statistically significant.
Standard deviations are in parentheses.

Whilst the current production level of briquettes is unknown, it is clear that it is a nascent industry with minimal entry barriers, and supportive and existing policies encouraging business development. There are several factors that will catalyze the development of the briquette industry: a) instituted government policies on renewable energy [favorable policies to improve charcoal trade standardization; certification will restrict illegal timber trade; plans to increase the National Forestry Authority levies on charcoal burners with the support of UNDP] and b) better efficiency on energy value that will increase market demand. Specific marketing strategies are however required as there are no established retail distribution networks as yet (only super markets and institutions); and there is a level of difficulty in linking up with the existing charcoal retail network. While there are currently limited financial incentives (e.g. VAT exemption; higher upfront production cost than for charcoal and firewood production), there are special lending schemes for briquette businesses. In terms of the market outlook of the product, the penetration of RRR briquette products can be facilitated by the prevailing market conditions. A lower market price than the prevailing price of charcoal may increase consumer adoption rates. Strong awareness programs coupled with promotional approaches will be important to further increase market demand due to the strong positioning of the charcoal market and further shorten the growth stage which is currently estimated between 5 – 8 years.

- ***Model 2a: Energy service companies at scale: agro-waste to energy and Model 4: Onsite energy generation by sanitation service providers***

The potential market for waste-generated electricity was assessed as measured by households and businesses' WTP estimates (table C). The results of the study indicate that businesses have a WTP (ranging between 319.07 – 355.94UGX/ kwh) lower than that of the current unit prices charged by the Uganda Electricity Transmission Company (UETCL) at a rate of 450UGX/kwh. Similarly, the WTP estimates for households are significantly lower than the current tariff set by UETCL. Generally, there is a significant and growing demand for electricity in Kampala and opportunities for waste-to-energy entities to fill this gap based on the anticipated rapid rural electrification program; foreseeable

increasing trend in electricity prices; structural and legal feasibility for private sector involvement (structural unbundling of the Ugandan power sector, vertically integrated monopoly and privatization of the generation and distribution); a lesser vertically integrated market; and supportive renewable energy policies among others. The WTP estimates however suggest that although there are incentives to catalyze investment, there is limited demand, which is predictive of the potential pricing strategy to be implemented. The increasing number of independent power producers (IPP) in the energy sector in recent years is also indicative of the structural feasibility of the Ugandan electricity sector. Electricity producers are however currently price takers and restricted to the price ceiling set by the state-owned transmission entity – UETCL (limited negotiation ability – monopolistic market). Thus, in actuality, the level of market concentration, price setting behavior and potential net profit margins (business performance) will determine the sustainability of a waste-to-energy business, which for the first two factors are significant limiting drivers. The opportunity for waste-generated electricity can only materialize when price offers in power purchase agreements (PPA) can substantially cover production costs. Additional limiting factors to business development and sustainability in the sector are: a) continued interest and large hydro-power potential; b) significant interest in small hydro-power projects and c) waste-to-energy projects currently viewed as high-risk ventures by financial investors. While producer prices can be increased, additional market failures inherent in the energy sector can only be rectified with the institution of sound policies.

Table C: Mean Willingness-to-Pay for Waste-generated electricity with and without cheap talk method

	Households (UGX/kwh)		**Businesses (UGX/kwh)**	
Scenario	Without cheap talk	With cheap talk	Without cheap talk	With cheap talk
Current state of affairs is unchanged	270.74	291.97	349.34	319.07
A policy allows the national electricity company (UMEME) to raise the price of the grid-power by 10% annually	280.78	297.25	400.06	347.36
Power shortages occur as much as twice compared to the current situation due to increasing number of electricity users	282.26	295.57	419.40	355.92
An environmental law instituted by the government that raises cost of treating wastes by other methods and applies a heavy fine for illegal waste dumping	282.08	292.97	420.06	349.34

Statistical significance of differences in estimates yet to be assessed.

- ***Model 9: On cost savings and recovery and Model 10: Informal to formal trajectory in wastewater irrigation***

Models 9 and 10 were assessed based on one product (i.e. treated wastewater) as we assume that untreated wastewater is not a formally marketable commodity given the associated human health risks. A choice experiment was implemented with two key customer segments: a) businesses/industries and b) farmers. About 98 percent of the enterprises surveyed expressed a high level of satisfaction with the current quality of water supplied by the National Water and Sewerage Corporation (NWSC) and 96% noted facing no shortages with water supply. Only 7% of the respondents expressed interest in using treated wastewater, particularly for washing purposes, and also noted willing to pay higher prices than the current fees at UGX 500/m^3. The results however indicated that this subset of enterprises did not have a strong preference for certification (i.e. had no valuation for 3rd certification that the wastewater delivered was treated to an acceptable level). However, it is quite clear that enterprises have a strong preference for connections provided by NWSC and that quarterly payments seemed more suitable.

Farmers, on the other hand, showed a higher interest in wastewater reuse for irrigation purposes. About 74% of the surveyed farmers were willing to pay for reliable supply of treated wastewater to their farms. This finding is supported by the sources that the farmers obtained water from - with about 37% dependent on groundwater, 13% on rain-fed irrigation, 26% received water through pipes and 10% from the canals. The remaining percentage relied on springs and swamps for irrigation water. The total payment elicited by the farmers for treated wastewater supplied by NWSC was UGX 530/m^3. It was also noted that the farmers would prefer supply from NWSC and interestingly were willing to pay more for certification. While 70% of the respondents preferred operation, maintenance and delivery by NWSC, 12% preferred KCCA and 10% opted for farmers' organizations. The results also indicate that farmers are willing to pay higher if the treated wastewater is delivered through canals and payments are made on a quarterly basis.

The total number of agricultural households in the urban and peri-urban areas of Kampala was estimated at 44,962 households (Makita, 2009). Assuming a conservative adoption rate of 70% by farmers, the total number of farms demanding treated wastewater would approximately be 31,473 farming households and total agricultural land at 31,473 hectares. Gross irrigation water requirement in Uganda is estimated at 8000 m^3/ha/year (FAO, 1997). Hence the total water requirement in the urban and peri-urban area of Kampala can be estimated to be about 250 million m^3 in a year. This demand estimate clearly exceeds the total wastewater generated in the city. It is important to note however that the estimated demand may be limited by costs related to delivery especially for farmers located far off from the wastewater treatment plants.

- ***Model 15: Large-scale composting for revenue generation (MSW-compost)***
- ***Model 17: High value fertilizer production for profit and Model 19: Compost production for sanitation service delivery (faecal sludge-based organic fertilizer)***

The market assessment for MSW-based compost, in addition to estimating consumers' WTP and demand for the product, evaluated their specific WTP for attributes of the compost product. This represents pertinent market information on the types of pricing strategies new businesses should implement. The results indicate that there is a significant demand for compost as measured by the consumers' WTP, which is significantly higher than the average market price for substitute products at 100 UGX/kg. The results indicated that the farmers were willing to pay more to know the source of the input materials used to produce the compost (i.e. MSW, faecal sludge and/or animal waste). The marginal WTP analysis shows that farmers are willing to pay 58.78 UGX/kg more to know the sources of materials used to produce compost, 45.97 UGX/kg for pelletized compost and 30.09UGX/kg for certified compost. This suggests that high quality compost product if labelled with information on source of the inputs, has 3rd party certification and is pelletized will command a market price of 234.84 UGX/kg - which is almost 2.5 times higher than the current market price. Likewise the demand for faecal sludge-based compost (models 17 and 19) was significant with average WTP values ranging between 713 and 1098 UGX/kg. The marginal WTP analysis shows that farmers are willing to pay 161 UGX/kg more for fortified compost and 580 UGX/kg more for certified compost. However, 97UGX/kg will be needed to compensate farmers to use pelletized compost.

The potential market for MSW-compost is noted to be substantial with the demand estimated at 0.78 million tons/year, with an adoption rate of 49% and application rate of 12.5 tons/ha/year. The potential market for Fortifer was estimated at 0.026 million tons/year, assuming an adoption of 38% and application rate of 0.5 tons/ha/year. It is important to note that notable surrounding agricultural

districts were considered in the market size estimation, i.e. Luwelo, Mpigi, Mukono and Wakiso in addition to Kampala. The total cultivated area under the 5 districts considered is 130,000 ha (Source: Uganda Census of Agriculture, 2008/09 Volume 4). Additionally, chemical fertilizer application rates were used as a basis for the calculation of the application rates for MSW-compost and Fortifer (IFPRI, 2012). The average chemical fertilizer applications were estimated at 107.5kg/ha and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product. MSW-based compost, on the other hand, is considered to be a complementary product to chemical fertilizer.

Whilst the current production level of compost is unknown, it is clear that it is a burgeoning industry with some entry barriers but supportive and existing policies encouraging business development. The organic fertilizer market is less commercialized and the related market structure and business dynamics are very informal. Given data limitations, the inorganic fertilizer market, which is more formal, commercialized and well-researched during past decades was used as the basis to the extent possible for the market structure and outlook assessment. A market condition that would potentially impact the development of compost businesses is the market power held by chemical fertilizer producers. The fertilizer market in Uganda is highly concentrated – the top four fertilizer importers (except the commercial farms) accounted for about 92% with the largest importer taking 56% of the fertilizer market. This suggests a very high concentration - which is characteristic of a strong oligopolistic market. The chemical fertilizer market has however never expanded to a significant level due to an ineffective fertilizer policy. Though liberalization of Uganda's fertilizer market had its own legacy to increase market competition via inducing the participation of private sector, high cost of entry and participation in fertilizer trade make the fertilizer market imperfectly competitive. Barriers to entry indicate an important determinant of market concentration of the fertilizer markets. Although chemical fertilizers represent the largest share of the market, a limited established distribution network represents an opportunity that organic fertilizer producers can capture. Additionally, there is neither a large-scale government fertilizer program that provides subsidized fertilizer to farmers nor an active private fertilizer sector that supplies fertilizer at competitive prices. Thus, this represents a great opportunity for waste-based organic fertilizer businesses who can take advantage of erratic chemical fertilizer prices and the limited number of actors in the respective market. On the other hand, the product mix available of chemical fertilizer products is rather extensive, reflecting the grade (nutrient)-specific requirements of the commercial crop growers (estates and horticultural crop farms). This suggests that new organic fertilizer businesses will need at the start-up a highly unique and differentiated product, and innovative marketing strategies to mitigate the effects of the currently limited marketing and distribution channels available in the fertilizer market.

The overall feasibility of the business models was then evaluated based on the different aspects (market demand, market structure and market outlook). It was noted that models 1a, 17, 19 have a high feasibility and model 15 - medium feasibility from a markets' perspective (Table D). On the other hand, waste-to-energy models, in particular agro-waste and faecal sludge to electricity have a low feasibility potential from a market perspective.

<u>Legend for Table D:</u>

- **BM 1a:** Dry Fuel Manufacturing: Agro-Waste to Briquettes
- **BM 2a:** Energy Service Companies at Scale: Agro-Waste to Energy (Electricity)
- **BM 4:** Onsite Energy Generation by Sanitation Service Providers (faecal sludge to electricity)
- **BM 9:** On Cost Savings and Recovery (wastewater use for irrigation, energy and nutrient recovery)
- **BM 10:** Incentivizing safe reuse of untreated wastewater
- **BM 15:** Large-Scale Composting for Revenue Generation (municipal solid waste to compost)

- **BM17:** High value Fertilizer Production for Profit (combination of municipal solid waste and faecal sludge to organic fertilizer)
- **BM 19**: Compost Production for Sanitation Service Delivery (faecal sludge-based compost and urine

Table D: Overall feasibility of the selected RRR business models from a market perspective

Business model	WTP and Market Demand	Market Structure	Market Outlook	Cumulative feasibility score	Value-added product/recovered resource
Model 1a – Dry fuel manufacturing: agro-waste to briquettes	WTP > Current market price of substitute product	1. Easy market entry 2. Low-to-medium level of concentration 3. Limited to no product differentiation 4. Price setter 5. Potential net profit margins	6 – 7 years to reach growth stage in business life cycle	**High feasibility**	**Briquettes**
Model 2a – Energy service companies at scale: agro-waste to energy (electricity)	WTP < Current market price	1. Difficult market entry 2. High level of concentration (oligopolistic market) 3. No product differentiation 4. Price taker 5. Potential negative profit margins (without subsidies)	Limited data to evaluate business life cycle	**Low feasibility**	**Electricity**
Model 4 – Onsite energy by sanitation service providers	WTP < Current market price	1. Difficult market entry 2. High level of concentration (oligopolistic market) 3. No product differentiation 4. Price taker 5. Potential negative profit margins (without subsidies)	Limited data to evaluate business life cycle		
Model 9 – On cost savings and recovery (wastewater reuse)	WTP < Current market price	With an inexistent formal wastewater market, the assessment of its structure would be limited to a base reference of the freshwater market, which in this case would result in a flawed assessment.	Not applicable	**Low feasibility**	**Wastewater**
Model 10 – Informal to formal trajectory in wastewater irrigation	WTP < Current market price	Same as for Model 9.	Not applicable	**Low feasibility**	
Model 15 – Large-scale composting for revenue generation (MSW to compost)	WTP > Current market price of competitive/ substitute products	1. Medium level of difficulty for market entry 2. Limited level of concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 – 7 years to reach growth stage in business life cycle	**Medium feasibility**	**Compost**
Model 17 – High value fertilizer production for profit	WTP > Current market price of competitive/ substitute products	1. Easy entry 2. Limited level of concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 – 7 years to reach growth stage in business life cycle	**High feasibility**	**Faecal sludge-based organic fertilizer**
Model 19 – Compost production for sanitation service delivery					

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Abbreviations

BETs	Biomass efficient technologies
CE	Choice Experiment
CL	Conditional Logit
CV	Contingent Valuation
FIT	Feed-in tariffs
FS	Faecal Sludge
GDP	National Gross Domestic Product
GEF	Global Environment Facility
IPP	Independent Power Producers
KCCA	Kampala Capital City Authority
MC	Market Concentration
MCA	Multi-Criteria Assessment
MSW	Municipal Solid Waste
NWSC	National Water and Sewerage Corporation
PCA	Principal Component Analysis
PPA	Power Purchase Agreement
REFIT	Renewable Feed-in tariffs
RET	Renewable Energy Tariff
RRR	Resource Recovery and Reuse
SCP	Structure–Conduct–Performance
UBOS	Uganda Bureau of Statistics
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company
UGX	Ugandan Shillings
UHS	Uganda Household Survey
UIA	Uganda Investment Authority
UNDP	United Nations Development Program
UNICEF	United Nations International Children's' Emergency Fund
VAT	Value Added Tax
WHO	World Health Organization
WtE	Waste to Energy
WTP	Willingness to pay

1. Introduction

Functioning markets, an enabling institutional environment and positive economic and financial conditions are essential for sustainable business activity in the resource recovery and reuse (RRR) waste sector. The feasibility study methodology builds on a multi-criteria assessment (MCA) and identified performance indicators which allow the accurate assessment of the viability and scalability potential of the RRR business models based on several elements including an institutional, policy and market, health and environmental assessment. Assessing the feasibility of a business model in settings of different levels of development means that (1) if a business was to be set-up based on a particular model would it be viable – *replication potential*, or (2) would a particular model be viable at different scales - *scaling-up potential.* This requires an in-depth understanding of the functionings of both the input and output markets, enabling institutional environments and positive economic and financial conditions, which are all essential in assessing the sustainability of business activity.

In particular, the set-up of any RRR business and/or commercialization of a new product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends among other factors particularly on market demand. Specifically, the question of whether a demand actually exists and the price end-users are willing to pay for this new product needs to be explored. For this reason, the market analysis sets out to assess the current and potential market for the recovered resource and a myriad of factors (e.g. socio-cultural aspects and perceptions, substitute products available in the market, etc.) that will influence market demand. Information on market segments, potential clients of the recovered resource, their actual and potential number and resource absorption capacity (e.g. who, what, when, where, how much, how often) and their willingness-to-pay was assessed. Additionally, businesses adopt different strategies ranging from establishing key partnerships, price markups, etc. to maintain a competitive advantage and ensure sustainability. This information base will serve the purpose of providing new and existing entrepreneurs with pertinent market information crucial for the start-up/development of their business but also opportunities to explore new market segments and further solidify the sustainability of their businesses. In that regard, the specific objectives of the market assessment were:

1. To assess the market value of the RRR products –
    a. To assess consumers' willingness-to-pay (WTP) and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
    b. To estimate the potential market size for the RRR product;
2. To assess the extent and characteristics of the market structure;
3. To evaluate the market outlook of the RRR products and to what extent the RRR products would be viable over time in the market.

A total of 8 RRR business models were selected for the feasibility studies in Kampala

Table **1**).

Table 1: Selected RRR Business Models for Feasibility Testing in Kampala

RRR Business Models	Brief Description
ENERGY	
Model 1a: Dry Fuel Manufacturing: Agro-Waste to Briquettes	The business entity processes crop residues like wheat stalk, rice husk, maize stalk, groundnut shells, coffee husks, saw dust etc. (any agro-based waste) and converts them into briquettes as fuel to be used in households, large institutions and small and medium energy intensive industries.
Model 2a: Energy Service Companies at Scale: Agro-Waste to Energy (Electricity)	The business processes crop residues like wheat stalk, rice husk, maize stalk, groundnut shells, coffee husks, saw dust etc. to generate electricity which is sold to households, businesses or local electricity authority.
Model 4: Onsite Energy Generation by Sanitation Service Providers	The business model is initiated by either enterprises providing a sanitation service such as public toilets or by residential institutions such as hostels, hospitals and prisons with a concentrated source of human waste (i.e. faecal sludge). The business concept is to process and treat human waste in a bio-digester to generate biogas to be used for lighting or cooking.
WASTEWATER REUSE	
Model 9: On Cost Savings and Recovery	The business concept is to treat wastewater for safe reuse in agriculture, forestry, golf courses, plantations, energy crops, and industrial applications such as cooling plants. The sludge from the treatment plant can be used as compost and soil ameliorant and energy generated can be used for internal purposes resulting in energy savings.
Model 10: Informal to Formal Trajectory in Wastewater Irrigation - Incentivizing safe reuse of untreated wastewater	Informal reuse of wastewater is commonly practiced by farmers in developing countries but it also entails significant health costs, often borne by the public and are of social nature. This social nature of these costs justifies public investments in incentives to promote safe reuse of wastewater and minimize risk along the entire value chain as such incentives could potentially turn this unsafe informal activity into a safe and formal one with shared rewards for all the stakeholders.
NUTRIENTS	
Model 15: Large-Scale Composting for Revenue Generation	The business concept is to better manage Municipal Solid Waste (MSW) and recover valuable nutrients from the waste that would otherwise be disposed off in landfills without reuse. Compost from MSW is sold to farmers, landscaping, and plantations and other entities.
Model 17: High value Fertilizer Production for Profit	Similar to Model 15 in concept but in addition to MSW, the business uses faecal sludge as an input from onsite sanitation systems which is rich in nutrients. There are opportunities for pelletization and blending of faecal sludge-based compost with rock-phosphate, urea/struvite or NPK which is an additional value proposition that can be explored under this business model, allowing the product to have nutrient levels specific for target crops and soils, and a product structure improvement (pellets) to improve its competitive advantage, marketability and field use.
Model 19: Compost Production for Sanitation Service Delivery	The business concept is to provide sanitation service provision and to manage and transform human excreta into safe fertilizer and soil conditioner.

For the purposes of the market assessment, an end-use typology of the business model was employed as although the underlying concept of the business models were different, the end products were the same. Thus for some business models, the related customer segments and relevant actors along the value chain considered would be the same. In that regard, for the selected business models, the following 5 value-added products were considered: 1) briquettes, 2) electricity, 3) treated wastewater, 4) MSW-based compost and 5) faecal sludge-based compost (Table 2). Untreated wastewater is not considered a marketable commodity as it is considered to increase human health risk and environmental pollution and thus potential users' valuation was not assessed.

Table 2: List of RRR business models and related products

Business Model	Value-added product	Recovered resource
Model 1a: Dry fuel manufacturing (agro-waste to briquette)	Briquettes	Energy
Model 2: Independent power producer (agro-waste to electricity)	Electricity	
Model 4: Onsite energy generation (faecal sludge to electricity		
Model 9: Treated wastewater for irrigation	Treated wastewater	Wastewater
Model 10: Untreated wastewater for irrigation and groundwater recharge	Untreated, partially treated wastewater	
Model 15: Centralized large-scale compost production (MSW to compost)	Compost	Nutrients
Model 17: High quality branded and certified organic fertilizer (faecal sludge to compost)	Faecal sludge-based compost	
Model 19: Sustainable sanitation service delivery via compost production (faecal sludge to compost)		

Chapter 2 provides an overview of the methods used in assessing each of the specific objectives. Chapter 3 is categorized into five sub-chapters covering the WTP, market structure and outlook assessment for each of the value-added products outlined in table 2. This chapter provides the results and discussions of the related analysis. The overall feasibility assessment of the business models is presented in Chapter 4.

2. Methodology

2.1 Overview of Methodology

The successful development of any RRR business will depend on the effective workings of different facets of the respective value chain including: (a) the market linkages between the related subsector markets; (b) the business dynamics between relevant economic actors and (c) consumers' responsiveness to newly developed/ available products. When introducing a new product into the market or simply entering a new industry, businesses are particularly interested in three factors: current and future consumer demand, competition and production costs. Though cost estimations are simple and straightforward, the assessment of consumer demand (as measured by willingness-to-pay) and competition are comparatively more complicated and not a straight forward calculation as historical data of consumer purchase patterns are guidelines at best (Lusk and Hudson, 2004). Specific methods were developed and used for the evaluation of the consumers' WTP, the assessment of market structure and outlook. The choice of methods for evaluating the different research questions were dependent on the context, the related RRR product, access to data and analytical tools to be employed. The subsequent sections will outline in detail the data collection tools and estimation approaches. The WTP and market outlook analysis viewed the business models from an end-product perspective, whilst the market structure was conducted from a sector perspective (a) alternative fuel market, b) electricity market, c) water market and d) fertilizer market).

2.1.1 Willingness-to-pay and Market size estimation

When introducing a new product into the market, businesses are particularly interested in two factors: consumer demand and production costs. Stated and revealed preference methodologies have gained immense popularity in eliciting consumers' valuation of new products (Lusk and Hudson, 2004; Kimenju and Groote, 2008).The choice between the use of stated or revealed preference methods is dependent on the RRR product under consideration. Stated preference methods such as contingent valuation method are typically used for assessing consumer WTP of products with inexistent market price (Adamowicz and Deshazo, 2006; Freeman, 2004). An example would be that of faecal sludge-based organic fertilizer which is a new product in the fertilizer market. Alternatively, revealed preference methods such as hedonic pricing can be used to obtain the price of a good via real market purchasing mechanisms. These methods are grounded in economic theory of welfare analysis and can normally also be used for the valuation of goods and services without market prices or shadow prices. Contingent valuation approaches have been successfully applied in the estimation of the demand for compost in Ghana (Danso et al., 2006); Tanzania (Valerian et al., 2011), and Ethiopia (Hagos et al., 2012). For the purposes of this study, contingent valuation methods were applied for the WTP assessment of the energy business models (i.e. briquettes, electricity) and choice modeling for the nutrient and wastewater business models. Based on the WTP measures, the potential market size of the RRR products was estimated.

2.1.2 Market structure assessment

This assessment was based on the notion that businesses require information on the extent and characteristics of the market structure for decision-making on strategies that ensure firm performance. To achieve this, a structure–conduct–performance (SCP) evaluation model was applied along the different stages of the product supply chain. The SCP approach provides insights into how markets function in the real world as opposed to in theory (Holtzman 2002; Wanzala et al. 2009). The SCP approach is based on the underlying rationale from economic theory of competitive markets, which suggests that competitive markets produce efficient prices and quantities. If a monopolist or oligopolist dominates a market, the lack of competition yields higher prices and lower quantities traded. If the market structure is monopolistic or oligopolistic, then prevailing prices may be higher than what they would be in a competitive market. The SCP approach assesses the structure of the market (number of actors involved), their conduct (what products/services they perform), and how those two things lead to the performance of the market—in terms of prices, quantities traded, and costs of performing various functions. Based on this analysis, insights of market performance and possible strategies that businesses can adopt (measured in terms of price and accessibility) can be drawn. To set the stage for assessing the market structure, the supply chain for competitive products was evaluated. This served to identify the constraints and distortions affecting the functioning of the markets of competitive products been considered and propose suitable mitigation measures to address these distortions. The supply chain analysis utilized data from the market size, key players in the supply chain, regulatory framework and subsidy programs. The SCP framework was applied as follows:

1. The **structure of the market** was assessed from four aspects: market concentration (MC), product differentiation (as measured by businesses' awareness of differentiated products), market integration (e.g. extension of credit between businesses) and conditions for entry in sector (threshold capital requirements, sources of funding). An MC ratio based on market share was calculated and monthly turnover data for relevant businesses was used to measure market share.
2. The **market conduct** was evaluated based on the behaviour (whether players are price-taking or price-making agents: pricing and promotion) and activities of existing competing businesses. If data was available, their performance was assessed as reflected in the variation of their cost elements. A structural pyramid of players, functions and the **performance** of the product markets was developed to highlight the different dynamics.
3. An overview of the factors affecting the functioning of the different market was evaluated to capture supply-side constraints (e.g. business environment, taxes, tariffs) and demand-side factors (access to financing, production risk, purchasing power).

Both primary and secondary data were collected and used for the supply chain analysis, although this was dependent on the RRR product. For example, supply chain analyses have been conducted on the fertilizer market in many agricultural dependent countries. If applicable to the city/country, these served as key sources for secondary data. Data on the number and size of key players, the characteristics of these players (e.g. economies of scale, access to financing, marketing and distribution costs, and level of integration and nature of contractual agreements) was collected from primary sources.

2.1.3 Market outlook assessment

The evaluation of the market outlook, i.e. market forecasting will aid new and existing RRR businesses in planning for the future. Because investment toward an uncertain future is very difficult and risky, market forecasting tools have been developed to alleviate the risk and to obtain more accurate or reliable information. This assessment is a projection of demand levels in the future, based on current or

past evolutions. A Bass model is usually used to describe consumers' behavior in relation to their loyalty towards a product. Most frequently, this model is used in marketing for dynamic forecasts of the market demand against the background of intense rivalry between products or brands. Since most of the RRR products are new in the market, it will be difficult to obtain time series data to develop a standard demand equation for the market trend analysis. Thus, to forecast the revenue or profit of a new product, the initial income from existing businesses if available was used. For a given RRR product, a Bass model was applied to analyze the market demand over time. In addition, this approach was used to estimate the growth in demand of an RRR-business product with other competing products.

2.2 Study Area and Data

The primary survey covered five key districts in Kampala as shown in the figure 1 below. For the WTP and market size assessment, primary data on price offers from market experiments, information on the demographics and socio-economic factors was collected from different groups of respondents depending on the RRR product. Additionally, data on price of substitute products, macro-economic factors, etc. were collected from secondary sources. WTP measures were derived directly from the purchase price and additional econometric analysis. For the market structure, both primary and mostly secondary data were collected and used for the supply chain analysis, although this was dependent on the RRR product. Data on the number and size of key players, the characteristics of these players (e.g. economies of scale, access to financing, marketing and distribution costs, and level of integration and nature of contractual agreements) was collected from primary sources. For the market outlook, data on market demand and market share were obtained from the WTP and market structure assessment components. Additional secondary data on alternative products, prices and quantity of sales of existing competing products in the market (e.g., quantity of fertilizer sold per year, time series data of fertilizer, etc.) was collected from relevant institutions (e.g. marketing boards and departments). Revenues and cost data was collected from existing business as well as alternative input and output products markets. The sampling strategy for the different research aspects and models are outlined in Table 3.

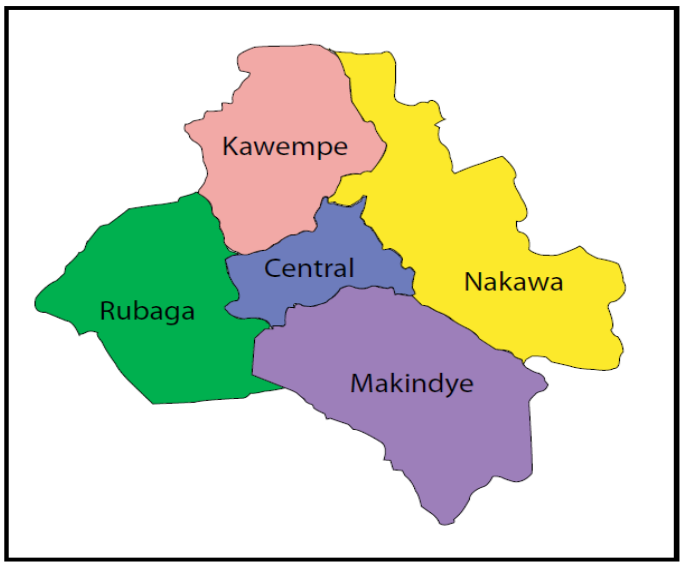

Figure 1: Map of Kampala City, Uganda showing administrative divisions of the city

(Source – Kampala, the Capital City of Uganda, 2005)

Table 3: Sampling Strategy for Market Assessment

Sub-research components	Business Models										
	BM 1a [Briquette]		Model 2a & 4 [Electricity]		Model 9 & 10 [Wastewater]		Model 15 [Compost]		Model 17 & 19 [Faecal sludge-based fertilizer]		
WTP and Market size	H = 527	B = 32	H =300	B = 81	F = 201	B = 95	H = 84	F = 254	H = 96	F = 179	L = 50
Market structure	*Alternative fuels sector* D = 40; P = 25 W = 25		*Electricity market* G =2 TD = 2		*Water sector*		*Fertilizer market* I = 10 D =10				
Market Outlook	Time series 2° data; 1° data from WTP assessment										

Legend:

H = Households
B = Businesses
F = Farmers
L = Landscape designers, floriculturists, golf clubs

D = Distributors
P = Producers & Processors
W = Wholesalers & Retailers

G = Generation
TD = Transmission & Distribution
I = Importers

2.3 Data Collection Tools and Estimation Approach

2.3.1 Willingness-to-pay and Market size estimation

When introducing a new product into the market, businesses are particularly interested in two factors: consumer demand and production costs. Stated and revealed preference methodologies have gained immense popularity in eliciting consumers' valuation of new products (Lusk and Hudson, 2004; Kimenju and Groote, 2008).

- ***Stated preference methods:*** Stated preference methods refer to a direct survey approach to estimating the value place on a non-market good or services. This approach attempts to measure the willingness-to-pay directly through surveys that ask respondents about their evaluation of changes in the level of quality of a good or services (i.e. value-added compost). The approach does not require the good or services to be linked to actual market transactions. It asks respondents in a hypothetical market if they would pay a specified amount for a prescribed product (Adamowicz and Deshazo, 2006; Freeman, 2004).
- ***Revealed preference methods****:* Critics argue that stated preference methodologies are not incentive-compatible as individuals' dominant strategies are not truthfully revealed with respect to their preference for the good as WTP values are elicited in a hypothetical and less than realistic environment and are based on intended behavior. Preference-revealing methods such as experimental auctions and real-purchase decision mechanism procedures address the problem of hypothetical bias when eliciting WTP values for new product attributes. Based on behavior rather than intentions, methodologies such as experimental auctions, real purchase decision mechanisms involve the exchange of real money and real goods in a market environment which offers great incentives for consumers to reveal their true preferences (Lusk et al., 2006; Shaw et al., 2006). With subjects aware of the fact that an exchange of real money and real goods occur even in an experiment, this enforces them to reveal their true valuation of the product. Revealed preference theory is based on the notion that consumers are rational and make purchasing decisions subject to

a budget constraint. They buy goods from a set of alternatives that maximize their utility, given prices of other goods and prices they can afford to pay and their socioeconomic and demographic characteristics (Deaton and Muellbauer, 1980).

The choice between the use of stated or revealed preference methods was dependent on the RRR product under consideration. Stated or revealed preference methods can be used in estimating the market size of RRR products. Stated preference methods such as contingent valuation method are typically used for assessing consumer WTP of products with inexistent market price (Adamowicz and Deshazo, 2006; Freeman, 2004). An example would be that of faecal sludge-based organic fertilizer which a new product in the fertilizer market is. Alternatively, revealed preference methods such as hedonic pricing can be used to obtain the price of a good via real market purchasing mechanisms. These methods are grounded in economic theory of welfare analysis and can normally also be used for the valuation of goods and services without market prices or shadow prices. Contingent valuation approaches has been successfully applied in the estimation of the demand for compost in Ghana (Danso et al., 2006); Tanzania (Domonko, 2011), and Ethiopia (Hagos et al., 2012). For the purposes of this study, the contingent valuation method was applied for the WTP assessment of the energy business models (i.e. briquettes, electricity) and choice modeling for the nutrient and wastewater business models. Based on the WTP measures, the potential market size of the RRR products was estimated. These results provide useful information that will help business owners and policy makers decide on the most cost effective means of obtaining inputs and setting their product market price. The estimation of the potential market size of any RRR product will be determined by: 1)identifying the major users of the product in each city; 2) developing a criteria to stratify and sample within each group with an appropriate sampling technique; and 3) estimating the demand for the product based on the willingness to pay and ability to pay of the end-users.

3. Results and Discussion of Market Assessment

3.1 Model 1a: Dry fuel manufacturing: agro-waste to briquettes

3.1.1 Willingness-to-pay and Market Estimation

3.1.1.1 Background and Justification

In the past years, there have been many challenges associated with the use of biomass for local economic developments. In recent years however, biomass as a renewable energy is getting better recognition internationally and locally because it can improve the basic energy supply in developing countries. Although there are many biomass products, briquettes and the pelletization of organic products have contributed to the energy crises in the developing world, where their primary need is for heating and cooking. The increasing demand of briquettes in many developing countries can be linked to increased socio-political discussions on future energy supply to technological progress, which has helped change the perceptions of biomass as a renewable energy source worldwide. It is obvious that the use of briquettes and other biomass products as a renewable energy source can improve the overall economic conditions of households and businesses. However, like many new technologies, economic and marketing challenges still remain to be resolved. This analysis seeks to contribute to this discussion via the assessment of the potential demand and influencing market factors for the briquette industry in Kampala, Uganda.

There are many approaches that energy economists, resource economists and other development economists apply to assess the demand for renewable energy products. In this study, a contingent valuation (CV) method was used to estimate the market demand for briquettes in Kampala. The CV approach is effective and efficient in assessing non market values of products and especially suitable in this case as there is very limited to no historical market data for the product. There are many applications of the CV approach for assessing the demand for renewable energy. Abdullah and Jeanty (2011) applied the approach to assess the demand for rural electrification connection in Kisumu district, Kenya. Zografakis et al. (2010) used the approach to assess public acceptance and willingness to pay for renewable energy sources in Crete as did Twerefou (2014) in Ghana. Based on our knowledge, this is the first study that applies a CV approach to assess consumers' WTP for briquettes in Uganda. To develop a solid baseline on consumer consumption of alternative fuels and their purchasing decisions, the key objectives of the analysis was:

1. To assess consumers' knowledge, current use and willingness-to-pay (WTP) for briquettes;
2. To determine factors that influence consumers' willingness-to-pay for briquettes;
3. To estimate current and potential market demand for briquettes in Kampala.

The subsequent sub-sections outline the research methods, data collection and analytical assumption and key findings.

3.1.1.2 Research Methods and Data Collection

Among the firmest criticisms of the CV approach is the tendency of survey respondent to overstate their WTP for improvements in a public good or an increase in quality of a private good(Lusk, 2003). Notable evidence of this problem can be found in many studies (Cummings, Harrison, and Rutstrom, 1995; List and Gallet, 2001; Loomis et al.1994; Neill et al.1994). Previous studies has shown the use of the cheap talk approach to effectively minimise the hypothetical bias (Fox et al., 1998; List and Shogren, 1998, Cummings and Taylor, 1999; List, 2001). Although successful at mitigating hypothetical bias, the application of the cheap talk approach has been limited to controlled experimental settings in the developed countries and widespread application in the developing world is insignificant (Lusk, 2003). To this end, two scenarios were implemented in the market experiments: 1) without cheap talk and 2) with cheap talk. The first scenario elicited respondents' WTP for briquettes based on their perceived benefits from briquette use compared with the alternative. Subsequently, respondents were asked to state their maximum WTP given the status quo and under three different government policies – allowing the assessment of the trade-offs associated with each government policy on consumers' WTP for briquettes. The states of the world considered were:

1. No change in the current legal environment (S1);
2. Government institutes a law that prohibits the use of non-renewable energy sources but the respondent is unsure if the law is enforceable yet (S2);
3. <u>An enforceable</u> law instituted by the government that prohibits the use of non-renewable energy sources with a fine when caught of an unknown amount *(could be lower or higher than* the current market price of fuel) (S3);
4. <u>An enforceable</u> law instituted by the government that prohibits the use of non-renewable energy sources with a <u>fine equivalent</u> to the current market price of the prohibited fuel when caught (S4).

In Kampala, two main customer segments were identified as potential users of briquettes: households and businesses. The latter segment in Kampala have been noted to consist mainly of institutions (academic institutions, hospitals); eateries (restaurants) and small to medium-scale industries (e.g. poultry). The survey was thus implemented for the WTP elicitation of 520 households and 30 businesses in Kampala; including both current users and non-users of briquettes.

3.1.1.3 Results and Discussion

- **Socio-economic characteristics of households**

<u>Households:</u> The survey was implemented in 5 major districts, namely: Kampala District, Luwero, Mpigi, Mukono and Wakiso.Table 4 provides an overview of the socio-economic characteristics of the respondents. Although a stratified random sampling strategy was implemented, the majority of the respondents were female (84%). A significant percentage of the respondents had at the least a primary education. This result is particularly important as this suggests that respondents understand the efficiency and potential incremental value derived from briquette use compared to alternative energy sources – thus being able to correctly evaluate their purchasing decisions. The average household size was 4.85 with the majority of respondents falling within the range of 0 to 4 members per household. The respondents are involved in different employment activities, with the majority falling within an annual income range of 1 – 5 million Ugandan Shillings (UGX).

Table 4: Socio-economic characteristics of respondents - households

Variable	Description	Frequency	Percentage (%)
Gender	Male	81	15.6
	Female	437	84.4
Age	less 25	173	33.33
	26-35	176	33.91
	36-45	90	17.34
	46-55	46	8.86
	56-65	22	4.24
	66+	12	2.31
Education	Never been to school	33	6.37
	Primary school	167	32.24
	Secondary school	270	52.12
	Post-secondary	48	9.27
Household size	0-2	71	13.73
	between 2-4	209	40.43
	between 4-6	152	29.40
	between 6-8	45	8.70
	between 8-10	23	0.04
	10+	17	3.29
Income	120000-1000000	74	14.48
	1000000-5000000	319	62.43
	5000000-10000000	89	17.42
	10000000+	31	6.07
Occupation	Business	316	60.77
	Farming	24	4.62
	government	9	1.73
	NGO/private	50	9.62
	Unemployed	114	21.92

Businesses: A total of 30 businesses were surveyed for the WTP analyses. The table below shows that there are 5 key types of enterprises in Kampala that could be potential users of briquettes - the key one being the entities in the food and restaurant sector.

Table 5: Types of businesses and institutions

Types of enterprises	Number of enterprises	Percentage of total enterprises surveyed (%)
Hospital	1	3.3
Agricultural industries	5	16.7
Schools	8	26.7
Food & Restaurants	15	50.0
University	1	3.3

- **Awareness, knowledge and current use of briquettes**

Households: Economic theory suggests that demand can be influenced by socio-economic characteristics, price of product and competitive products and also importantly the attributes of the product (Lancaster, 1966). In the frame of these theories, the current knowledge and usage of briquettes among the respondents were evaluated. The survey results indicate that about 86% of the respondents had prior knowledge of briquettes. The respondents mostly obtained information about briquettes through briquettes dealers (41%), friends and family members (27%), neighbours (24%) and through the media (8%). Of those that were familiar with the briquette product, 61% currently used briquettes for household cooking. The majority of users note cost effectiveness, higher energy value and smokeless attributes as key factors that influenced their use of briquettes. It is important to note that the majority of users were female (82%), engaged in diverse business activities (62%) with higher educational levels (55%).

Businesses: The results indicate that the surveyed enterprises have all heard about briquettes and have all previously used the product. Interestingly, over 90% of the enterprises are still currently using briquettes mainly for cooking purposes. Only 50% of the enterprises use charcoal and 20% use firewood. This is an interesting result suggesting the gradual product switch by enterprises. The enterprises' perceptions of the benefits gained from the use of briquettes over other fuel types were also assessed. The results indicate that the enterprises rank the following factors as providing the greatest benefits - briquettes are: a) less costly, b) longer burning time, c) higher energy value compared to alternative products. This result was corroborated from their assessment of the level of importance of these benefits to them.

Table 6: Entrepreneurs' perceptions of benefits gained from briquette use over other fuels

Assessment factors	Number of enterprises	Percentage of total enterprises surveyed (%)
Less costly	22	73.3
Longer burning time	28	93.3
Higher energy value	22	73.3
Easy to handle and store	7	23.3
Environmental friendly	3	10.0
Less ash content	1	3.3
Smokeless (minimal health hazard)	11	36.7
Time saving	4	13.3

- **Willingness-to-pay (WTP) for briquettes**

This section presents the results from 2 scenarios (without and with cheap talk) implemented in the contingent valuation survey for both the households and businesses. In addition to assessing the effects of the cheap talk approach on the respondents' WTP, non-parametric analyses was conducted to evaluate the statistical significance of any differences in the WTP values under different states of the world (i.e. implementation of governmental laws related to non-renewable energy sources). In this sub-section, the survey results of respondents mean WTP are reported and later compared with the mean WTP under considerations of cheap talk. The Kolmogorov-Smirnov (K-S) test carried out in SPSS shows

that the sample data is normally distributed. The base scenario (i.e. S1) captures the current situation when there is no change in the legal environment on the use of non-renewable energy sources. S2 is the scenario considered when the government institutes a law that prohibits the use of non-renewable energy sources, but there are uncertainties as to whether this law is enforceable or not. S3 is the scenario where there is an enforceable law that prohibits the use of non-renewable energy sources with an unknown fine. S4 is the scenario which implements an enforceable law, but also institutes a fine equivalent to the current market price of the prohibited fuel when one is caught.

The results indicate that there is a growing and substantial market demand for briquette in Kampala as measured by the estimated WTP values. Overall, the results suggest that most of respondents are aware of the benefits and costs of briquettes and are willing to pay over and above the current market price of 1000 UGX (Ugandan shillings)/kg. The analysis shows that households are willing to pay about 1913 UGX/kg for briquettes, which is about 2 - 3 times higher than the current market price of competitive products. However, the mean WTP decreases by 4% when scenario, S1 is compared to scenario S2 (Table 7). This result indicates that respondents tend to place a lower valuation on the use of briquettes, if there is uncertainty associated with the current law governing the use of non-renewable energy sources. Conversely, households are willing to pay more (40 - 44%) when the government institutes an enforceable law that prohibits the use of non-renewable energy sources with a fine when caught.The statistical analysis across these scenarios shows that these differences are significant at 1% and 5% levels. Overall, these results tend to suggest that respondents are more willing to pay for briquettes if government regulations restrict the use of non-renewable energy sources even though there are no clear enforcement mechanisms.

Table 7: Mean Willingness-to-Pay with and without cheap talk - Households

					Statistical difference test between without & with cheap talk			
	Households		**Businesses**		**Households**		**Businesses**	
Scenario	Without cheap talk	With cheap talk	Without cheap talk	With cheap talk	t-value	*P-value*	t-value	*P-value*
No change in current legal environment(S1)	1913.2 (6558.34)	1660.38 (4431.59)	866.67 (296.34)	826.67 (283.98)	.974	.330	1.185	.246
Government institutes a law that prohibits the use of non-renewable energy sources but you are unsure if it is enforceable yet (S2)	1839.2[a] (5787.45)	2517.02[a] (6656.48)	1083.33[b] (512.66)	1226.67[b] (635.14)	-2.697	.007	2.586	.015
An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine when caught of an unknown amount *(could be lower or higher than* market price of fuel) (S3)	2755.1 (8466.45)	2716.73 (7110.73)	1350.00[c] (543.77)	1483.33[c] (662.85)	.112	.911	2.504	.018
An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price of the prohibited fuel when caught (S4)	2678.6 (7784.09)	2806.92 (6886.65)	1516.67[d] (885.55)	1633.33[d] (937.10)	-.438	.662	2.536	.017

[a, b, c, d] Differences in estimates are statistically significant.
Standard deviations are in parentheses.

Additional comparisons as noted in Figure 2 show that non-users, on average, have a higher WTP estimated at 2890 UGX/kg than the current users of briquettes at 2047 UGX/kg, across all the policy scenarios. This is indicative of the fact that current users are able to exact their valuation of the benefits of briquettes given prior knowledge and experience from use.

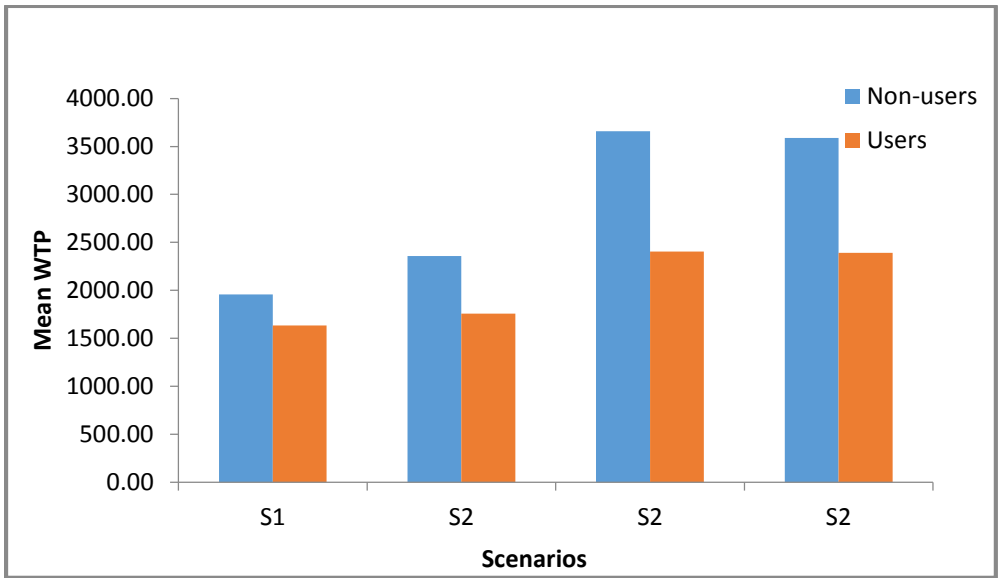

Figure 2: Mean WTP of User and Non-Users of Briquettes - Households

Similarly, the WTP estimates for businesses are higher than the current market price of competitive products at about 1.5 – 2 times higher than the latter; although on average lower than the WTP of households. This result may be indicative of the ability of businesses to negotiate a lower price given their larger scale. Comparisons of WTP estimates across the different policy scenarios yielded results similar to that of the households. Due to data limitations, the businesses were classified into three main groups: 1) food industries (i.e. restaurants, roasters), 2) institutions (i.e., schools, universities and hospitals) and 3) agricultural-based enterprises (i.e., poultry, industry). The analysis shows across all the scenarios that agricultural-based enterprises are willing to pay more than either the institutions or the food industries (Figure 3). This provides pertinent information on pricing strategies for businesses - where there can take advantage of customer segmentations.

A comparison of the cheap talk scenario of the mean WTP estimates show significant trade-offs among the respondents' choices for both households and businesses. Previous studies have shown that cheap talk can improve willingness to pay estimates by correcting hypothetical bias, which is associated with CV of studies. In this regard, the mean WTP was compared across the four scenarios and variations in the mean willingness to pay of the respondents were evaluated. Respondents were willing to generally pay less with cheap talk; and its statistical significance suggest that the use of the cheap talk method can influence a respondent's decisions.

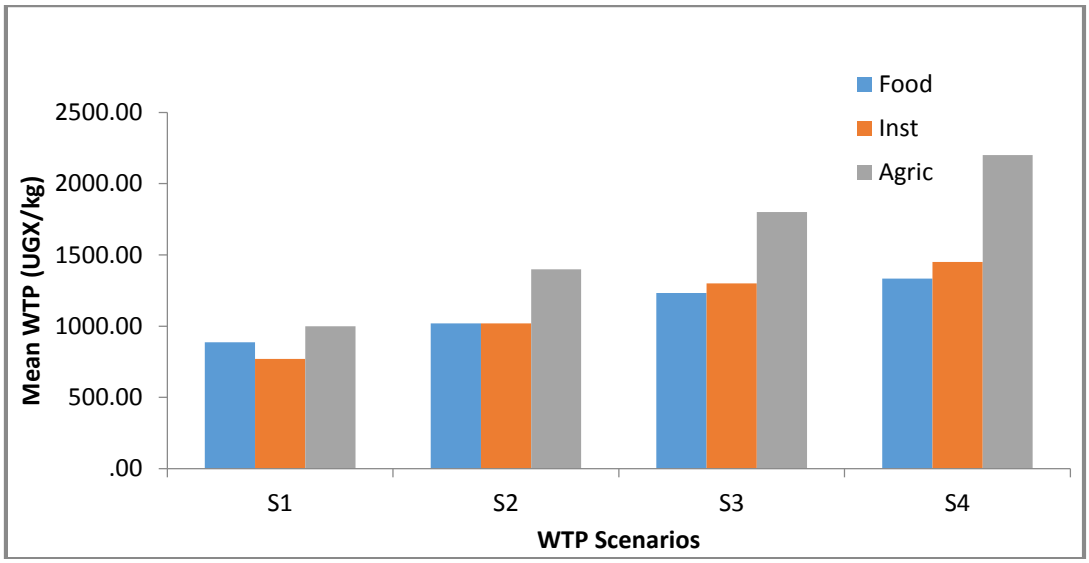

Figure 3: Mean WTP of Enterprises

The potential total market demand was estimated under the following assumptions: a) under 2 scenarios - S1 (status quo - no change in legislation regarding use of non-renewable energy sources) and S4 (an enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price of the prohibited fuel when caught); b) an adoption rate for households of (78.5% under S1 scenario, 82% under S4 scenario) and businesses (63% under S1 scenario, 93% under S4)[2]; c) notable potential markets were included in the market size estimation, i.e. Luwelo, Mpigi, Mukono and Wakiso in addition to Kampala. The potential market demand for briquette from households is significant and estimated at 55,400 tons/year. The difference in potential market demand with the implementation of an enforceable law (S4) is fairly notable but not significant. Table 9 presents the potential market of briquettes by businesses. Unlike household demand, the institution of an enforceable law limiting the use of non-renewable energy sources results in a significant incremental demand mainly attributable to the percentage increase in adopters.

Table 8: Estimated market demand for briquettes from households

			S1 Baseline Case: No change in legislations regarding use of non-renewable energy sources		**S4: An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price**	
	Number of Households	**Average Quantity Consumption/ week (in kg)**	**Number of Households willing to use to briquette**	**Estimated total annual demand for briquettes (tons)**	**Number of Households willing to use to briquette**	**Estimated total annual demand for briquettes (tons)**
Kampala	418,787	1.19	328,748	**18,781**	328748	**18,781**
Luwero	106,235	1.19	83,394	4,764	87431	4,995
Mpigi	60,256	1.19	47,301	2,702	49591	2,833
Mukono	145,575	1.19	114,276	6,529	119808	6,845
Wakiso	504,620	1.19	396,127	22,630	415302	23,726
Total	1,235,473	1.19	969,846	**55,407**	1,000,880	**57,180**

[2]Based on the assumption that adopters are considered to have a WTP $\geq$ 1000 UGX/kg. Percentages were derived from cumulative demand curves.

Table 9: Estimated potential demand for briquettes from businesses

									S1 - Baseline scenario	S4 - Legislation institution
	Kampala	Luwero	Mpigi	Mukono	Wakiso	Total number of businesses & institutions	Number of businesses & institutions willing to use	Average Quantity consumed/ week(kg)	Estimated total annual potential demand for briquettes (tons)	Estimated total annual demand for briquettes (tons)
Restaurants (accommodation & food services)	17,144	20,425[3]				37,569	23,781	92.30	**105,360**	**155,294**
Agricultural industries (ag.& food processing industries)	1,771	3,295				5,066	3,207	227.50	35,018	51,614
Hospitals/health units	200	67	64	77	99	507	321	420.00	6,470	9,536
Schools (primary and secondary)	799	318	170	414	841	2,542	1,609	1,153.00	89,053	131,259
Universities (colleges and other higher educ. inst.)	123	5	3	1	4	136	86	840.00	3,471	5,116
Total	20,037						29,004	2,732.80	**239,372**	**352,819**

3.1.2 Market Structure

3.1.2.1 Background and Justification

Energy is one of the most important sectors that drives the economic growth in Uganda. Ensuring proper energy balance is one of the major challenges Uganda currently faces due to limited sources of affordable energy. Making use of cheaper alternative energy substitutes such as wood fuel has resulted in growing deforestation and thus an increasing and timely need for the greening of the energy sector. In many developing countries, there are policy strategies that aim to encourage private sector investment in the energy sector due to the poor financial resources base. Private sector participation in green energy production, however, greatly depends on the degree of freedom in the market structure (i.e. ease of entry and long-run sustainability). New RRR businesses can only be successful if their operations are fine-tuned to the existing market structure, which in turn influences their performance. Thus, new businesses require information on the characteristics of market structure to identify the existing opportunities to enter and further penetrate the market. Moreover, information on the existing level of competition in the market, characteristics of competitors and factors which drive the market's competitiveness or collusiveness are necessary for decisions on investment. This also requires an evaluation of relevant actors' pricing and distribution strategies.

[3]Central region (includes 4 districts: excluding Kampala).

3.1.2.2 Research Methods and Data Collection

Given that the briquette industry is fairly nascent, the respective markets of alternative fuels were considered for the market structure assessment as these are representative of the direct competitors to new briquette businesses. The following aspects were evaluated as follows: a) the supply chain analysis was analyzed via the identification of main actors along the value chain, their behavior and roles, product flows along the supply chain and quality; regulatory and policy environment which affect performances of the supply chain; b) performance of the supply chain actors was assessed based on their profit margins and average profits. Data was obtained from primary and secondary sources, Ugandan organizational reports and websites on the Ugandan energy market. In particular, data used for the supply chain analysis was obtained from State instructional reports such as from Ministry of Energy and Mineral Development and prevailing pricing policies and rules and regulations on energy (particularly charcoal) sector were sourced from institutional reports and relevant newsletters and Ugandan websites.

3.1.2.3 Results and Discussion

- **Energy consumption in Uganda**

More than 90% of the population depends on biomass for their energy requirements (charcoal, firewood, biomass residues). Biomass including firewood and charcoal are the main sources for cooking energy in Uganda (UHS[4],2010). Table 10 indicates the percentage of households that use different sources of available cooking energy by sectors and in Kampala, the capital of the country. The majority of households (95%) still use wood fuels (wood and charcoal) as a main source of energy for cooking. Firewood is most commonly used by rural households (86%) while charcoal is commonly used by urban households (70%). Regional variations reveal that 88 percent of households in the Northern region mainly use firewood while 75 percent of households in Kampala used charcoal as the main source of fuel for cooking. It is worth noting that the proportions of households that use electricity for cooking is still very low which can be attributed to high unit tariffs. All four regions in Uganda consume a higher percentage of firewood compared to charcoal and other sources. The lack of modern and affordable (comparatively cheaper) fuels for domestic use has forced both urban and rural populations to depend entirely on wood charcoal and firewood as a source of cooking fuel. The situation is exacerbated by the ever rising costs of other alternative sources of energy, namely hydroelectric power, kerosene and gas.

Table 10: Distribution of Households by Cooking Fuel in Kampala, Uganda.

Residence	Firewood	Charcoal	Kerosene	Electricity	Other*	Total
Rural/Urban						
Rural	86.3	10.4	1.7	0.3	1.3	100
Urban	15.4	69.8	4.9	1.6	8.2	100
Region						
Kampala	**2.4**	**74.5**	**7.8**	**3.4**	**11.9**	**100**
Central	57.8	36.4	1.7	0.4	3.7	100
Eastern	85.2	11.3	1.7	0.4	1.4	100
Northern	87.6	10.5	0.8	0.2	1.0	100

[4] Uganda National Household Survey

Western	84.2	10.8	3.1	0.4	1.5	100
Uganda	73	21.5	2.3	0.6	2.6	100

*includes LP gas, saw dust, biogas Source: UHS 2009/2010

Table 11 depicts the annual household expenditure for charcoal and firewood over the years. National statistics indicate that household expenditures on charcoal increased from 4.076 billion UGX in 1995/97 to 9.345 billion UGX in 2005/06, and 98.7 billion UGX in 2009/10, which can be accounted as 23 times change in charcoal and 21 times of firewood consumption expenditure. At the same time charcoal consumption has increased by 5.7 times compared to 1996/97.The availability of cheap (and often free) firewood and charcoal has been part of the reason why biomass has prevailed as the dominant source for energy in developing countries (GVEP, 2012).

Table 11: Household Consumption of Firewood and Charcoal (in million UGX)

Fuel type	1996/97	2002/03	2005/06	2009/10
Charcoal	4,076	6,936	9,345	98,699
Firewood	13,967	20,677	23,425	310,440
Total	18,043	27,613	32,770	409,139

Source: UBOS[5],2013

In recent years Uganda has faced a significant increase in charcoal prices. More recent changes in prices have been more dramatic and quarterly price data from between 2000 and 2012 indicate that charcoal prices increased 13 percent on average per year over this period (figure 4). The price hike of charcoal provides an immense opportunity for alternative energy businesses such as briquette businesses, to capture a percentage of the market share at comparatively competitive prices. In 2012, the retail market price of charcoal in Kampala was in the range of 800 to 1,000 UGX/kg and is expected to increase exponentially in the future.

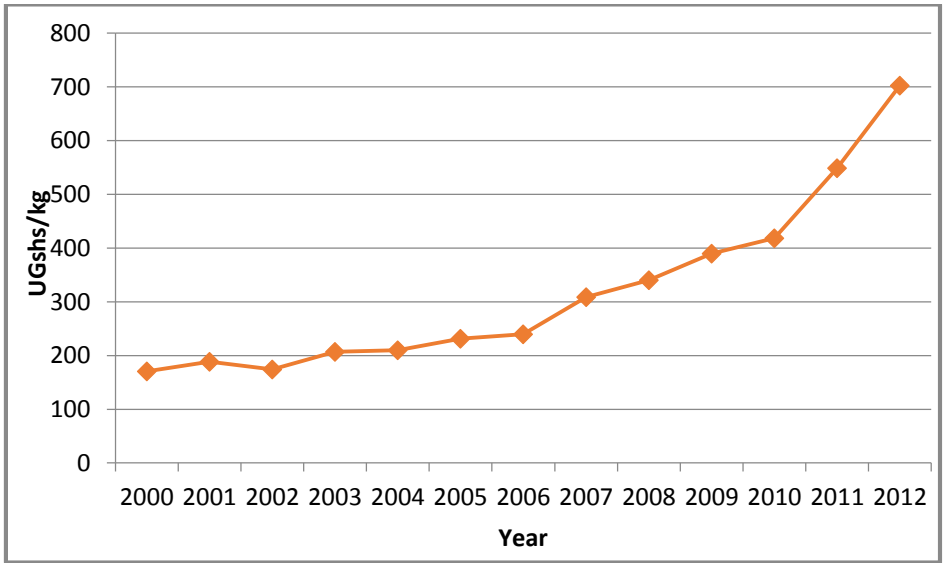

Figure 4: Average annual price of charcoal in Kampala city (Source:UBOS,2013).

[5] Uganda Bureau of statistics

Business Development in the Alternative Fuels Sub-sector

- **Briquettes as an alternative energy source for charcoal**

Recent information on the Ugandan energy sector suggests that the briquette industry is a nascent and burgeoning sector. Households are noted to primarily depend on charcoal and briquette as their main source of energy[6]. Although the briquetting technology has been present in Uganda for a while, the scaling-up to a commercial scale has been limited. However, with the current rate of rising charcoal prices, lack of firewood and increased deforestation leading to increased levies on charcoal burners, the economics of briquette production are narrowly becoming feasible and more ventures are beginning to appear in recent years. There are hundreds of micro-scale producers in operation who use primitive equipment and are largely engaged in income supplementing ventures. Production levels are less than 2 tons per year and mainly for household consumption and minimal sale in local neighborhoods. There are several medium and large-scale briquette businesses in Uganda which produce more than 200 tons per year (up to more than 20,000 tons per year). Increasingly medium and large-scale producers are making use of other biomass residues such as agricultural waste and municipal solid waste, etc. for the production of briquettes. Although there are several businesses that use the above mentioned feed stock, this input resource remains largely untapped in Uganda. The recent rise in the number of briquetting businesses is a good indicator of its market feasibility in Ugandan markets. This is mainly driven by increased competition due to recent price hikes of charcoal; and reflective of increasing consumer interest and awareness of briquette as a competitive source of fuel. However, the absence of a wide retailer network currently limits the sales of briquettes to a few big retail units such as super markets in town areas and other institutional and industrial users.

- **Policy on renewable energy and incentives**

The most recent government strategy related to biomass use is reflected in the Renewable Energy Policy 2007, which is an extension to the wider Energy Policy for Uganda 2002. The policy focuses on demand-side management through the dissemination of more energy efficient technologies (such as improved cook stoves). Where supply is considered, the approach is largely through afforestation and reforestation. The policy directly addresses catalyzing the commercialization of briquette to a small extent by aiming to "promote research and development, technology transfer, international cooperation and adoption of standards in RETs" (EEP,2013). Increased attention has been given to small-scale rural based bio-energy technologies such as improved cook stoves, gasification, biogas and briquettes (GVEP, 2012). Direct support to the energy sector can be accounted for from the initiative by the UIA (Uganda Investment Authority) which recently published a list of energy investment opportunities, including the manufacturing and marketing of briquettes and drafted the proposal for a briquetting plant based on dried organic municipal solid waste in Kampala. The Global Environment Facility (GEF) is also partnering with a number of Ugandan and international partners to develop a series of stakeholder recommendations to formalize Uganda's biomass sub-sector including: a) the development of a comprehensive biomass resource use database; b) standards and certification schemes for biomass efficient technologies (BETs); c) formulation of a National Biomass Energy Strategy and d) development of a Biomass Energy Investment Guide (Sustainable Energy for All, 2012; GEF, 2013). Such formalization of the biomass subsector is critical to scale-up private investment in green fuel production. Additionally, any policy that restricts charcoal supply or production and sale price of charcoal (cost of production) in the Ugandan market will increase the competitiveness of briquette businesses, resulting in more interest for green energy investment. Although data on direct policy

[6]About 60% of households noted using mainly charcoal as their source of energy and 40% using charcoal in conjunction with briquettes.

influence on the charcoal sector is scarce, recent information reveals that with support from the UNDP, the government is implementing key interventions in charcoal production which includes increasing the charge that the National Forestry Authority levies on charcoal burners, thus providing an opportunity for alternative fuels to compete with charcoal (GVEP, 2012).

- **Opportunities for briquette businesses as identified from competitor's supply chain**

The Ugandan charcoal sector is informal, highly unorganized and mostly unlicensed. Shively et al (2010) and Knöpfle (2004) identified five major value chain actors: producers, agents, transporters, traders and retailers. Agents serve as middlemen between producers and traders. They however do not buy or sell charcoal, but rather collect commissions for establishing the connections between producers and traders. Traders, in contrast, purchase charcoal from producers and sell to retailers. They may contact producers directly or operate with the assistance of an agent. Transporters (typically truck owners, but also drivers responsible for loads) move charcoal from one location to the next point up the value chain. Transportation of charcoal is often unorganized and frequently involves overloaded trucks of varying capacities; and involves a large spectrum of people looking to take advantage of the relatively high price difference between the money paid to the producers and the final price paid by consumers (UNDP n.d.). Retailers are the final point observed on the supply side of the value chain. Retailers sell charcoal directly to consumers. Due to the unorganized and informal nature of the charcoal market, pricing information flow is not perfect among the actors and charcoal pricing behaviour mainly depends on the negotiation power of the actors. Margins are not only affected by the marketing or bargaining power and the competiveness of the market of the actors of the charcoal trade, but can also be partially explained by the degree of monitoring and enforcement of charcoal production and trade in the district as higher the taxes and levies lower the profit margins. Market distortions in the charcoal industry (main competitor for briquette businesses) represent opportunities that new briquette businesses can take advantage off to gain entry into the fuel sector and capture a share of the market.

- **Barriers to business development in briquettes market**

Higher cost of production of briquettes relative to wood energy is currently the major barrier of briquette businesses. Besides manual briquetting, medium and large-scale production is associated with higher capital costs from the use of more technologically sophisticated machinery. Furthermore, relatively lower calorific values (though ignite time is higher than charcoal) of briquettes especially in the case of MSW-based briquette may be less appealing to consumers. Besides the lack of consistency in feedstock supply (especially agro waste and MSW availability can also be seasonal), limited access to financing to scale-up production and exorbitant interest rates from financial institutions are other challenges noted for briquette businesses. From the policy perspective, long-term governmental strategies and polices do not directly address briquette production like other types of energy production (e.g. electricity sector improvement (i.e. production from alternative sources)) at policy level besides encouragement of research and technology on the briquettes sector. Additionally, a weak regulatory structure continues to encourage illegal timber production and charcoal supply without implementation of appropriate levies and fees. This suggests that charcoal may still be able to competitively price-out briquettes from the market.

3.1.3 Market Outlook

3.1.3.1 Background and Justification

Market forecasting is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting is to aid businesses in planning for the future. Because investment toward an uncertain future is very difficult and risky, market forecasting tools have been developed to alleviate the risk and to obtain more accurate or reliable information. The most fundamental variable in determining an appropriate business strategy is the stage of the product life cycle (Hofer, 1975; Anderson and Zeithaml, 1984). The product life-cycle management is the succession of strategies used by businesses as a product goes through its life-cycle. The condition of the market in which a product is sold changes over time and business strategies must be managed as it moves through its succession of stages. The goals of product life cycle management are to reduce time to market, improve product quality, reduce prototyping costs, identify potential sales opportunities and revenue contributions, and reduce environmental impacts at end-of-life. To create successful new products the product manufacturing company must understand its customers, markets and competitors.

3.1.3.2 Research Methods and Data Collection

Given the limited data on the proposed RRR products, the Bass model (1969) was used to assess the market outlook for briquettes. The model took into consideration the probability of purchase given that no previous purchases were made and the total number of potential buyers as parameters reflecting the rate of diffusion and the initial probability of first-time purchases (Proctor, 2000). A variant of the discrete time bass model function was applied. Satoh (2001) justified the adoption of the discrete time model when data used is discrete, as the Bass model is a continuous-time model. Satoh (2001) further noted that the discrete Bass model conserves the characteristics of the Bass model because the difference equation has an exact solution. Therefore, the discrete Bass model enables us to forecast the innovation diffusion of products and services without a continuous-time Bass model.

$$f(t) = \frac{\frac{(p+q)^2}{p} e^{-(p+q)t}}{\left(1 + \frac{q}{p} e^{-(p+q)t}\right)^2}$$

$$F(t) = \sum_{i=0}^{t} f(i)$$

$$A(t) = M\ F(t) \text{ and } a(t) = M\ f(t)$$

The optimal time to peak sales is given by:

$$\frac{\ln\left(\frac{q}{p}\right)}{p+q}$$

Other variables in the Bass Model calculated from M, p, q and t, are:

f(t): the portion of M that adopts at time t.

F(t): the portion of M that have adopted by time t,

a(t): adopters (or adoptions) at t and
A(t): cumulative adopters (or adoptions) at t.

The most critical determinants of the model are the innovation and imitation coefficients p and q and the potential market size (M) of the briquette market. In the absence of data on p and q estimated for the briquette product, the study used an average estimation of those coefficients as per the findings of Sulthan at al. (1990). Accordingly, the assumed estimate of p used was 0.03 and q, 0.38. Low diffusion rates were assumed due to the strong habitual behaviour of Ugandan consumers on charcoal (low switching behaviour) in the absence of strong alternative products in the market. Additionally, the total (p+q) is assumed to lie between 0.3 and 0.7. The potential market size is estimated at 294,780 tons (S1 Baseline Case: No change in legislations regarding use of non-renewable energy sources) and 410,000 tons (S4: An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price) based on the WTP assessment.

3.1.3.3 Results and Discussion

Figures 5 and 6 show the behavior of new and cumulative product sales over the years with 0.38 and 0.03 average coefficients of innovation and imitation. The results indicate that peak sales can be achieved between 6 to 7 years. A lower peak time, however, can be reached with strong business strategies including promotional and awareness programs for farmer communities and other potential industrial users. The estimated quantity of sales at the peak will be 32,550 tons. Businesses can adjust their production capacity and other financial requirements to target a higher average peak volume at the average peak time. According to the figures of both scenarios, it will take approximately 14 years for new businesses to capture the total market size.

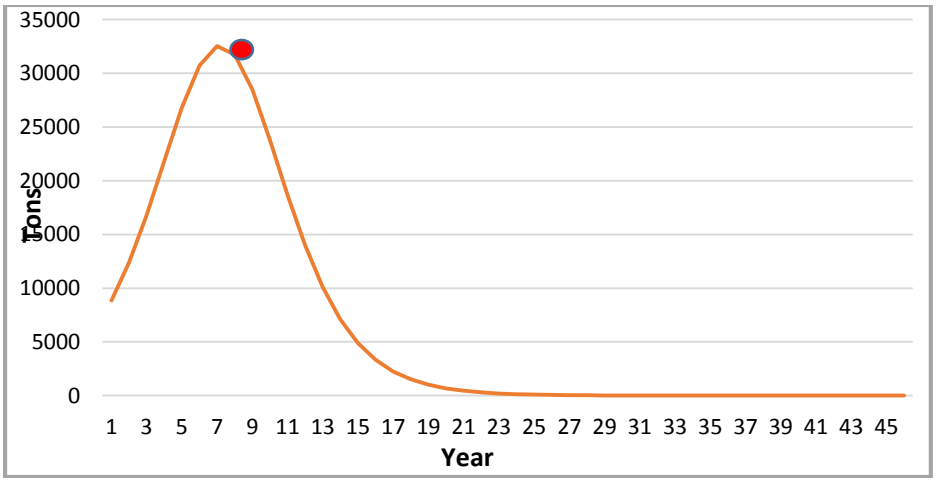

Figure 5: Volume of new sales over the years

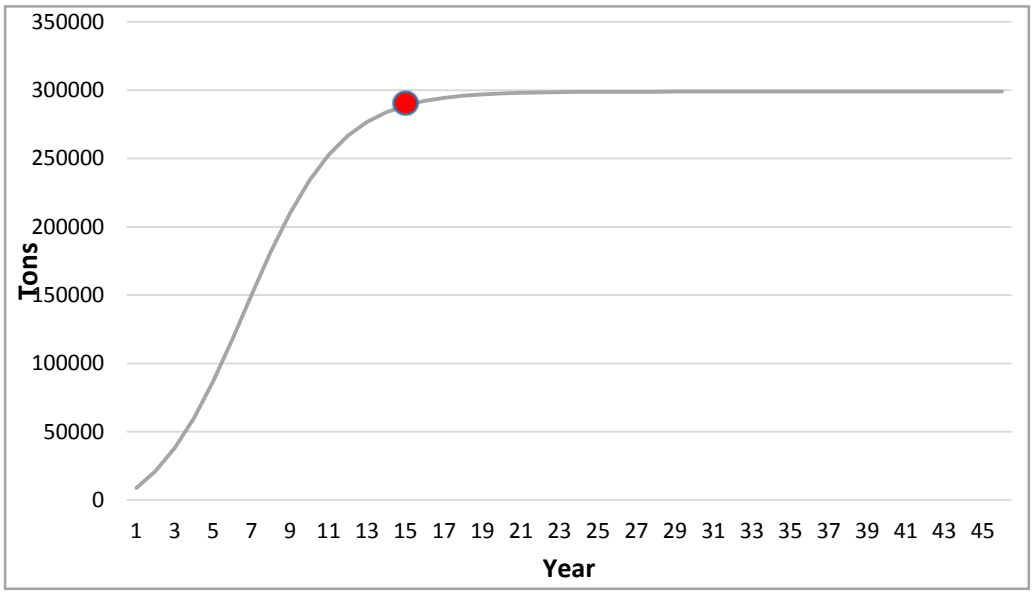

Figure 6: Cumulative sales over the years

Product Life Cycle

- **Introduction stage**

Generally, the introduction of a new product is facilitated when the existing competitive products are at the stage of maturity. Interest in existing products is assumed to be on the decline and consumers are seeking new products with new and improved features. In Kampala, the most dominant cooking energy source is charcoal, whilst others like firewood, kerosene and cooking gas constitute a very small share of the market. Charcoal demand seems to be increasing over the years, reflective of either limited alternative fuel choices or steady popularity for charcoal in Kampala market. The latter trend may be attributable to its fairly steady availability and accessibility compared to other prevailing cooking fuel sources in the market. However given the increasing prices of charcoal (due to limited production), the current prevailing competitive market prices for briquettes represent an opportunity for briquette businesses to capture a share of the market. Thus, the penetration of briquettes will be facilitated by prevailing market conditions but also the improved product attributes (e.g. smokeless product) over charcoal. Due to the strong positioning of charcoal in the market, early adoption may be low. Strong awareness programs coupled with promotional initiatives such as testing with free samples will eventually increase the recognition of the product by the market. Thus, cost for research and development (sunk cost) and negotiations maybe higher in the introduction phase and may lead to lower profit overall.

- **Growth stage**

Based on the average diffusion coefficients, the briquette product shows a fair growth rate during the growth stage and takes between 6 - 7 years to reach its peak sales. This is mainly attributable to the assumed and conservative lower diffusion coefficients due the traditional nature of low adoptability of Ugandan consumers. Product growth sales can thus be increased via the adoption of innovative marketing and pricing strategies and strongly positioning the product in the market in the introduction stage. Businesses can also adjust their production capacity and other financial requirements in order to

target a higher average peak volume at the estimated average peak time. To achieve a comparatively higher (steady) growth, businesses can also adopt new strategies to reach new customer segments, new marketing and distribution strategies. In addition, regular customer testing and evaluation is necessary to further tailor product features such as briquette size, binding material, packaging and branding to consumer preferences. Promotional and awareness programs may still be important at this stage to reach additional customer segments.

- **Maturity stage**

Figure 6 indicates that it will take 6 -7 years for new businesses to capture the total market size. This is the stage where firms maximize profit and recover all cost of operation and development where sales grow at slower rates and finally stabilize. The main goal in this stage is to maximize the production capacity. Prices can be increased or matched with competitors' price. Although the cost of research and development are lower at this stage, experiments for development of new product features is important so as to buffer the potential decrease in demand in the declining stage. Product promotion will still be necessary to avoid possible brand switching. Competition for market share is stiff in this stage and strategic pricing and quality adjustment will be necessary depending upon the behavior of the competitive products.

- **Declining stage**

During this stage, sales are likely to fall due to the loss of consumer interest in products and consumers start to switch to new competitive products. Thus, focus should be placed on the development of new product features and quality improvement to buffer effects of competitors' innovations. Generally, costs of operations are minimized in this stage in order to increase profit levels. Accordingly, a reduction of distribution outlets, means of distribution (selective means of distribution) and promotional costs can be observed during the declining stage. More specifically, prices will need to be set lower to attract more price sensitive consumers and increase sales.

3.1.4 Conclusions

The results indicate that there is a growing and substantial market demand for briquette in Kampala. Most of the respondents are aware of the benefits and costs of briquettes and are willing to pay over and above the current market price of 1000 UGX (Ugandan shillings)/kg. The WTP estimates for businesses and households are 1.5 – 2 and 2 – 3 times higher than the current market price of competitive products, respectively. The potential total market size for households and businesses is estimated at 294,780 tons (S1 Baseline Case: No change in legislations regarding use of non-renewable energy sources) and 410,000 tons (S4: An enforceable law instituted by the government that prohibits the use of non-renewable energy sources with a fine equivalent to the current market price). Subsequent scenario analyses to assess the impact of trade-offs associated with different government policies on consumers' WTP for briquettes indicates that households, in particular, are willing to pay a price 3 times higher than the current price of substitute products with the institution of an enforceable law which prohibits the use of non-renewable energy sources with a fine equivalent to the current market price. A similar effect on WTP estimates was observed for businesses although the marginal price increase was lower than that of the households.

Whilst the current production level of briquettes is unknown, it is clear that it is a nascent industry with minimal entry barriers, and supportive and existing policies encouraging business development. There are several factors that will catalyze the development of the briquette industry: a) instituted

government policies on renewable energy [favorable policies to improve charcoal trade standardization; certification will restrict illegal timber trade; plans to increase the National Forestry Authority levies on charcoal burners with the support of UNDP] and b) better efficiency on energy value that will increase market demand. Specific marketing strategies are however required as there are no established retail distribution networks as yet (only super markets and institutions); and there is a level of difficulty in linking up with the existing charcoal retail network. While there are currently limited financial incentives (e.g. VAT exemption; higher upfront production cost than for charcoal and firewood production), there are special lending schemes for briquette businesses. In terms of the market outlook of the product, the penetration of RRR briquettes products can be facilitated by the prevailing market conditions. A lower market price than the prevailing price of charcoal can increase consumers' adoption rate. Strong awareness programs coupled with promotional approaches will be important to eventually increase market demand due to the strong positioning of the charcoal market and further shorten the growth stage which currently is estimated between 6 - 7 years.

3.2 Model 2a: Energy service companies at scale (agro-Waste to electricity) and Model 4: Onsite energy generation by sanitation service providers (faecal sludge to energy)

This sub-chapter presents the results of the market assessment for the following business models: a) Model 2a: Energy Service Companies at Scale: Agro-Waste to Energy (Electricity) - where the business processes crop residues like wheat stalk, rice husk, maize stalk, groundnut shells, coffee husks, saw dust etc. to generate electricity which is sold to households, businesses or local electricity authority; and b) Model 4: Onsite Energy Generation by Sanitation Service Providers. Model 4 is initiated by either enterprises providing a sanitation service such as public toilets or by residential institutions such as hostels, hospitals and prisons with a concentrated source of human waste (i.e. faecal sludge). The business concept is to process and treat human waste in a bio-digester to generate biogas to be used for lighting or cooking.The organizational structure of this sub-chapter is as follows: a) the willingness-to-pay and market size estimation results are presented for the 2 business models, noting that both models have the same end-product - electricity. The market structure assessment is conducted from the perspective of the key competing market - electricity market as is the market outlook assessment.

3.2.1 Willingness-to-pay and Market Estimation

3.2.1.1 Background and Justification

Rapid population growth coupled by urban migration has resulted in an increased demand for food which has in turn led to the production of large amounts of agricultural wastes, both at the farmer, municipality and city levels (Sabiiti 2011) in Kampala. The resulting waste (both agricultural wastes and faecal sludge) problems has been exacerbated by the lack of weak public awareness, weak governmental policy and laws, insufficiency of qualified personnel, weak institutions or structures, limited community participation, as well as lack of or insufficient utilization of resources (Sabiiti and Katongole n.d.). Agricultural wastes chiefly take the form of crop residues and animal waste and such wastes are widely available, renewable and can be converted into heat, steam, charcoal, methanol, ethanol, bio diesel as well as raw materials (Sabiiti 2011). Unlike cities in industrialized countries, which mostly generate waste with low organic material (Sabiiti and Katongole n.d.; Hoornweg 1999), Kampala generates solid waste rich in vegetable matter or crop waste, of which the biggest fraction is generated in several markets from selling crops in their raw form. Burning of agricultural wastes, which a common practice in Uganda, is a source of atmospheric pollution by releasing carbon monoxide, nitrous oxide, nitrogen dioxide and particles (Sabiiti 2011).

Similarly, considering faecal sludge, it is noted that despite improvements in worldwide access to sanitation over the last decade, 70% of the population in Sub-Saharan Africa still lacks access to improved sanitation (Diener et al. 2014; UNICEF and WHO 2012). Provision of adequate, safe and sustainable sanitation coverage is an ever-increasing challenge facing urban areas in Sub-Saharan Africa (Muspratt et al. 2014). An estimated 2.4 billion users of on-site sanitation systems generate faecal sludge that goes untreated resulting in pervasive environmental contamination (Muspratt et al. 2014; Koné et al. 2010). The majority of urban dwellers in Uganda depend on onsite sanitation and untreated sludge from these facilities is usually disposed of untreated directly in the environment, leading to environmental pollution.

As much as there is an abundance of agricultural waste and faecal sludge in Kampala, there is also a need for electricity or energy generation as a result of urbanization. The current energy supply deficits in Uganda are largely due to the overdependence on the few traditional energy sources despite the rich endowment of energy resources that could be used to diversify the energy sector (MAK 2010). Efforts to increase energy supply in a bid to match the increasing energy demand are been sought and therefore the use of animal and crop waste to boost supply in Uganda becomes an important and readily available option (MAK, 2010). Reusing waste (faecal sludge and agro-waste) for energy generation purposes has the potential to effectively decrease the quantities of waste disposed of in landfills or open dumps. Viable business models can emerge from designing faecal sludge management systems around resource recovery, which would in turn help ensure sustainable provision of adequate sanitation (Diener et al. 2014; Murray and Ray 2010). The gap in sanitation services can be fulfilled with profitable business based approaches to waste management, in contrast to the current status quo where sanitation services in low-income countries are not profitable (Diener et al. 2014). However, like many new technologies, economic and marketing challenges still remain unsolved. This analysis thus seeks to contribute to this discussion via the assessment of the potential demand and influencing market factors for the waste-to-energy industry in Kampala, Uganda.

There are many approaches that energy economists, resource economists and other development economists apply to assess the demand for renewable energy products. In this study, a contingent valuation (CV) method was used to estimate the market demand for waste-generated electricity in Kampala. There are many applications of the CV approach for assessing the demand for renewable energy. Abdullah and Jeanty (2011) applied the approach to assess the demand for rural electrification connection in Kisumu district, Kenya. Zografakis et al. (2010) used the approach to assess public acceptance and willingness to pay for renewable energy sources in Crete as did Twerefou (2014) in Ghana. Based on our knowledge, this is the first study that applies a CV approach to assess consumers' WTP for waste-generated electricity in Uganda. To develop a solid baseline on consumer consumption of alternative fuels and their purchasing decisions, the key objectives of the study are:

1. To assess consumers' knowledge, current use and willingness-to-pay (WTP) for waste-generated electricity (WGE);
2. To determine factors that influence consumers' willingness-to-pay for WGE;
3. To estimate current and potential market demand for WGE in Kampala.

The subsequent sub-sections outline the research methods, data collection and analytical assumptions ad key findings.

3.2.1.2 Research Methods and Data Collection

Among the firmest criticisms of the CV approach is the tendency of survey respondent to overstate their WTP for improvements in a public good or an increase in quality of a private good (Lusk, 2003). Notable evidence of this problem can be found in many studies (Cummings, Harrison, and Rutstrom, 1995; List and Gallet, 2001; Loomis et al.1994; Neill et al.1994). Previous studies has shown the use of the cheap talk approach to effectively minimize the hypothetical bias (Fox et al., 1998; List and Shogren, 1998, Cummings and Taylor, 1999; List, 2001). Although successful at mitigating hypothetical bias, the application of the cheap talk approach has been limited to controlled experimental settings in developed countries and widespread application in the developing world is insignificant (Lusk, 2003). To this end, two scenarios were implemented in the market experiments: 1) without cheap talk and 2) with cheap talk. The first scenario elicited respondents' WTP for WGE based on their perceived benefits from WGE use compared with the alternative (no access to electricity). Subsequently, respondents were

asked to state their maximum WTP given the status quo and under three different government policies – allowing the assessment of the trade-offs associated with each government policy on consumers' WTP for WGE. The states of the world considered were:

1. No change in the current legal environment (S1);
2. A policy allows the national electricity company (as a monopoly) to raise the price of the grid-power by 10% annually (S2);
3. Power shortages occur as much as twice compared to current situation due to increasing number of electricity users in your area (S3);
4. Environmental law instituted by the government that raises cost of treating wastes by other methods and applies heavy fine for illegal waste dumping (S4).

In Kampala, two main customer segments were identified as potential users of WGE: households and businesses. The latter segment in Kampala were noted to consist a diverse number of enterprises. The survey was thus implemented for the WTP elicitation of 300 households and 80 businesses in Kampala.

3.2.1.3 Results and Discussion

- **Energy consumption patterns of households and businesses**

The results suggest that the majority of households use electricity, charcoal, kerosene and firewood as their key sources of fuel (Table 12). Businesses, on the other hand, are heavily reliant on electricity and charcoal. It is important to note that a diverse number of businesses were interviewed in the survey (e.g. livestock producers, restaurants, metal manufacturers), with the largest percentage represented by welders. The type of businesses and their scale greatly influence their preferences for certain fuel types.

For the businesses, of the 78.6% that use electricity as a fuel source, 74% of them use it for lighting purposes and the remaining percentage use it for heating. Charcoal-using businesses mainly use this preferred fuel source for cooking. This result is similar for households, where charcoal, firewood, briquette users prefer to use these types of fuels for cooking. Electricity, on the other hand, is mainly used for heating as is kerosene.

Table 12: Consumption of fuel types by households and businesses

Types of fuels used	% of surveyed businesses	% of households surveyed
Firewood	3.70	45.33
Charcoal	20.99	67.67
Biogas	2.47	1.67
Electricity	78.64	69.33
Gas	1.23	0.67
Kerosene	4.94	47.33
Briquettes	0.00	1.00
Other sources	7.41	13.33

- **Awareness, knowledge and current use**

In assessing, the businesses' and households' awareness and knowledge of waste-based energy sources, it was important to evaluate their perceptions of the main alternative energy source currently been used - electricity. The key disadvantages noted by the respondents from the use of electricity supplied from the national grid were: a) inconsistent supply - power blackout and b) high cost rates - expensive fuel source. Interestingly, although electricity is considered relatively expensive, households believe that that prices will remain relatively constant in the future whilst businesses (87%) think that prices will increase significantly in the near further and they will need to look for alternative energy sources.

Table 13: Disadvantages of grid power

Reasons	% of businesses surveyed	% of households surveyed
1. Expensive	69.14	34.67
2. Inflated bills	8.64	4.33
3. Low voltage	11.11	4.67
4. Poor customer care	3.70	3.00
5. Power blackout	71.60	57.00
6. Power shocks/accidents	4.94	10.00
7. None	2.47	-

In that regard, the respondents were asked about the factors that would motivate them to switch from their current energy sources to waste-generated fuel sources. Not surprisingly, lower prices was the key motivating factor, followed by reliability of electricity supply. This result is indicative of the potential demand of waste-generated energy/electricity by both businesses and households. Although, a very small percentage of the businesses and households have used or currently use waste-generated power, a significant percentage have heard about this fuel source (i.e. businesses = 74%; households = 82%) and would be interested in using it.

Table 14: Factors that would motivate a switch to waste generated power

Motivating factors	% of businesses surveyed	% of households surveyed
1. Ease to access and operate	7.41	1.67
2. Low prices	85.19	68.00
3. Safe to use	4.94	7.33
4. Should be reliable	40.74	33.67
5. High voltage	4.94	11. 33

- **Willingness-to-pay (WTP) for waste-generated electricity**

Generally, there is a significant and growing demand for electricity in Kampala and opportunities for waste-to-energy entities to fill this gap based on the anticipated rapid rural electrification program; foreseeable increasing trend in electricity prices; structural and legal feasibility for private sector involvement (structural unbundling of the Ugandan power sector, vertically integrated monopoly and

privatization of the generation and distribution); a lesser vertically integrated market; and supportive renewable energy policies among others. The WTP estimates however suggest that although there are incentives to catalyse investment, there is limited demand, which is predictive of the potential pricing strategy to be implemented. Table 15 presents the results from the estimation of the WTP for waste-generated electricity of households and businesses. The results suggest that businesses have a WTP (ranging between 319.07 – 355.94UGX/ kwh) lower than that of the current unit prices charged by the Uganda Electricity Transmission Company (UETCL) at a rate of 450UGX/kwh. Similarly, the WTP estimates for households are significantly lower than the current tariff set by UETCL.

Table 15: Mean Willingness-to-Pay for Waste-generated electricity with and without cheap talk method

Scenario	**Households (UGX/kwh)**		**Businesses (UGX/kwh)**	
	Without cheap talk	With cheap talk	Without cheap talk	With cheap talk
Current state of affairs is unchanged	270.74	291.97	349.34	319.07
A policy allows the national electricity company (UMEME) to raise the price of the grid-power by 10% annually	280.78	297.25	400.06	347.36
Power shortages occur as much as twice compared to the current situation due to increasing number of electricity users	282.26	295.57	419.40	355.92
An environmental law instituted by the government that raises cost of treating wastes by other methods and applies a heavy fine for illegal waste dumping	282.08	292.97	420.06	349.34

These results imply that although there is a significant gap in the demand and supply of electricity, consumers are willing to pay less than the current market prices. This can be attributable to their view of electricity provision as mainly a public service and deserving a subsidized price and particularly given that the use of waste as the input resource. The Accelerated Rural Electrification Report, 2011 indicates that in Kampala the electrification varies between 10-45% in the urban and peri-urban areas. Table 16 below uses an optimistic scenario of 45% of existing electrification to estimate the gap in electrification. The monthly requirement for electrifying 55% of the households is estimated at 6,435,150 kWh which is equals to 25 MW on an annual basis.

Table 16: Potential demand for electricity among households in the district of Kampala

Division	**Population**	**Housing**	**Number of households to be electrified#**	**Estimated total potential demand (Assuming 30 kWh consumption monthly)@**
Central	109500	28313	15572	467164
Kawempe	326400	85651	47108	1413240
Makindye	405300	106494	58571	1757150
Nakawa	299500	73795	40589	1217667
Rubaga	367400	95756	52666	1579974
Total	**1,508,100**	**390,009**	**709,107**	**6,435,150**

It is assumed that about 45% households are already electrified. (Accelerated Rural Electrification Report, 2011)

@ Buchholz and Da Silva (2010) Potential of distributed wood-based bio-power systems serving basic electricity needs in rural Uganda, Energy for sustainable development, 14, 56-61.

3.2.2 Market Structure

3.2.2.1 Background and Justification

Electricity is considered as one of the major household and industrial utility service in any country which powers the country's economic growth. In many countries, the electricity market is highly regulated and controlled by the government to: a) assure affordable prices and b) ensure consistent balance between power demand and supply balance to enhance economic growth. In Uganda, there is an anticipated electricity supply gap due to growing household and industrial demand. There is potential for energy generation from alternative sources (e.g. human waste) to fill this gap. Private sector participation in the energy sector, in particular, the success of future waste-based generators will depend on the degree of freedom in the market structure for business entry and long-run viability. RRR businesses in the energy sector will require information on the characteristics of the market structure (i.e. level of competition in the market, characteristics of competitors and factors driving market competitiveness and collusiveness) in order to make the appropriate investment decisions. Thus, this analysis assesses the market structure of the electricity market of Uganda, in light of identifying key external (market) and internal factors which will drive the success of new waste-to-energy (WtE) businesses. As the key output from the 2 business models (Model 2a: Energy Service Companies at Scale: Agro-Waste to Electricity & Model 4: Onsite Energy Generation by Sanitation Service Providers: faecal sludge to energy) is electricity, the assessment is conducted from the perspective of the electricity market.

3.2.2.2 Research Methods and Data Collection

Similar to the other business models, the structure-conduct-performance (SCP) approach was used in this assessment - in particular the electricity market. Details of the approach are outlined in the methodology section in chapter 2. The SCP approach typically measures how the market structure of industries vary, how different market structures influence the market conduct of firms and how their conduct influence their market performance. As per the objective of the study, inferences will be were drawn to describe the potential feasibility of WtE businesses in Kampala, Uganda. The SCP approach measures the structure of the market, the conduct and performance (profitability) of the relevant economic actors through the use of different indicators.

- **Structure:** The structure of the electricity market was assessed based on the level of market concentration in the industry, for which data was extracted from already published findings due to unavailability of data on market share of different actors. Additional market dimensions, such as barriers to market entry and exit were also evaluated.
- **Conduct:** The conduct of the players was assessed by their price setting behaviour, factors or determinants of pricing of the electricity market, buying and selling practices and distribution strategies of actors.
- **Performance:** The performance along the supply chain was evaluated, via the assessment of indicators such as the profitability, gross and net profit margins of electricity generators, growth of employment, and transmission and distribution network coverage.

Although, Kampala is the proposed implementation location for the RRR business models, the study area for the analysis was extended to cover the whole of Uganda given the sector (energy) under assessment and data availability. The Ugandan national power grid access covers only 12% at the national level and 5% - 6% in rural areas[7]. The grid is split up into transmission (above30-33 kV) and

[7] https://energypedia.info/wiki/Uganda_Energy_Situation#Overview

distribution (30 kV and below) with 14312 km length domestic transmission and distribution lines (MEMD and GIZ, 2012). The assessment used data and information obtained from existing secondary literature, Ugandan organizational reports and websites on the energy sector in Uganda. Information on the structure of the market, sales shares, pricing behavior indicators and prevailing pricing policies were obtained from the state instructional reports (Ministry of Energy and Mineral Development, Electricity Regulatory Authority).

3.2.2.3 Results and Discussion

A. Electricity production and consumption of Uganda

Uganda has one of the world's lowest per capita electricity consumption, owing to the fact that only 1.35% of the population consume electricity as an energy source. More than 90% of the population depend on biomass for their energy requirements (charcoal, firewood, biomass residues) (Figure 7). Low levels of electricity consumption have been attributable to poor access (poor transmission and distribution infrastructure) and the overall low income base of the Ugandan people[8].

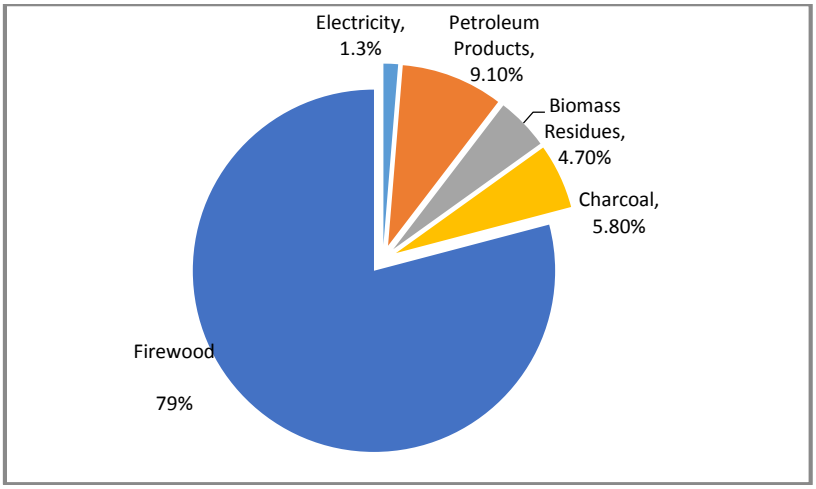

Figure 7: Uganda's energy mix in 2011.
Source: (Ndawula, 2014)

- **Electrification and access to electricity**

The electrification rate in Uganda is very low with 12% at national level but only 5% - 6% in rural areas. There has been significant increment in electricity access, and overall electricity access rates have risen from 6 percent in 1991 to 11 percent in 2009. This is attributable to significant increments from urban households whose electrification rates increased from 36.1 percent in 1992 to 46.5 percent in 2009 (Mawejje, n.d). The number of customers also increased from 103,920 in 1990 (Electricity Regulatory Authority and the World Bank) to 513,000 in 2012 (UMEME Annual Report,2012). Overall, new customer connections have been growing at an average rate of 3 percent per annum for the periods. It should be noted that from 1990-2010, rural electrification only increased marginally from 1.9 percent in 1992 to 2.7 percent in 2009. Thus, the increase in customer growth seems to have been urban based and not rural centered (Mawejje, n.d).

[8]85-90% of the country's population has no access to electricity (Sustainable Energy for ALL, 2012).

- **Electricity consumption by sectors**

Uganda currently has one of the lowest per capita electricity consumption (70 kWh/year) in the world (Africa's average: 578 kWh per capita, World average: 2,572 kWh per capita, Germany: 7,111 kWh per capita). About 72% of total electricity supplied by the main grid is consumed by 12% of the domestic population concentrated in the Kampala metropolitan area and nearby towns of Entebbe and Jinja. Table 17 shows the energy and electricity demand of the main consuming sectors. The industrial sector stands as the main consumer of electricity, having more than 50% of share, followed by the residential sector (25%). Although, the domestic sector consumes lesser quantities than the industrial sector, consumption growth rates of both domestic and industrial grew by 12% in the last couple of years.

Table 17: Energy and electricity demand of key consuming sectors.

Sector	Energy Demand (%)	Electricity Demand (%)
Residential	66.20	25.70
Commercial	14.30	14.90
Industrial	12.80	59.40
Transport	6.20	0.00
Total	100	100

Source:

- **Electricity Demand, Import and export**

Besides several slowdowns due to power deficits in certain years, the Ugandan electricity sector demand has increased over the time. Electricity demand has grown at an average of 8% per annum over the past two decades; and this has been attributable to the significant GDP growth of over 6% during the past two decades and particularly growth in the manufacturing sector by 11% per annum.

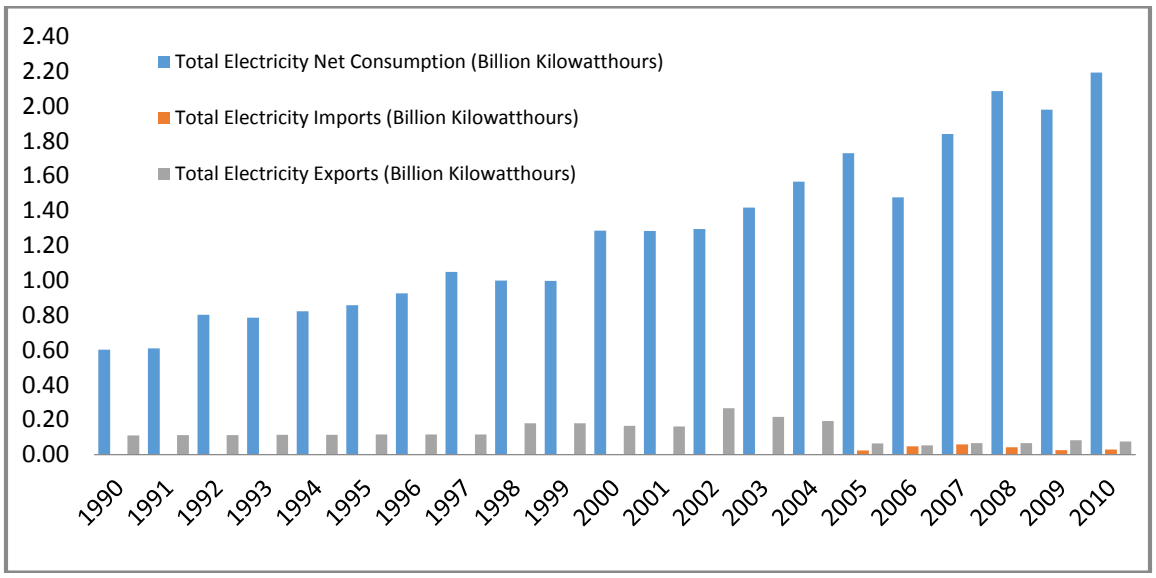

Figure 8: Electricity demand, import and export pattern over the time.
(Source: US Energy Information Administration)

- **Electricity production**

The current installed capacity of 870[9] megawatts (MW), consists of hydropower (80%), thermal power (10%), and cogeneration from biomass (3%), with projects developed by both public and private actors (Figure 9) . Although the country's installed generation capacity is over 800 megawatts (MW), the generation capacity fluctuates at around 558 MW. Hydro installations in Uganda have continuously produced less power than initial projected capacity. For instance, Owen Falls produces 74 MW instead of the planned 180 MW and the Kiira Dam produces 50 MW instead of the planned 200 MW (Taremwa, 2013). Heavy dependency on (large) hydro power has resulted in uncertain power supply, which remains one of the largest obstacles to broader investment in Uganda. Consistent and unpredictable load shedding (rolling blackouts) as a result of insufficient power generation causes major disruptions to households and businesses (Kreibiehl and Miltner, 2013). In 2005, the shrinking water levels of Lake Victoria due to prolonged drought resulted in massive electricity rationing and forced the country to resort to emergency expensive thermal generation. This is the result, in part, of underinvestment in energy infrastructure and the fact that the government has traditionally focused its limited resources on the development of large hydropower schemes, while neglecting the country's extensive small-scale hydro and biomass energy resources for power production (Sustainable Energy for ALL, 2012). Although available installed capacity of hydropower is prominent over the years, its potential of electricity generation has reduced over time, while power generation from other two sources, particularly thermal sources has increased over time. This result suggests that there is great potential for WtE businesses to fill this supply gap as electricity production is comparatively less expensive than thermal energy production.

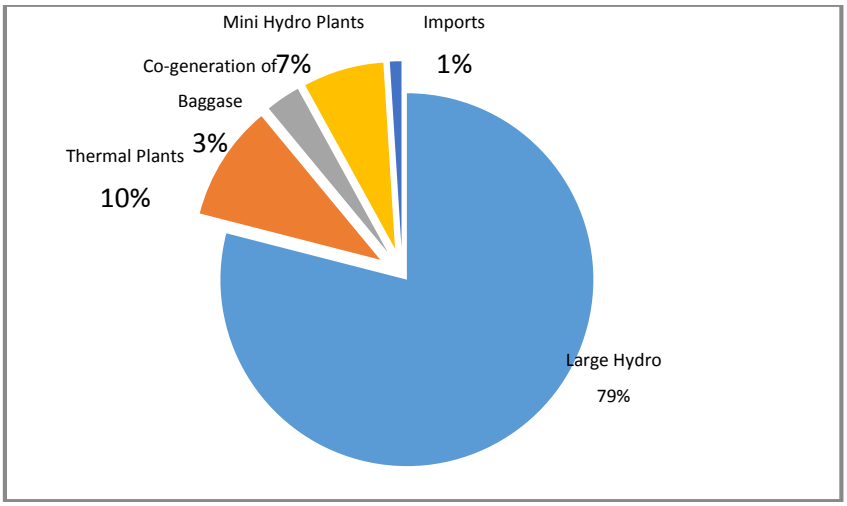

Figure 9: Uganda's electricity generation mix, 2012.

Source: Ndawula, 2014.

B. Policy on renewable energy and incentives

Over the past decades, the Ugandan electricity sector has been a priority of policy concern for the government, with a priority to increase generation capability and access to electricity. Poor generation potential and limited transmission and distribution network remains the key constraints to electricity demand. To address this issue, the National Energy Policy (specifically the Renewable Energy Policy), was developed and approved to reinstitute the government's commitment to the development and

utilization of renewable energy resources and technologies (ERA,2012). In line with the Renewable Energy Policy 2007, the government's policy vision for renewable energy is "to make modern renewable energy a substantial part of the national energy consumption" (ERA,2012). The overall policy goal is to increase the use of modern renewable energy from the current 4% to 61% of the total energy consumption by the year 2017 (ACODE,2014). The Renewable Energy Policy 2007 defines modern renewable energy as renewable energy resources that are transformed into modern energy services such as electricity, which can be generated from solar energy, wind power, water power, geothermal energy and biomass cogeneration. In addition, it also refers to clean fuels derived from renewable energy resources like biogas, ethanol, methanol, hydrogen or solar water heating as well as biomass utilized in efficient biomass technologies, like improved charcoal stoves and improved firewood stoves (ERA,2012). It also seeks to maintain and improve the responsiveness of the legal and institutional framework to promote renewable energy investments; establish an appropriate financing and fiscal policy framework for RET investments; promote research and development, international cooperation, technology transfer and adoption of standards in renewable energy technologies, utilize biomass energy efficiently, promote the sustainable production and utilization of bio-fuels, and promote the conversion of municipal and industrial waste to energy. This policy is a key incentive for investors in WtE initiatives as they are aware of policies that will support their investment decisions.

A major incentive under the renewable energy policy is the introduction of feed in tariffs for renewable energy sources. Feed-in tariffs (FIT) are an internationally recognized regulatory mechanism used to promote and increase the amount of electricity generated from renewable sources, by providing a fixed tariff based on the levelized cost of production for a guaranteed period of time. This mechanism is aimed to encourage and support greater private sector participation in power generation from renewable energy technologies, through the establishment of an appropriate regulatory framework[10].
The tariff is paid for a guaranteed payment period of 20 years, with O&M costs adjusted on an annual basis for inflation. The Uganda Renewable Energy Feed-in Tariff Guidelines REFIT stands as an investment security for developers. The penetration of renewable energy into the market largely hinges on investment security. With a FIT, the risk premium required by investors can be minimized by the high level of price security in the system. Tariffs provided are high enough to cover investment costs and provide a reasonable rate of return. To boost investment in grid-connected renewable electricity supply, the Ministry of Energy along with development partners established through a Deutsche Bank an approach called the tariff top-up program for renewable energy investors (Kreibiehl and Miltner, 2013). Whilst these incentives will catalyze investment in renewable energy, the Ugandan program however specifies capacity caps for each technology by year. This is a clear policy guidance on how much the country presumably needs/wants of which technology on an annual basis (with higher capacity limits given to the small hydro plants, followed by wind, bagasse, geo-thermal and biomass).This will however potentially limit the capacity of renewable energy that investors of a particular technology can operate at. In addition to the facilitation of the wider national electrification program, there are a number of electrification policies that will also act as incentives for renewable (WtE) energy project developers. The government plans to finance grid connection to plants that are more than 5 km from the grid, and where the interconnection is less than 5 km, investors can initially cover the costs and recover it through the tariff structure (ACODE, 2014).

[10] The REFIT applies to small-scale renewable energy systems, of prescribed priority technologies, up to a Maximum Installed Project Capacity of twenty (20) MW, and greater than 0.5 MW, as defined by the Electricity Act 1999 (ERA,2012).

C. Opportunities for WtE businesses as assessed from the power market structure

- **Institutional and supply structure**

In 2004, Uganda reformed its energy sector to include a new legal and regulatory framework to accommodate for public -private partnerships. The restructuring of the power sector consisted of unbundling the vertically integrated, composite functions into separate business functions of generation, transmission and distribution business. This resulted in the following3 companies, registered in accordance with the Companies Act under the following names (ERA,2006);

- Uganda Electricity Generation Company (UEGCL);
- Uganda Electricity Transmission Company (UETCL); and
- Uganda Electricity Distribution Company (UEDCL).

The institution of this reform aimed to permit greater transparency in electricity pricing, and in the monitoring of the efficiency of the three business segments, thereby assisting the Electricity Regulatory Authority (ERA) in the task of regulation, improving corporate governance in the power sector, introducing competition in the sector and providing a basis for the privatization of the generation and distribution businesses via long-term concessions; thus providing an enabling environment for private sector investments in generation and distribution of electricity.

The Ugandan power sector operates a single buyer market model. UETCL purchases all the generated electricity and sells it to electricity distribution concessionaires (MEMD & GIZ, 2012). State owned single buyers decide on price and sell at a bulk price to distributors. The power sector reforms have come with its own challenges, particularly related to accessing funding for hydropower projects from public sector funds and multi-national development agencies. This has led the government to rely on independent power producers (IPP) to develop hydropower projects as well as energy from other sources. This also resulted in smaller plants been licensed, and by 2010, approximately 30% of available generation capacity was supplied by IPPs (Kapika and Eberhard, 2013). Rapid increase in IPP engagement is indicative of a fair ease of entry into the Ugandan power sector.

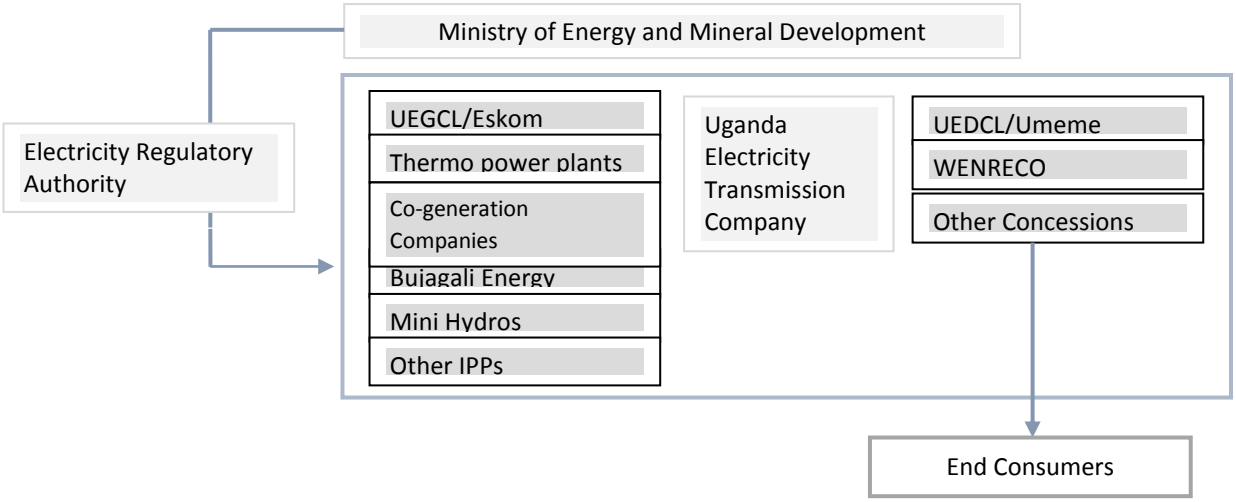

Figure 10: Structure of the Electricity Sector, Uganda

Source: XXXX

- **Product differentiation**

In terms of product differentiation, electricity is considered a homogeneous product, and hence has no market leveraging or discrimination based on the product's quality.

- **Barriers to entry**

Based on recent reforms, there is fairly easy entry and exit from the energy market, however transaction cost associated to long negotiation processes can be representative of a barrier to market entry. Additionally, high capital requirements and difficulty in accessing funds can be a disincentive for new WtE businesses. By nature of the industry, the lead time for the projects is long and the cost of loan appraisal is huge, especially for small projects. Lenders tend to be concerned about the government's apparent interference in the tariff review process and which has increased the tariff risk (regulatory risk) and viewed as reducing businesses' repayment ability. Furthermore, poor lending capacity of development banks is characterized by their inherent limited net worth. Commercial banks on the other hand prefer short-term lending. The interest rates in Uganda's financial sector are regarded as the highest in the world in real terms. Most of the commercial banks require a debt-equity ratio of 50:50 while the development banks find a debt-equity ratio of 60:40 acceptable. The lenders are interested in dealing with companies with a strong track record and a strong O&M operator to avoid risk. An additional noteworthy barrier relates to power purchase agreement (PPA) negotiations which can be lengthy and involve a large number of institutions. The litigation process is regarded as long and costly although the judiciary is seen to be independent. Furthermore, limited knowledge among potential investors on the legislations and regulations in the power sector, government interference in end-user tariff setting (considered as a high risk factor particularly to the lenders)[11], limited transparency in the methodology for deriving feed-in tariffs, no options for direct energy sale to distribution companies (sole buyer market model) are all factors representation of market entry barrier.

- **Electricity Tariff Setting Process**

The ERA regulates both the level and structure of the electricity tariffs and issues the guidelines for tariff setting to be followed by all operators (ERA, 2006).The prices between the generation and transmission company are negotiated between themselves in a form of a Power Purchase Agreement, which is subject to oversight, and approval by ERA. The transmission company can sell power to any distribution company (buyer) that is connected to the transmission network at a bulk supply tariff; which is reflective of the costs of power acquisition and transmission costs (ERA, 2006). On a quarterly basis, all tariffs are adjusted to allow for a pass-through of the changes in fuel prices, inflation and exchange rates. Tariffs set for end-users are differentiated by consumer type and per unit cost of power transmission, thus resulting in fees charged to residential consumers' been the highest followed by the commercial and industrial consumers. End user tariff is not a cost reflective one, is heavily subsidized by the government[12]. The government spent approximately €390 million on power subsidies, resulting in a huge financial burden on the government. The brunt of a cut or even a capon subsidy levels will be borne primarily by consumers who will invariably face a price hike(MEMD &GIZ,2012). Although the subsidies have not been completely removed[13], it is predicted that subsequent rounds of price hikes will be implemented in the near future. This reform represents an opportunity for the government to reallocate funding and actively pursue alternative and sustainable energy sources (e.g. WtE).

[11]Although ERA is generally perceived to be independent from political leadership.

[12]The subsidies were used to minimize the shock of high tariffs when thermal generation was introduced in 2005.

[13] Latest websites depicts that subsidy has been removed in the sector.

WtE businesses also have the opportunity to benefit from the special tariff instituted for renewable energy investors (REFIT).The tariffs are applicable for renewable projects with a capacity of <20 MW. The tariffs are based on set priority technologies and determined using a US$/kWh levelized cost approach, based on the electricity generation costs from the renewable energy sources. This mechanism ensures that the after-tax internal rate of return provided to equity holders is equal to their cost of equity capital. This ensures that sufficiently high tariffs are provided but also mitigate on the other hand windfall profits. Tariffs are paid for a guaranteed payment period of 20 years, with operation and maintenance costs adjusted on an annual basis for inflation. A maximum annual capacity allocation for specified technologies is also implemented to limit excessive increases in consumer electricity prices. As noted earlier, the Ugandan program also specifies capacity caps for each technology by year. This is a clear policy guidance on how much the country presumably needs/wants of which technology on an annual basis (with higher capacity limits given to the small hydro plants, followed by wind, bagasse, geo-thermal and biomass). This will however limit the capacity of renewable energy that investors of a particular technology can operate at.

Table 18: 2011 REFIT Tariffs and Maximum Technology Capacity Limits (2013 - 2016)

Technology	Tariff (US$)/kWh	O&M %age	Cummulative Capacity Limits (MW)				Payment Period (Years)
			2013	2014	2015	2016	
Hydro (9 ><= 20 MW)	0.079	7.61%	30	90	135	180	20
Hydro (1 ><= 9 MW)	Linear tariff	7.24%	30	75	105	135	20
Hydro (500kW ><= 1 MW)	0.109	7.08%	1	2	2.5	5.5	20
Bagasse	0.081	22.65%	30	70	95	120	20
Biomass (MSW)	0.103	16.23%	5	15	25	45	20
Biogas	0.115	19.23%	5	15	25	45	20
Landfill gas	0.089	19.71%	0	10	20	40	20
Geothermal	0.077	4.29%	10	30	50	75	20
Wind	0.124	6.34%	25	75	100	150	20

Source: ..

3.2.3 Market Outlook - Models 2a and 4

This sub-chapter presents the results for the market outlook assessment of the business models on agro-waste and faecal sludge to energy. The assessment is viewed from the end-product, i.e. electricity and thus like the market structure assessment, uses this sector as the base.

3.2.3.1 Background and Justification

The forecasting of electricity is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting will aid businesses in planning into the future. Because investment toward an uncertain future is very difficult and risky, market forecasting will help alleviate the risk and obtain more accurate or reliable information. Market forecasting will helpful for business owners to make pricing decisions, assess the future capacity requirements, or make decisions on whether to implement new business strategies etc. In contrast to other type of markets, the energy market is highly regulated and controlled by the governments, waste-based energy generators will be highly vulnerable to governmental policy changes. Thus any investment in the power sector will be affected by the policy planning in the power sector. An assessment of the market outlook and trend will provide greater clarity on anticipated market growth and will better inform investors on which strategic investment decisions to make. Thus, the key objective of this analysis is to assess the market potential for electricity production from agro-waste and faecal sludge by forecasting future demand, identifying possible gaps in supply and policy opportunities in support of future power supply in Uganda.

3.2.3.2 Research Methods and Data Collection

A forecast is an estimate of a future event achieved by systematically combining and casting forward in a predetermined way data about the past. Good forecasting is a valuable tool in long-run planning decisions in the business sector and it is adopted in predicting the future of demand, cash flows, and other factors etc. Previous studies has shown the application of numerous quantitative techniques for forecasting for which only historical data can be used. In some instances, for example projecting the demand of a new product or technology, quantitative forecasting methods are not an option because historical data is typically not available. In such cases a reliable forecast can be obtained using qualitative forecasting techniques which uses qualitative data. Over the last few decades, many different forecasting techniques have been developed in a number of different application areas.

To assess the future potential demand for new investors in the Ugandan power market, consumption data will be projected for the next 20 years, i.e. 2015-2035.This will serve the purpose to identify any gaps in future supply and which can be filled by new waste-to-energy (WtE) projects. To forecast, power demand and supply, this study adopted a least square method of trend projection technique as the data series used, showed a continuous trend without any seasonal or cyclical patterns. For demand trend projections, an exponential trend fitting was adopted as the data used was characterized by an exponential shape and a high R^2 value was obtained for the exponential trend. The Ugandan government has planned for future power generation in the country so as to meet the expected increase in future demand. Thus the future market for new RRR investors is assessed assuming the government power generation plan will be implemented as proposed. Herein opportunities are identified within the proposed power master plan in Uganda and difficulties in implementing some policy options are also discussed in light of drawing opportunities for RRR investors in the power

industry. This assessment used data primarily obtained from secondary data sources, existing secondary literature, Ugandan organizational reports and websites on power market in Uganda. Data for the demand forecasting was obtained from the U.S. Energy Information Administration[14] website for the period of 1980-2011. Additional information on power planning policies and other influential policies on RRR investments in the power sector was sourced from current company reports on electricity market, relevant newsletters and Ugandan websites.

3.2.3.3 Results and Discussion

A. Demand forecasting for Electricity

Electricity demand in Uganda for the next 20 years is forecasted with an exponential trend projection (least squares method) using data on power demand over the period of 1980-2011 (Source: US Energy Information Administration). Figure 11 shows that the demand of Ugandan power consumption will increase exponentially over the next couple of decades[15].

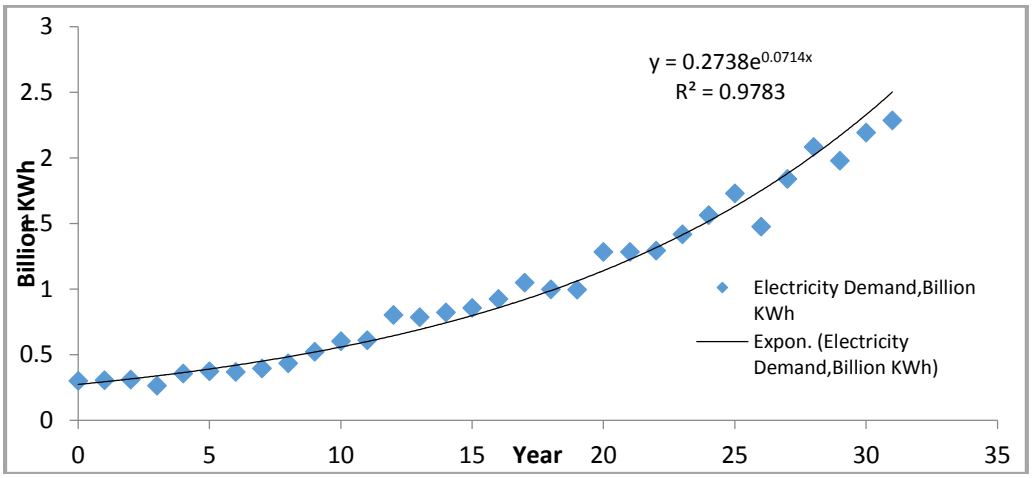

Figure 11: Trend Projection of Ugandan power demand.
Source: Author's results[16]

- **Scenario 1: Considering current generation potential (822 MW; 4319 GWh[17])**

According to the forecasted results, Uganda will face 3.33 Billion Kwh power demand in 2015, 4.76 Billion Kwh in 2020, 6.81 Billion Kwh in 2025, 9.73 Billion Kwh in 2030, 13.89 Billion Kwh in 2035, with a resulting power capacity deficit[18] of -187.81 MW in 2015, 84.29 MW in 2020, 473.14 MW in 2025, 1028.82 MW in 2030, 1822.91 MW in 2035. Under the assumption that the current supply will continue in the future and there is no additional investment for new power projects as planned by the Ugandan government; this is expected to increase the demand for imports from other countries. This result

[14] http://www.eia.gov/countries/country-data.cfm?fips=ug#elec
[15] Best fitted line for demand trend was obtained with R^2 squared value of 0.978.
[16] Data source; US Energy Information Administration
[17] Eastern Africa Power Pool (EAPP) and East African Community (EAC) – Regional Power System Master Plan and Grid Code Study; sourced from MEMD & GIZ report, 2012.
[18] Assuming the capacity factor (maximum hours of operation) of power generation plants to be consistent over time (based on the division of total current output by installed capacity of existing power plants).

shows that there will be a large market potential for new waste-based power generation projects in the Ugandan energy market, either as IPPs (Independent power producers) or PPP (pubic private partnerships) to fill the anticipated gap in the local electricity market.

- **Scenario 2: Considering future generation plan of the government (3533 MW; 23620GWh)**

The government has put in place a comprehensive plan to address the current energy deficit to meet the country's long term energy needs. In addition to the operational electricity projects described in the market structure assessment above, the Government has earmarked the following projects as priority for development in the near future: Karuma, 700 MW; Isimba, 100 MW; and Ayago, 550 MW. Other potential projects include Kalagala, Murchison Falls and several small scale power generation plants (from hydropower and cogeneration) are under different stages of development and these may, in aggregate, result in 100MW of generating capacity. In addition, Tullow Oil (an international oil and gas company) is conducting an oil exploration project in the Lake Albert (Western region) and has applied to the Electricity Regulatory Authority for an electricity generation license for a 57MW power plant. The future expected thermal power potential will be 394 MW (MEMD &GIZ,2012). Based on the above mentioned initiatives, future energy generation is estimated at 23,620 GWh[19] by 2020 and onwards. This supply will more than satisfy the future electricity demand, if planned objectives are achieved in a timely fulfilled. Under this scenario there will be no power deficit at least in the next couple of years. However it is important to note that the actual supply capacity may be lower than this amount as the plan is highly reliant on hydro-power generation, which is subject to frequent capacity fluctuations[20]; and thus still a great potential for waste-based energy generators.

3.2.4 Conclusions - Models 2a and 4

The potential market for waste-generated electricity was assessed as measured by households and businesses' WTP estimates. The results of the study indicate that businesses have a WTP (ranging between 319.07 – 355.94UGX/ kwh) lower than that of the current unit prices charged by the Uganda Electricity Transmission Company (UETCL) at a rate of 450UGX/kwh. Similarly, the WTP estimates for households are significantly lower than the current tariff set by UETCL. Generally, there is a significant and growing demand for electricity in Kampala and opportunities for waste-to-energy entities to fill this gap based on the anticipated rapid rural electrification program; foreseeable increasing trend in electricity prices; structural and legal feasibility for private sector involvement (structural unbundling of the Ugandan power sector, vertically integrated monopoly and privatization of the generation and distribution); a lesser vertically integrated market; and supportive renewable energy policies among others. The WTP estimates however suggest that although there are incentives to catalyze investment, there is limited demand, which is predictive of the potential pricing strategy to be implemented. The increasing number of independent power producers in the energy sector in recent years is also indicative of the structural feasibility of the Ugandan electricity sector. Electricity producers are however currently price takers and restricted to the price ceiling set by the state-owned transmission entity – UETCL (limited negotiation ability – monopolistic market). Thus, in actuality, the level of market concentration, price setting behaviour and potential net profit margins (business performance) will determine the sustainability of a waste-to-energy business, which for the first two factors are significant limiting drivers. The opportunity for waste-generated electricity can only materialize when offered prices in the power purchase agreement (PPA) can substantially cover production costs. Additional

[19]Eastern Africa Power Pool (EAPP) and East African Community (EAC) – Regional Power System Master Plan and Grid Code Study; sourced by MEMD & GIZ report,2012

[20]Also current operational capacity is also below actual capacity.

limiting factors to business development and sustainability in the sector are: a) continued interest and large hydro-power potential; b) significant interest in small hydro-power projects and c) waste-to-energy projects currently viewed as high-risk ventures by financial investors. While producer prices can be increased, additional market failures inherent in the energy sector can only be rectified with the institution of sound policies.

3.3 Model 9 & 10: Cost savings and Recovery - Treated wastewater for irrigation/fertilizer/energy

3.3.1 Willingness-to-pay and Market Estimation

3.3.1.1 Background and Justification

Rapid population growth and industrialization has resulted in increasing demand and competition for water resources while generating an exponentially increased volume of wastewater in Uganda, especially in Kampala. In Kampala, sewer coverage is still relatively low in key urban centers with only 6.4% of the urban population connected to the sewer (NETWAS 2011; MWE 2010). The Bugolobi treatment plant in Kampala is the only facility in the country that sanitizes the sludge to make it fit for reuse (NETWAS 2011). The absence of proper disposal methods of generated wastewater due to limited financial resources has led to the release of untreated wastewater directly to open water bodies. The total wastewater generated is estimated at 64,294 m^3/day and the total built treatment capacity is 14,000 m^3/day in Kampala. Water pollution is consequently severe and waterborne diseases are widespread. The manufacturing sector of Uganda has grown by 15% to a total of 209 individual manufacturing units (UBOS 2008) and these units include processing facilities like breweries, abattoirs, processors, tanneries and soft drink factories (NETWAS 2011). The wastewater from such industries is mostly discharged into the surrounding environment untreated or partially treated. Untreated sludge from household toilets is usually disposed off in areas that are unsuitable including wetlands, storm water drainage channels, natural water courses, manholes and undeveloped plots (NETWAS 2011; SPR 2009). Local and central governments lack the capacity to cope with unplanned urbanization and industrialization and lack sufficient human and financial resources to enforce compliance to ideal standards of discharge (Kakembo 2012; MWE 2010).

Resource demand is the other side of the problematic equation in Kampala. For example, water demand for domestic, industrial and agricultural needs is growing and this has created intense competition for water among different users. Moreover over 95% of agricultural land depend on rainwater and farmers suffer severe water scarcity during dry seasons due to poor irrigation infrastructure network, which does not cover the total potential irrigative land area. This has resulted in poor agricultural productivity due to low water consumption in the absence of other available alternative water sources. Spatial variation of water resources, distribution inefficiencies and less storage capacity constructions (water dams) reduce the potential of water uptake by all users. Uganda is not only well known for lower water consumption in agriculture, but also as the country with the lowest applied crop nutrients in agriculture. The use of wastewater has been identified as a potential solution to help meet fertilizer and water demand around the world and it has been shown that farmers are making use of it in peri-urban areas to grow vegetables and aquatic products. Every 1,000 m^3 of treated wastewater contains, on average, 52.9 kg nitrogen, 13.9 kg of P_2O_5 and 28 kg K_2O (Huong VTT, 2001; in WHO et al., 2011). Properly managed safe wastewater irrigation will reduce the pressure on available water resources, while adding value to agriculture via provision of nutrient enriched water input. Moreover agricultural reuse will reclaim the wastewater via extracting heavy nutrient load, which will in turn reduce the potential pollution of final water recipients. The recovery of wastewater from industrial and domestic sources is very low in Kampala and Uganda as a whole. Wastewater reuse has significant potential for cost recovery to the public sector and mitigation of health and environmental risks.

The use of treated wastewater for agricultural, irrigation and energy purposes will reduce environmental damage, prevent adverse human health and can even generate revenue for stakeholders involved. The business models considered here, evaluates the operation of a public entity or public-private partnership to recover the cost of wastewater treatment. Cost recovery is realized through two revenue streams; wastewater sales and compost sales, and a cost-saving mechanism using the treatment processes to capture biogas and convert it to electricity used to partially power the plant. The system will most likely be operated by a public entity or in partnerships as the driving motives are both profit and social responsibility.

The undertaking and sustainability of a business component to wastewater reuse requires an assessment of the market in its entirety to include an evaluation of market demand of wastewater, in particular, for irrigation and multiple uses. Thus, an assessment of market demand and potential size is crucial prior to implementing such an operation and to understand the existing level of demand and driving factors of demand for treated wastewater products. It is possible that farmers may already have access to freshwater or are using untreated wastewater for free, making the implementation of such an initiative infeasible. Kakembo (2012) notes that one of the conditions necessary, as requested by farmers, for turning wastewater into a valued commodity is the existence of private service providers where their services are delivered through public-private-partnerships. It is important to note that the main end-product considered in this analysis is treated wastewater for irrigation and other uses. The other end-products: energy generation and compost production are covered in the other business models [i.e. BM 4 and BM 19 (although the input source for BM19 is different, the end-product is assumed to be the same)]. Although, two key customer groups were considered for wastewater use: a) businesses and b) households; given data limitations, the WTP assessment was conducted only for farming households. Thus, the objectives of this analysis are to use a choice experiment approach to:

1. Estimate farmers' and businesses WTP for treated wastewater;
2. Estimate farmers' and businesses WTP for attributes of treated wastewater;
3. Estimate the potential market demand for treated wastewater.

The subsequent sub-sections outline the research methods, data collection and analytical assumptions, results and finally the policy implications of the assessment.

3.3.1.2 Research Methods and Data Collection

Theoretical Framework

According to Lancaster (1966), the demand for a product is influenced by its attributes rather than the product itself. The theoretical foundation of the Choice Experiment (CE) is based on Lancaster's consumer choice theory, but also from the random utility theory developed by McFadden in 1974. Thus, it is assumed that in any CE, farmers will select an option from many choices, provided the selected option has attributes that provide them with the maximum utility. According to the random utility theory, a utility function comprises of a deterministic and a random component (McFadden, 1974; Arnot et al. 2006; Ndunda and Mungatana, 2013). In most cases, the researcher is able to observe the deterministic factors but the unobservable factors are captured in the random component of the utility function. Hence, the utility U associated with individual n whose choice is alternative i is given by:

$$U_{in} = V(Z_{in}) + \varepsilon(Z_{in}) \qquad (1)$$

where $V(.)$ is the deterministic component and $\varepsilon(.)$ is the error component in the utility function. The probability of an individual n choosing alternative i from a set of alternatives J can be estimated using a conditional logit model (CL) (Greene, 2002; McFadden, 1974; Maddala, 1999) and specified as:

$$\Pr(Y_i = n) = \frac{\exp[V(Z_{in})]}{\sum_{j=1}^{J} \exp[V(Z_{jn})]} \quad (2)$$

If $V(.)$ is taken to be a linear function of specific characteristics whose random error term is identically and independently distributed (IID) with a type 1 extreme value (Gumbel) distribution, the conditional indirect utility function becomes (Ndunda and Mungatana, 2013; McFadden, 1974; Arnot et al. 2006):

$$V_{jn} = \delta_j + \sum \beta_{jk} Z_{jk} + \sum \alpha_{jn} (M_n . \delta_j) \quad (3)$$

Where δ_j is an alternative specific constant, Z_{jk} is the k characteristic value of the choice j; β_{jk} is the parameter allied to the k characteristic, M_n is the socio-economic characteristic vector of individual n and α_{jn} is the vector of the coefficients related to the individual socio-economic characteristics.

The Choice Experiment Design

In addition to the estimation of the farmers' and businesses WTP and potential demand, the analysis also evaluated their preferences towards diverse attributes of treated wastewater. The primary step of the research was to select applicable attributes, which was based on a literature review and in collaboration with local partners. Given the difficulties associated with the exact changes in the attributes' features, the levels of choices were qualitatively presented. The price levels used for the choice experiment were provided by the local partners and based on current market prices. Table 19 presents all the possible combinations considered for the choice experiment. Taking the full factorial design for three alternatives (A, B, C and D), each with three attributes with three levels, two attribute with two levels, we obtained ($3^3 x 2^2$)^4 different treatment combinations.

Table 19: Description of selected attributes for the choice experiment

Attribute	**Number of Levels**	**Description**
Price	3	Low (UGX 500/m^3); Medium (UGX 900m^3); High (UGX 1900m^3)
Entity providing certification	3	None, National Water & Sewerage Corporation (NWSC), Ministry of Health (MOH)
Delivery mechanism	2	Trucks, NWSC Connection
Payment method	2	Credit (quarterly payment), Cash on delivery/monthly

An experimental design technique was used for the final design (Louviere et al. 2000) and implemented with the SAS software. Pair-wise combinations of attributes were randomly blocked to nine groups of nine choices using a blocking factor. Therefore, each of the randomly selected farmers was presented with a nine choice set, as shown in the example of choice set (Table 20). The respondents were required to indicate their preferred choice on each choice set, which contained alternatives A, B, C and D (status quo) “no change" option. The respondents were provided with detailed description of the benefits and costs of compost made from organic waste.

Table 20: An example of a choice set presented to the respondents

Wastewater Attributes	A	B	C	D
Price (UGX/m^3)	500	900	1900	If options A, B, and C were all that was available at my local farm input shop I would not purchase compost from that shop.
Entity providing certification	None	NWSC	MOH	
Delivery mechanism	Trucks	NWSC Connection	NWSC Connection	
Payment method	Credit	Cash on delivery	Cash on delivery	
I would choose . .	○	○	○	○

The choice experiment survey was conducted in five main districts: Kampala city and notable surrounding agricultural districts, i.e. Luwelo, Mpigi, Mukono and Wakisoin Kampala. Selected respondents were randomly sampled from farmers and businesses. A total of 201 farming households and 95 businesses were selected and fully completed the survey.

3.3.1.3 Results and Discussion

- **Characteristics of farming households and business entities**

a) Businesses - A diverse number of businesses were surveyed in the sample, all involved in production activities with the potential for wastewater use. The majority of the businesses were noted to be small-scale (i.e. 60%), with 30% noted being medium scale and 10% as large-scale. The assessment of their scale was based on their production level, number of employees, and specific to the sector within which they operated. Over ninety percent of them used personal funds to fund their business operations.

Table 21: Characteristics of businesses

Types of businesses	Percentage of respondents (%)	Gross Annual Income (in millions UGX)		
		Average	Min	Max
Abattoir	1	250	250	250
Construction	14	108	50	500
Education	6	117	50	250
Food processing	5	150	50	250
Hospitality	13	77	50	100
Public toilets	62	67	50	500
Total	100	-	-	-

b) Farming households - The majority of farming households (51%) irrigate their farms. The average size of irrigated land was noted at 0.63 ha which is slightly lower than the national average range of 0.8 - 1.1 ha. Key crops grown by the farmers are: tubers (bananas/plantains, yams, sweet potatoes), vegetables and fruits (cabbage, egg plant, tomatoes, carrots) and beans. The majority of surveyed farmers have at least primary education. This is an important result especially for farmers' understanding of the potential risks from the use of untreated wastewater.

- **Water sources and use**

The main source of water for farmers for irrigation is from wells, whilst for businesses it is from NWSC connection. Twenty-six (26) percent of the surveyed farmers use piped water and also rely on rainwater as their water irrigation source. A significant percentage of the surveyed businesses also substantially rely on wells and their own ponds. The farmers were noted to use water primarily for irrigation whilst the businesses mainly used water for a myriad number of activities (i.e. washing, sanitation-related activities, and other production activities). Table 22 presents the water use activities of the surveyed businesses.

Table 22: Water use activities of the businesses

Water use activities	% of surveyed businesses
Cooling	5.33
Diluting	2.96
Production (Water as a medium)	9.47
Production (Water as an Input)	19.53
Sanitation	21.89
Washing	40.83

Both farmers and businesses noted a high level of satisfaction with the quality and supply of water (

Table **23**). Key factors noted by the respondents for limited water supply were related to: a) broken pipes, b) low water pressure and c) a relatively high cost of water. The majority of both farmers and businesses noted that water supplied by an entity different from themselves was based on volume. It is important to note on the other hand that the majority of both groups, in particular the businesses, noted receiving water from free. The National Water Sewerage Corporation (NWSC) was noted to the main supplier and recipient of the users' fees.

Table 23: Satisfaction with quality and supply of water

	Satisfaction on supply of current water		Satisfaction on quality of current water	
	% of businesses surveyed	**% of farmers surveyed**	**% of businesses surveyed**	**% of farmers surveyed**
No - not satisfied	4.21	8.46	2.11	3.48
Yes - satisfied	95.79	91.54	97.89	96.52

- **Perception of wastewater use**

As noted from Table 24, the majority of farmers and businesses are not willing to pay more than they are currently paying for water for reliable supply of treated wastewater; although farmers are comparatively more willing to do so. This is somewhat an expected result as Kampala is water rich and farmers typically have access multiple sources of water. A similar result was found when asked if both groups were willing to pay for the delivery of additional water supply. The respondents were also asked about their preference for payment in the instance that they were willing to pay for improvement of water quality and supply. Businesses, in particular, generally preferred to be billed via the current water utility service system.

Table 24: Businesses and Farmers' willingness to pay for reliable treated wastewater service

Response to willingness to pay more for reliable treated wastewater	% of surveyed businesses	% of surveyed farmers
No	93.68	74.37
Yes	6.32	25.63

Both group of respondents were asked about their preferred entity for the supply of treated wastewater. The majority of the businesses and farmers who noted wastewater use as an option, stated NWSC as their preferred supplier. This result may be indicative of the respondents' trustworthiness of their key supplier which is a public entity. Although representing a smaller percentage, some farmers noted KCCA and farmers' associations as their preferred supplier of treated wastewater.

Table 25: Entity responsible for the supply of treated wastewater

	% of surveyed businesses	% of surveyed farmers
National Water and Sewerage Corporation (NWSC)	94.64	70.35
Kampala Capital City Authority (KCCA)	-	11.56
Business Association	1.79	-
Farmers Association	1.79	9.55
NGO	3.57	4.02
Health Organization	-	2.51
None	-	2.01

- **Willingness-to-pay (WTP) for treated wastewater**

A common set of attributes and corresponding levels were used to formulate 9 choice sets which were used for both the enterprises and the farmers such that WTP values for each of the consumer groups could be estimated. Table 20 shows the attributes and the corresponding levels used for the choice experiment.

a) Willingness to pay for treated wastewater among enterprises

The willingness to adopt the use of treated wastewater among businesses in Kampala was noted to be insignificant. About 98 percent of the enterprises noted that a high level of satisfaction with the quality of water supplied by NWSC and 96% noted facing no shortages in terms of water supply. The enterprises were generally satisfied with the services provided by the NWSC as most of the enterprises surveyed were found to be connected to NWSC for water (about 70%). Among the 94 surveyed enterprises, only 7% of them expressed interest in using treated wastewater and also noted willing to pay higher prices than their current water supply costs. The following observations elicit the finding mentioned above:

1. 7% of the enterprises were willing to pay a premium for certification and for a connection provided by NWSC at a monthly cash payment of UGX 500/m^3,

2. 4.25% of the enterprises were willing to pay a premium for certification provided by NWSC and for a connection provided by NWSC with a credit payment of UGX 900/m^3,
3. 6.4% of the enterprises were willing to pay a premium for certification provided by MoH and for a connection provided by NWSC with a credit payment of UGX 500/m^3,
4. 4.25% of the enterprises were not willing to pay a premium for certification, but had a valuation for connection provided by NWSC and at a credit of UGX 500/m^3,

All the enterprises who expressed that they would adopt to the use of treated wastewater, noted using water primarily for washing purposes. It can be inferred from the first two elicitation observations assuming that all other levels of the corresponding attributes remain the same, a provision of credit payment will increase the WTP for the enterprises. Similarly, the comparison of the second and third elicitation observations, suggest that enterprises are indifferent to the type of certifying agencies and with no variation in the WTP. Subsequently, the third and the fourth elicitation observations suggest that enterprises have a relatively low valuation for certification. This leads to the conclusion that the enterprises do not have a strong preference for certification or a preference for a specific certifying agency. However, it is quite prominent that enterprises have a strong preference for connections provided by NWSC and quarterly payments are the most preferred form of payment. The WTP for enterprises is estimated at UGX 500/m^3which is the most prominent choice among all the alternatives.

b) Willingness to pay for treated wastewater among farmers

In contrast to the enterprises, about 74% of the farmers were willing to pay for reliable supply of treated wastewater services at the farm. Among the farmers surveyed, about 37% were dependent on groundwater while 13% relied on rain-fed irrigation. Twenty-six(26%) of the farmers received water through pipes and 10% from the canals. The other farmers however relied on springs and swamps for irrigation water. Given the available data, the WTP for treated wastewater among the farmers were estimated using a conditional logit model. The results are explained in the following table (Table 26).

Table 26: Estimated model for treated wastewater among farmers

	Coefficients of the Conditional Logit Model		**WTP**
Variables	**Coefficient**	**Std. Error**	**UGX/m^3**
price	- 0.00178***	0.0008	---
cert_moh	0.10871	0.0881	61.20
cert_nwsc	0.82954***	0.0871	467.01
del	0.1058***	0.0392	59.10
pay	0.00608	0.4137	3.42
Log-likelihood	- 1923.15		
Wald $Chi^2(4)$	118.30		
Prob> Chi^2	0.000		
McFadden R^2	0.2321		
AIC	3856.3		
BIC	3890.74		
Number of obs.	7236		

The variables used in the conditional logit model are: (i) certification from MoH (cert_moh), (ii) certification from NWSC (cert_nwsc), (iii) delivery of water either through canal or trucks/tankers (del),

(iii) payment mechanism – cash on delivery or credit paid quarterly (pay). The negative sign of the payment coefficient suggests that the effect on utility of choosing a choice set with a higher payment is negative. In other words, scenario improvements with 'cheaper' alternatives are preferred to 'expensive' alternatives. For all the other variables, the signs are positive which implies that farmers have a positive valuation of certification and are willing to pay a premium for it. Additionally, they have a marginal premium for water distribution via canals and a higher weightage towards credit facilities. The variable for water delivery through trucks and cash payment was considered as the base case over which the payments for water delivery and payment mechanisms were estimated. The results also suggest that the farmers are willing to pay a higher fee if water is delivered through canals, provided they have the option of making quarterly payments. The total payment elicited by the farmers for NWSC water supply is estimated at UGX 530/m^3. It is also clear that the farmers prefer for NWSC to provide certification of the treated wastewater, manage and operate the supply of treated wastewater. About 12% of the surveyed respondents noted that they preferred operation and maintenance by KCCA, and 10% preferred farmers' organizations. Another interesting result was that about 70% of the farmers noted preferring to make payments to NWSC and also chose NWSC as their preferred entity for the management of the wastewater treatment plant and delivery services.

c) Demand for treated wastewater among the farming households

The total number of agricultural households in the urban and the peri-urban areas of Kampala was estimated at approximately 44,962 (Makita, 2009). Assuming an estimate of 70% of farmers willing to use treated wastewater, the total number of farms demanding treated wastewater is estimated at 31,473. The average land holding size ranges from 0.8 to 1.1 ha (UBOS), hence the total agricultural land is estimated at 31,473 hectares. Gross irrigation water requirement in Uganda is approximately 8000 m^3/ha/year (FAO, 1997). Thus, the total water requirements in the urban and per-urban area of Kampala can be estimated to be about 250 million m^3 in a year.

3.3.2 Market Structure

3.3.2.1 Background and Justification

As with the market structure assessment of the other business models, the sustainability of any entity engaged in wastewater reuse require it to understand the market in which it operates. In the case of the wastewater business models, the water market was evaluated to understand the characteristics of the market structure (i.e. level of competition in the market, characteristics of competitors and factors driving market competitiveness and collusiveness) in order to guide potential investors' decisions. The business models considered here have the key end-product of treated wastewater for irrigation in agriculture; and the analysis is conducted from that perspective. It assesses the market structure of the irrigation water market, in light of identifying key external (market) and internal factors which will drive the sustainability of wastewater treatment and reuse (WtR)businesses. It is important to note that the analysis is limited in its assessment due to data limitation which resulted in the assessment been done from a national perspective rather than that of the city. The key findings are however applicable to Kampala as the majority of wastewater reuse in any form will most likely occur closer to the wastewater treatments.

3.3.2.2 Research Methods and Data Collection

Similar to the other business models, the structure-conduct-performance (SCP) approach was used in this assessment with a focus on the sanitation/wastewater management and irrigation service sector in Kampala, Uganda. Details of the approach are outlined in the methodology section in chapter 2. The SCP approach typically measures how the market structure of industries vary, how different market structures influence the market conduct of firms and how their conduct influence their market performance. As per the objective of the study, inferences will be drawn to describe the potential feasibility of WtR businesses in Kampala, Uganda. The SCP approach measures the structure of the market, the conduct and performance (profitability) of the relevant economic actors through the use of different indicators.

- **Structure:** The market structure of the water market is assessed based on the level of market concentration in the industry, for which data were extracted from already published findings due to unavailability of data on market share of different actors. Additional market dimensions, such as barriers to market entry and exit were also evaluated.
- **Conduct:** The conduct of the players is assessed by their price setting behaviour, factors or determinants of pricing of the water market, buying and selling practices and distribution strategies of actors.
- **Performance:** The performance along the supply chain was evaluated, via the assessment of indicators such as revenue generation, service cost coverage of service providers.

Although, Kampala is the proposed implementation location for the RRR business models, the study area for the analysis was extended to cover the whole of Uganda given the sector and data availability. The market structure of the wastewater management and irrigation management sector was assessed primarily via the wastewater and irrigation service supply structure and institutional structure. The assessment used data and information obtained from existing secondary literature, Ugandan organizational reports and websites on the wastewater and irrigation service sectors sector in Uganda. Information on the structure of the market, sales shares, pricing behavior indicators and prevailing pricing policies were obtained from the state instructional reports.

3.3.2.3 Results and Discussion

- **Water resources availability**

Uganda is known to be a water abundant country with available vast surface water resources internally and externally. The Nile basin constitutes about 98 percent of the total area of the country, while a fringe of 5,849 km^2 along the country's border with Kenya belongs to the Rift Valley basin. About 8 percent of the Nile basin lies within Uganda (NBI, 2012). Uganda's freshwater resources are considered a key strategic resource, vital for the sustenance of livelihoods, promotion of economic and sustainability of the environment. Rapid population growth, increased agricultural production, urbanization and industrialization have however led to the incremental depletion and degradation of the available water resources. By 2030, the total renewable water resources are expected to drop to 948 m^3/year per capita (based on UNDESA population prospects 2012), almost corresponding to the water scarcity threshold. The total water demand for production is projected to rise to 994 million m^3 in 2015, 1266 million m^3 in 2020 and 2113 m^3 in 2035 (MWE, 2009).

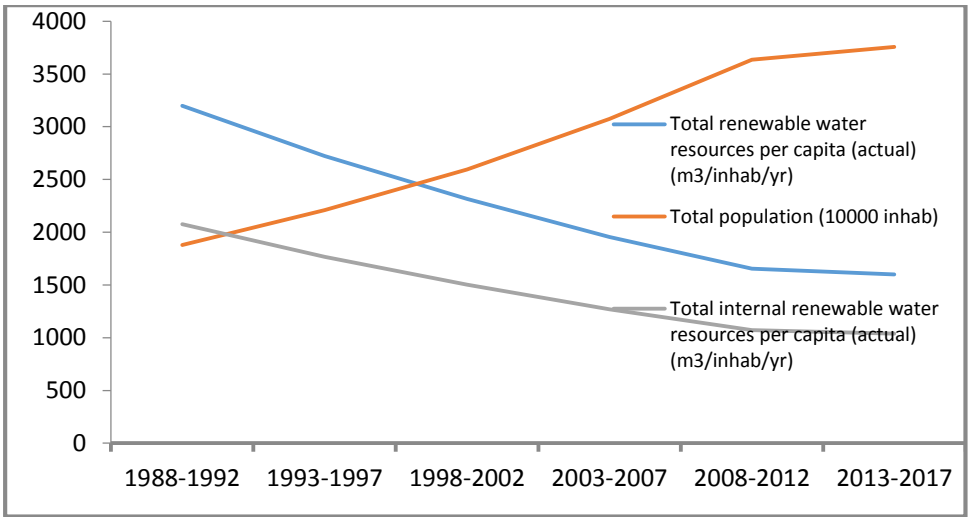

Figure 12: Total renewable water resources per capita.
Source: AQUASTAT,2014

Uganda has major water bodies that include lakes Victoria (the world's second largest freshwater lake), Kyoga, Albert, George and Edward while major rivers include the Nile (the world's longest river), Ruizi, Katonga, Kafu, Mpologoma and Aswa covering up to 15% of the total land area. The majority of the freshwater resources originate from rainfall and to a small extent snow from the Mt. Rwenzori Mountains. The annual rainfall is in the range of 600 – 2500 mm. With open water covering close to 12% of total land area, Uganda is considered fairly well endowed with water resources (estimated at approximately 6540 m^3 of available water as per the AQUASTAT, 2013); with sufficient water catchment-wise to meet the crop water demand. It is important to note however that, 33% of the districts are located in different catchments especially those in water stressed areas and do not have adequate surface water to meet the crop water demand (NIMP,2011). Furthermore, surface water resources tend to be affected by wet and dry seasons and also exhibit spatial variability.

- **Water Consumption**

Total water withdrawal in Uganda increased from 317 million m^3 in 2002 to 637 million m^3 in 2008 (with an 17% annual average growth rate). The greatest water user was the municipal sector withdrawing 328 million m^3, followed by irrigation and livestock withdrawing 259 million m^3, and industry withdrawing 50 million m^3 representing 51%,41% and 8% of total water withdrawal (Figure 13). It is observed that total water agricultural and municipal water withdrawal increased by annual average of 20% from 2002 to 2008, where industrial consumption only showed a 1% annual growth. A notable statistic is that only 1% of Uganda's total renewable water resources are withdrawn; however available water resources are under pressure due to rapid population growth and the urbanization. Groundwater represents the main source of municipal water supply for the rural population of Uganda, which is also important for livestock use, particularly in the drier regions. Groundwater extraction takes place from springs, boreholes and to a lesser extent from hand dug wells.

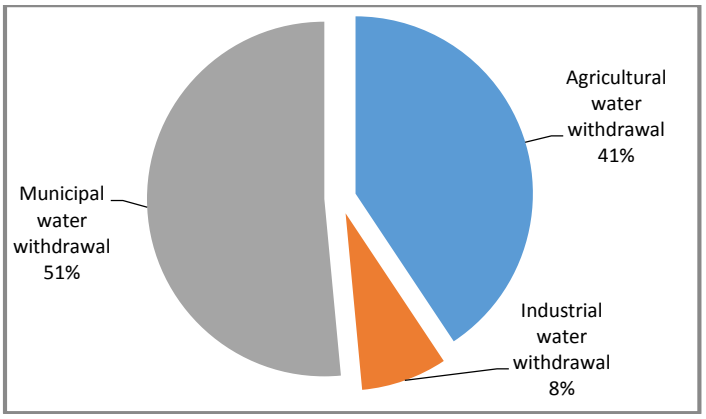

Figure 13: Water withdrawal by users,2008
Source: AQUASTAT, 2014.

- **Importance of irrigation in agriculture, Uganda**

The Ugandan economy is predominantly supported by agriculture, which contributes almost 24% of the National Gross Domestic Product (GDP) and accounts for over 73% of all exports (MFPED, 2010). The agricultural sector is central to the country's economic growth and food security. Although the agricultural sector's share of total GDP has declined from over 50% in the 1990s to about 24 % in 2008/09, (UBOS, 2010) because of faster growth in the service and industrial sectors, agriculture still remains the most important sector from a social perspective as livelihoods of over 70% of the population are derived from this sector (UBOS, 2007). Agricultural productivity in Uganda is noted to be poor due the low consumption levels of agricultural inputs and irrigation. The majority of Ugandan farmlands are rain-fed, where only a small percentage of croplands has access to irrigation. The viability of rain-fed farming systems is becoming increasingly compromised by climate change. Owing to the fact that irrigation has the potential to increase the viability and the productivity of crops, Ugandan farmers suffer from poor returns from agriculture due to limited consumption of irrigation water. Increasingly irrigation has been identified as the necessary infrastructure provision of the country which has potential need to contribute to food security, poverty alleviation and economic growth (NIMP,2011).

- **Irrigation potential and land area equipped for irrigation**

Despite the country's plentiful water resources, estimates of Uganda's spatial potential for improved irrigation vary from 170,000 ha to over 560,000 (NIMP[21], 2011), whereas the total arable land area is 4,400,000- 6,900,000[22] ha. The difference between the two represents the potential for rainfed agriculture. Various estimates for Uganda's irrigation potential has been made over the years. A study from 2003, identified only 90,000 ha of irrigation potential (MWLE, 2003); but the 2011 Irrigation Master Plan classified 567,000 ha in two types of irrigation potential: (Type A) 295,000 ha close to surface water resources and thus does not need any storage facilities and 272 000 ha (Type B) that would require storage to be developed (MAAIF, 2011). Only 14,418 ha are identified as equipped for formal irrigation and with another 53,000 ha of informally water managed wetlands (NIMP, 2011). According to AQUASTAT data in 2012, the area equipped for irrigation is estimated at 11,137 ha.

[21]National Irrigation Master Plan for Uganda 2010-2035:Final Report
[22] Aquastat,2012

- **Policy and regulation framework**

Wastewater management and reuse: The Government of Uganda has put in place a number of policy and legal instruments regarding environmental protection. The National Environment Act, 2000 with its accompanying regulations: Environmental Impact Assessment Regulations 1998; The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations 1999, and the National Environment (Waste Management) Regulations of 1999 were put in place to ensure sustainable use of environment and natural resources across the country (MWE, 2010). The Water (Waste) Discharge Regulations, 1998 provide for the regulation of wastewater discharge through the use of permits. Discharge of effluent or waste is prohibited on land and into the aquatic environment contrary to established standards and without a discharge permit (NETWAS, 2011). There are also other legal and policy provisions that relate to waste pollution and to promote the safe storage, treatment, discharge and disposal of waste which may pollute water or otherwise harm the environment and human health, namely: the Water Statute to promote the safe storage treatment, discharge and disposal of waste which may pollute water or otherwise harm the environment and human health. The National Environmental Health Policy of 2005 was instituted to ensure healthy living conditions in rural and urban areas. Wastewater has become an alternative source of water for many Ugandan farming communities especially in urban areas with scarce water sourced for agriculture. The legal and policy framework is generally lacking and weakly address wastewater reclamation and reuse. According to MWE (2010), the use of wastewater sludge is guided by the World Health Organization (WHO) Guidelines but these have not been localized to reasonable standards that can be observed by the generators (NETWAS, 2011).

Development of urban agriculture and the potential for wastewater reuse: Whilst growing urban agriculture is indicative of the potential that wastewater reuse has, a lacking legal and policy framework will most likely limit its potential. Urban agriculture plays a key role in urban and peri-urban Kampala, where agriculture activities contribute up to 40% of the total food consumption. More than half of the land both within Kampala's municipal boundaries and peri-urban areas is used for agricultural purposes, with an estimated 30%of the households engaged in urban agriculture. The Urban Agriculture Ordinance has a clause on human waste which prohibits the use untreated human waste as manure for agriculture purposes. However, MAAIF is in the process of developing an Urban Agriculture Policy that will provide guidelines on the use of wastewater sludge. However, urban agriculture is still illegal in other municipalities in Uganda. Currently, MAAIF, in collaboration with KCCA and other stakeholders, is in the process of developing a national policy on Urban Agriculture in Uganda. Additionally, NAADS, the government program for agricultural development, has mainstreamed UPA in its implementation framework and has rolled out its program activities in Kampala. This has been done by rezoning Kampala into urban agricultural production zones, namely the core zone, intra-urban and peri-urban zones (Elly et al,2012).

Alternative sources of water use in agriculture in Kampala: While most agriculture in Kampala is rain-fed, farmers are increasingly using irrigation from a variety of sources due to seasonal and spatial variations in rainfall pattern and the spatial variations in distribution on surface and groundwater resources. Two primary water sources are used in the urban and peri-urban areas of Kampala: piped and spring water. During dry seasons most of the springs can be dried off and limits the water extraction level of the available groundwater resources. Although there is constant provision of water and sewage services, piped water can be too expensive for daily agriculture activities such as irrigation, dipping of animals and processing animal feeds. Some urban farmers do not have access to national water services; they thus depend on water from swamps and springs. Safe water coverage for major and small

towns in Uganda stands at 66% of the population. In this case, treated wastewater use represents an option for urban and peri-urban farmers.

Around 7.62 million m^3/year of wastewater is produced in Uganda and Kampala is the largest producer of wastewater owing to its rapid population growth (6% population growth rate, UBOS (2006-2012)) and the growth of industrialization. The residential and industrial area of the city almost doubled between 1980-2002, while forcing agricultural and swamp forest land area to be squeezed out (Landsat images (1980–2002) and Nyakaana et al. (2007)). As noted earlier municipal water withdrawal is the largest water user of Uganda and in Kampala as well, contributing 51% of the total water withdrawal (317 million m^3) and this amount has dramatically increased over the last decades (AQUASTAT, 2008).Thus, invariably wastewater production has also increased over the time owing to the significant municipal water consumption. Kampala being the most populous region, it is obvious that city has the highest wastewater generation potential in whole Uganda. The city has both small industries, such as metal fabrication, pottery and carpentry, and large-scale processing and manufacturing industries (Elly et al.,2012). Although only 7% of Kampala city is connected to the sewerage network and the majority of wastewater is discharged directly into open drainage channels and open wet lands, the quantity that is treated (21%) can used for both industrial and agricultural purposes. Thirty-two (32%) percent of total irrigation demand of total crop land for Kampala, estimated at 72 million m^3 of water, can be satisfied with treated wastewater, hence serving as a potential alternative source of irrigation water for farmers.

As Table 27 below shows wastewater consumption seems to be common practice particularly by horticultural farming businesses in Kampala. Specifically they use a range of wastewater varying from undiluted to diluted wastewater and wastewater mixed with freshwater. Several studies show that the use of wastewater for irrigation in Kampala is seen to be a necessary technique that supports farming and enables essential crops to be grown, particularly during dry seasons. This has led to increased productivity and cropping intensity, favoring crop diversity. This opportunity is yet to be fully exploited in Kampala. Key limitations however relate to the lack of mechanisms for supply of safe and treated wastewater to urban farmers and supportive legal and national policies.

Table 27: Sources of irrigation water in sampled farming groups in Kampala

Source of irrigation water	**Use (% of surveyed farmers)**	**Crops grown by farmers**
Open stream (domestic and industrial waste) untreated	38	Vegetables, floriculture, tree nurseries, yams, maize, and beans
Treated/dilute wastewater	20	Vegetables, floriculture, tree nurseries
Mixed wastewater and pipe water	27	Vegetables, floriculture, tree nurseries, yams, maize, and beans
Water tankers/trucks	4	Grassed compounds and flowers
Other (e.g. pool, deep well, and main sewerage)	11	Flowers, vegetables, and tree nurseries

Source: Muwembe, 2008.

3.3.3 Market Outlook

3.3.3.1 Background and Justification

This sub-chapter presents the results of the market outlook assessment of the wastewater use business models. The assessment is viewed from the end-product, i.e. irrigation water and thus like the market structure assessment, uses this sector as the base. The forecasting of water demand is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting will aid business development management in planning into the future. Because investment toward an uncertain future is very difficult and risky, market forecasting will help alleviate the risk and obtain more accurate or reliable information. Market forecasting will be helpful for future investors in wastewater reuse in making strategic decisions on product pricing, future capacity requirements, and implementation of other innovative business strategies, etc. In contrast to other types of markets, the water sector management including urban water supply, irrigation and sanitation (wastewater) management sector is highly regulated and controlled by the governments. Thus, similar to the energy sector, any investment in the wastewater reuse sub-sector will be affected by the policy planning in the power sector. An assessment of the market outlook and trend will provide greater clarity on anticipated market growth and will better inform investors on which strategic investment decisions to make. Thus, the key objective of this analysis is to assess the market potential for treated wastewater demand by forecasting future demand, identifying possible gaps in supply and policy opportunities in support of future water supply in Uganda. As with the market structure assessment, it is important to note that the analysis is limited in its assessment due to data limitation; which resulted in the assessment been conducted from a national perspective. The key findings are however applicable to Kampala as the majority of wastewater reuse in any form will most likely occur closer to the wastewater treatments.

3.3.3.2 Research Methods and Data Collection

Sophisticated demand projections to asses future demand of water resources in Uganda, with the objective of assessing the gap between future water availability and demand was restricted due to limited data availability in the water sector in Uganda in both country and international data bases. Available data was limited to a number of years and was employed for assessing the prevailing water scarcity issues and future prospects. To evaluate the future demand potential for new investors in Ugandan water sector, water extraction data for several years and trends were identified. Water availability, extraction efficiency and potential, supply and distribution efficiencies for each sector especially for irrigation were also assessed. This served to identify any current and future supply gap or prevailing inefficiencies; and which can be fulfilled by new RRR wastewater initiatives for agricultural projects. Herein, opportunities were identified within the water sector in Uganda, where new wastewater businesses can grow and serve as an alternative source for water scarce areas. Data was primarily obtained from secondary sources (i.e. existing literature, international reports, Ugandan organizational reports and websites on water sector in Uganda). Water extraction, availability and distribution coverage data were sourced from international data bases such as AQUASTAT (FAO).The abovementioned data was assessed in detail in the market structure assessment and thus not repeated in this sub-section. A time series analysis to forecast the potential demand growth for treated wastewater was not possible given data limitations; thus the market outlook assessment gleaned from the assessment of the market structure.

3.3.3.3 Results and Discussion

The potential demand growth for treated wastewater for irrigation although difficult to forecast, is presumed to potentially increase given limitations of water availability and access. Although, Uganda is well-endowed with water resources, the spatial distribution of these resources is creating an increasing level of water stress in many areas, and thus an increase in competitiveness among multiple users. This situation worsens during the dry seasons, when available water resources are limited due to limited storage capacity of surface water in Uganda. This invariably reduces water availability for agriculture crops and livestock, resulting in considerable crop and livestock damages particularly during dry periods. Additionally, the renewable water resource per capita has consistently declined over the years in Uganda with rapid population growth and urbanization; suggesting the potential for Uganda to become a water scarce country in the future, if water resources are not managed well.

Significant water supply gaps attributable to inadequate irrigation infrastructure have been observed in Kampala and Uganda as a whole. The majority of farmlands are rainfed and only 3% of the potential irrigated land area is equipped for irrigation due to poor financial resource allocation on the irrigation infrastructure development sector. Farmers thus have to depend on available alternative sources including groundwater, piped water and wastewater. However, groundwater extraction is costly and requires investment. Moreover the spatial variation in the groundwater table and limitations on extraction restricts access of some areas for groundwater. Piped water is also a costly alternative, only practiced by the small percentage of farmers. These factors have led some farmers in certain locations to rely on wastewater from nearby drainage channels, especially in Kampala. This is indicative of increased demand for treated wastewater for agriculture in the instance where budget allocations do not support infrastructure improvement. Additionally, there is increasing user experience and awareness of wastewater reuse in agriculture as in several locations around urban areas in Uganda, where wastewater exists as the only source of irrigation water for their crop lands, farmers are directly involved in the use of wastewater for irrigation and use of dried fecal sludge as source of nutrients. Flower growing farmers (cottage and commercial level) in Kampala is an example for informal use of wastewater.

Farmers are supposed to pay an irrigation water fee for the service and labor supplied for the regular cleaning and maintenance of water supply. While farmers' ability to pay these fees is indicative of their willingness-to-pay for these services, the government policy suggests that the service fees set should reflect the actual cost of water access and should be based on the actual WTP of farmers in specific locations. Some research findings explain that farmers in certain areas are willing to pay much higher fees depending on their demand for water and the scarcity. This result is indicative of the potential demand for treated wastewater for irrigation as measured by the farmers' willingness to pay for supply services in addition to the product; and thus invariably the increased viability of private businesses wanting to be engaged in the wastewater reuse business in Uganda.

Whilst, the demand growth for treated wastewater is forecasted to increase in the future, there are potential limitations that need to be taken into consideration for future entities looking to invest in wastewater reuse. Firstly, more than 90% of the city area is still not connected to the central sewer network. The lack of wastewater treatment facilities in the city as compared to the quantity of wastewater generated may limit the actual quantity of treated wastewater available for supply. Infrastructure improvement will be necessary to keep supply up to par with demand. Secondly, there are policies supportive of increased of wastewater use. In particular there are recent policy initiatives that are tailored more to private sector involvement in the irrigation development sector given the poor

financial base of the Ugandan government, thus providing more administrative and legal feasibility for private sector involvement. However this policy does not directly make a provision for wastewater irrigation businesses. Thirdly, there is no proper mechanism to separate wastewater flows to the open system. The main sewer system is mixed with different wastewater streams. Difficulties in enforcement of regulation on wastewater discharge into the open drains make the wastewater business difficult as well as farming. Initial investment cost for storage and channel construction can be high. Additionally, current experiences of existing service providers suggest significant financial difficulties associated with irrigation service provision, making the wastewater irrigation business less attractive for private investors.

3.3.4 Conclusions

Results from the market assessment, specifically the WTP analyses indicate that about 98 percent of the enterprises surveyed expressed a high level of satisfaction with the current quality of water supplied by the National Water and Sewerage Corporation (NWSC) and 96% noted facing no shortages with water supply. Only 7% of the surveyed enterprises expressed interest in using treated wastewater, particularly for washing purposes, and noted not willing to pay higher prices than the current fees - with a WTP estimate of UGX 500/m^3. The results however indicated that this subset of enterprises did not have a strong preference for certification (i.e. had no valuation for 3rd certification that the wastewater delivered was treated to an acceptable level). However, it is quite clear that enterprises have a strong preference for connections provided by NWSC and that quarterly payments seemed more suitable. Farmers , on the other hand, showed a higher interest in wastewater reuse for irrigation. About 74% of the surveyed farmers were willing to pay for reliable supply of treated wastewater services to their farms. This is supported by the sources that the farmers obtain water from - about 37% were dependent on groundwater, 13% on rain-fed irrigation, 26% received water through pipes and 10% from the canals. The remaining percentage relied on springs and swamps for irrigation water. The total payment elicited by the farmers for treated wastewater supplied by NWSC is UGX 530/m^3. It is also noted that the farmers would prefer supply from NWSC and are interestingly willing to pay more for certification. While 70% of the respondents preferred operation, maintenance and delivery by NWSC, 12% preferred KCCA and 10% opted for farmers' organizations. Thus overall, whilst there is a fair demand for treated wastewater, the demand is higher among farmers but characterized by a WTP lower than the current market prices for irrigation water.

The total number of agricultural households in the urban and the peri-urban areas of Kampala was estimated at about 44,962 households (Makita, 2009). Assuming an adoption rate of 70% by farmers, the total number of farms demanding treated wastewater would approximately be 31,473 farming households and total agricultural land at 31,473 hectares. Gross irrigation water requirement in Uganda is about 8000 m^3/ha in a year (FAO, 1997). Hence the total water requirement in the urban and per-urban area of Kampala can be estimated to be about 250 million m^3 in a year, clearly exceeding the total wastewater generated.

Although urban agriculture is practiced widely, business oriented reclamation of wastewater in urban areas may be difficult due to the scattered nature of urban farmers. Large-scale farming activities are sometimes located far off from urban areas, and where wastewater infrastructure is not planned to be implemented, this would require the treated wastewater to be piped long distances. Thus, it is important to note that the estimated demand may be limited by costs related to delivery especially for

farmers located far off from the wastewater treatment plants. There is a potential for the establishment of a cooperation with the National Water and Sewerage Corporation (NWSC) as part of a public-private partnership agreement to consider a strategy for upgrading the wastewater treatment infrastructure and incorporating reuse. However, it is important to note that, considering the high investment costs associated with wastewater treatment infrastructure, the retro-fitting of existing plants may not only come at high cost but negate the potential economic benefits to be derived from reuse. The infeasibility of BM 10, on the other hand, is mainly driven by institutional regulations, which note the use of untreated wastewater for irrigation as impermissible under the city and national policies on wastewater and irrigation. Additionally, the associated negative health risk and impact will likely not support the promotion of untreated wastewater for irrigation in Kampala. On the other hand, given the extensive benefits of wastewater treatment, a comparative assessment of the net social benefits will better inform policy makers to justify the institution of subsidies for the farmers.

3.4 Nutrient Business Models

The organizational structure of this sub-chapter differs from the other sub-chapters on energy and wastewater. The willingness-to-pay and market size estimation results are presented first for all the 3 business models, noting that models 17 and 19 have the same end-product - faecal sludge-based organic fertilizer *(termed here as Fortifer).* As the products - MSW-based compost and Fortifer do not as yet have an established market in the fertilizer market/industry, the market structure assessment is conducted from the perspective of the key competing market - chemical fertilizer market for both end-products. A subsequent section is also presented for the market outlook assessment with respective sub-sections for the two products.

A. Model 15: Large-Scale Composting for Revenue Generation (MSW to Compost)

3.4.1 Willingness-to-pay and Market Estimation

3.4.1.1. Background and Justification

Agricultural production contributes immensely to the livelihoods of farmers in urban and peri-urban Kampala, Uganda. Recent changes in climate patterns has resulted in farmers facing exacerbated challenges with access to basic farming inputs such as water, land and fertilizers. Particularly, farmers have deal with increasing land degradation and related fertilizer costs. This trend has resulted in many farmers moving to urban areas and seeking other productive sectors of the economy. The short and long-term impacts of this structural change is expected to be detrimental to the Ugandan economy. Previous research shows that the use of compost provides significant benefits to farmers and has the dual benefit of reducing public budget allocated to waste management, particularly waste collection and treatment (Danso and Drechsel, 2014). In addition, previous studies show that composting of municipal solid waste is comparatively more beneficial than other existing options such as land filling, incineration or open disposal (Drechsel et al. 2004). However, many compost businesses in Africa have short life cycles and create additional challenges by contributing to poor sanitation management. It is pertinent to mention that very few good empirical cases can be found in Bangladesh (Waste Concern), Sri Lanka (Balangoda) and in Ghana (Zoomlion). A review of these cases show that their success is hinged on a strong market assessment, resulting in implementation of appropriate pricing, distribution and marketing strategies. Thus, similar to the previous business models, the introduction of a compost product in the fertilizer market will require an assessment of the consumers' WTP and the potential market size. This will serve to better inform future investors on the appropriate pricing and marketing strategies to implement and also the optimal production capacity at which to operate.

Farmers in Kampala are aware of the benefits and costs of chemical fertilizers and other farming inputs. But the use of compost made from organic waste and faecal sludge is fairly novel to the farmers. In that regard, the use of a contingent valuation (CV) approach is appropriate to assess farmers' demand for MSW-based compost. The application of this approach can be found in Danso et al. (2006), who used CV to assess farmers' demand for compost in Ghana. Similarly, Awunyo et al. (2013) used this approach to assess households' willingness to pay for improved sanitation in Kumasi Metropolis, Ghana; as did

Agyekum et al. (2014) in estimating the demand for faecal compost by farmers in southern Ghana. These studies used a stated preference approach with either open-ended or closed-ended questionnaires to elicit respondents WTP. This approach has some shortcomings related to hypothetical bias, cultural bias and a starting point bias. To mitigate these shortcomings, a choice experiment (CE) approach was used for the demand estimation of MSW-based compost in this study. Several applications can be found in Hanley et al.(2006); Ndunda and Mungatana (2013); Lim et al. (2013) and Agimass and Mekonnen (2011). Based on our knowledge, this is the first study to apply a CE approach in the estimation of the demand for compost in Kampala, Uganda. The objectives of this sub-section is to use the CE approach to:

4. Estimate farmers' WTP for MSW-based compost;
5. Estimate farmers' WTP for attributes of MSW-based compost;
6. Estimate the potential market demand for MSW-based compost.

The subsequent sub-sections outline the research methods, data collection and analytical assumptions, results and finally the policy implications of the assessment.

3.4.1.2. Research Methods and Data Collection

Theoretical Framework

According to Lancaster (1966), the demand for a product is influenced by its attributes rather than the product itself. The theoretical foundation of the Choice Experiment (CE) is based on Lancaster's consumer choice theory, but also from the random utility theory developed by McFadden in 1974. Thus, it is assumed that in any CE, farmers will select an option from many choices, provided the selected option has attributes that provide them with the maximum utility. According to the random utility theory, a utility function comprises of a deterministic and a random component (McFadden, 1974; Arnot et al. 2006; Ndunda and Mungatana, 2013). In most cases, the researcher is able to observe the deterministic factors but the unobservable factors are captured in the random component of the utility function. Hence, the utility U associated with individual n whose choice is alternative i is given by:

$$U_{in} = V(Z_{in}) + \varepsilon(Z_{in}) \qquad (1)$$

where $V(.)$ is the deterministic component and $\varepsilon(.)$ is the error component in the utility function. The probability of an individual n choosing alternative i from a set of alternatives J can be estimated using a conditional logit model (CL) (Greene, 2002; McFadden, 1974; Maddala, 1999) and specified as:

$$\Pr(Y_i = n) = \frac{\exp[V(Z_{in})]}{\sum_{j=1}^{J} \exp[V(Z_{jn})]} \qquad (2)$$

If $V(.)$ is taken to be a linear function of specific characteristics whose random error term is identically and independently distributed (IID) with a type 1 extreme value (Gumbel) distribution, the conditional indirect utility function becomes (Ndunda and Mungatana, 2013; McFadden, 1974; Arnot et al. 2006):

$$V_{jn} = \delta_j + \sum \beta_{jk} Z_{jk} + \sum \alpha_{jn} (M_n . \delta_j) \qquad (3)$$

Where δ_j is an alternative specific constant, Z_{jk} is the k characteristic value of the choice j; β_{jk} is the parameter allied to the k characteristic, M_n is the socio-economic characteristic vector of individual n and α_{jn} is the vector of the coefficients related to the individual socio-economic characteristics.

The Choice Experiment Design

In addition to the estimation of the farmers' WTP and potential demand, the analysis also evaluated farmers' preferences towards diverse attributes of compost. The primary step of the research was to select applicable attributes, which was based on a literature review and in collaboration with local partners. Given the difficulties associated with the exact changes in the attributes' features, the levels of choices were qualitatively presented. The price levels used for the choice experiment were provided by the local partners and based on current market prices. Table 28 presents all the possible combinations considered for the choice experiment. Taking the full factorial design for three alternatives (A, B, C and D), each with three attributes with three levels, two attribute with two levels, we obtain $(3^3 x 2^2)^4$ different treatment combinations.

Table 28: Selected attributes for the choice experiment

Attribute	Levels	Description
Price(UGX/kg)	3	50, 100, 150
Source of waste input	3	MSW, Faecal Sludge, Animal Manure
Certification of product by 3rd party	2	Yes, No
Pelletization of compost	2	Yes, No

Experimental design technique is used for the final design (Louviere et al. 2000) and implemented with the SAS software. Pair-wise combinations of attributes were randomly blocked to nine groups of nine choices using a blocking factor. Therefore, each of the randomly selected farmers was presented with a nine choice set, as shown in the example of choice set (Table 29). The respondents were required to indicate their preferred choice on each choice set, which contained alternatives A, B, C and D (status quo) "no change" option. The respondents were provided with detailed description of the benefits and costs of compost made from organic waste.

Table 29: An example of a choice set presented to the respondents

Compost Attributes	A	B	C	D
Price (UGX/kg)	150	100	50	If options A, B, and C were all that was available at my local farm input shop I would not purchase compost from that shop.
Source	Faecal sludge	Animal Manure	MSW	
Certification	Not certified	Yes Certified	Not certified	
Pelletization	No Pelletization	No Pelletization	Pelletized	
I would choose . .	○	○	○	○

The choice experiment survey was conducted in five main districts: Kampala city and notable surrounding agricultural districts, i.e. Luwelo, Mpigi, Mukono and Wakisoin Kampala. Selected respondents were randomly sampled from farmers with and without compost experience. The farm household heads from the selected sample were provided with different types of compost with the attributes explained in table 29. A total of 339 farmers were selected and fully completed the survey,

which included either option A, B, C or option D and thus provided a total of 3051 (339*9) valid observations for choice model estimation.

3.4.1.3. Results and Discussion

- **Socio-economic characteristics of farming households**

Farmers' decision to purchase soil inputs and which types of inputs is determined by many factors (i.e. price, socio-economic factors, etc.). It has been noted that agricultural demand for organic inputs will increase if consumers have better information on product attributes and related benefits. To assess how different factors influence farmers' decisions, this section describes the characteristics of the respondents (such as age, education, gender, farming experiences and income); which will subsequently be used to assess their influence on farmers' purchasing decisions. The results indicate that most of the respondents interviewed were female and have secondary school education. It is also observed that most of the farmers are between the age group of 26-45 years, indicating that most of the farmers are in their productive age group and contribute immensely to the agrarian economy of Uganda. The farmers are noted to having many years of experience in using different types of inorganic and organic fertilizers. As evident in the survey results, most of the farmers have more than five years of farming experience and mostly come from large households (Table 30). Pertaining to households' income status, large-scale farmers have the highest average annual income, ranging from 120,000 to 60,000,000 (UGX).

Table 30: Socio-economic characteristics of farmers

Characteristic	Description	Frequency	Percent
Gender	Male	137	40.41
	Female	202	59.59
Age	Less than 25	57	16.91
	Between 26-35	99	29.38
	Between 36-45	92	27.30
	Between 46-55	44	13.06
	56+	45	13.35
Education	No formal education	18	5.37
	Primary education	100	29.85
	Secondary education	137	40.90
	Technical/training college	54	16.12
	University	26	7.76
Household size	Less than 2	18	5.33
	Between 3-6	194	57.40
	Between 7-10	93	27.51
	11+	33	9.76
Farming experience	Less than 5	149	44.61
	Between 6-10	87	26.05
	Between 11-15	31	9.28
	Between 16-20	25	7.49
	21+	42	12.57

Income	120000-500000	45	17.31
	500000-1000000	51	19.62
	1001000-5000000	138	53.08
	5100000-10000000	26	10.00
	10000000+	12	4.62

- **Awareness, knowledge and current use of compost**

Background of current soil inputs

The survey results indicate that poultry manure, cow dung, compost and inorganic fertilizers are the main soil inputs for farming (Table 31). Major reasons for using these soil inputs are; (1) accessibility, (2) nutrient value, (3) scarcity of alternative soil inputs and (4) easy of transportation. Farmers obtain these soil inputs from diverse sources at different prices. The survey results show that most of the farmers obtained fertilizers from agro-chemical dealers, cattle keepers, and poultry farmers. In some cases, farmers used home-made compost for farming.

Table 31: Major soil inputs

Soil inputs	Number of respondents surveyed	Percentage of respondents surveyed
Compost	46	13.6
Cow dung	81	23.9
Farm residue	39	11.5
Goat waste	3	9
Inorganic fertilizer	43	12.7
Pig waste	8	2.4
Poultry manure	119	35.1

However, the use of these key soil inputs are not without challenges. The results indicate that issues of price, bulkiness of the input, and intensive labor demands are the main constraints associated with the use of these soil inputs. In particular, 12% of the farmers believe these current inputs are expensive and require an extensive period of preparation time before they are ready for use. This result suggests that efficient planning and budgeting are required prior to the start of the farming season. Farmers claim that there are many constraints associated with the use of soil inputs for farming which affect their cropping pattern and profits. In this context, the survey strives to understand the sources where these farmers obtain their current soil inputs. It is interesting to note that these major soil inputs are mainly produced by the farmers either at home or in their farm settings. Sixty-four percent (64%) of the respondents stated that they produce their fertilizer inputs themselves; whilst 20% are supplied by the local agro-input supplier; 2.4% are supplied by their neighbors; 4.1% from other farmers and 5% did not know the sources of their purchasing inputs. In support of these trends of results, the analysis reveals that farmers produce their own fertilizers so as to reduce costs, to ensure its quality and to minimize transportation costs. Conversely, 15% of the farmers claim that there are no challenges associated with their current soil input for farming.

Current soil inputs are noted to be expensive and one of the key reasons why most farmers produce their current soil inputs, mainly to minimize cost and ensure high quality of the product. In that regard, we evaluated farmers' preference for local and/or imported soil inputs for farming. It is believed that if farmers purchase local inputs for farming, this will promote local compost businesses. The results reveal that most of the farmers do prefer local soil inputs to imported ones. Interestingly, farmers still prefer local soil inputs even if prices are higher than current market input prices and even if the quality is low (Table 32).

Table 32: Preferences for local inputs

Evaluation questions	**Responses**			
	Yes		**No**	
	Frequency	%	Frequency	%
Would you prefer local inputs?	283	42.33	56	17.11
if yes, even if quality was a little bit lower	185	32.23	101	31.02
if yes, even if price was a little higher	169	25.44	117	51.87

Factors influencing consumers' purchasing behaviour

This section evaluates the factors (i.e. both economic and locational) that affect farmers' purchasing decisions of soil inputs - fertilizers for farming activities (Table 33).To set the optimal pricing strategy, a compost business will need to understand the factors that influence farmers' purchasing decisions particularly of competitive products such as inorganic fertilizers. A five-level Likert scale was used to assess the effects of these factors on farmers' purchasing decisions. Overall, 14 questions were used and farmers had the opportunity to agree or disagree using their current purchasing decisions as well as farming experiences. Of the 339 surveyed respondents, a total of 332 valid responses was obtained and analyzed; suggesting that the majority of farmers believed these factors to play a significant role in their purchasing decisions. Sixty (60%) percent of the farmers noted price to be the most important factor they considered when purchasing fertilizer for farming activities. Conversely, only 15% did not consider price as a key factor in their purchasing decisions. Farmers also believe that factors such as organic matter content, NPK levels, water holding capacity and safety of the product are important attributes they consider in their purchasing decisions. Contrary to expectations, famers noted product branding and suitable credit offer to not necessarily influence their purchasing decisions. About 40% of the farmers were unsure if suitable credit would influence their purchasing decisions. To minimize transportation and related labor costs, most farmers noted that a convenient location to buy the product and proper packaging options would influence their purchasing decisions. Additionally, the surveyed farmers believe that fertilizer application methods and recommendations by another trusted farmer would most likely influence their purchasing decisions, especially if they know someone who had used it before. This result tends to suggest that farmer-to-farmer promotions and learning strategies would be important to incentivize farmers' adoption.

Table 33: Factors influencing farmers' purchasing decisions

	Ranking of farmers' perceptions of different factors				
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Evaluation questions	**%**	**%**	**%**	**%**	**%**
Price is the most important	29.2	31.63	23.8	11.4	3.92
NPK levels content most important	21.6	50.3	14.67	10.5	2.99
Organic matter most important	38.8	40.53	17.16	3.55	0
Water holding capacity	32.2	42.6	18.93	6.21	0
Safety is the most important	33.4	36.75	21.69	6.63	1.51
Packaging is the most important	9.34	32.23	29.82	21.7	6.93
A label showing certified fertilizer(MAAF)	15	38.74	26.43	17.1	2.7
Brand name is the most important	9.61	27.03	35.44	20.1	7.81
Suitable credit offer	8.36	23.28	40.3	25.4	2.69
Convenient location to buy	19.9	53.61	18.37	7.83	0.3
Volumes to apply most important	19.8	58.86	18.32	2.7	0.3
Fertilizer application important	23.2	56.33	16.87	2.41	1.2
Recommended by trusted source	29.1	51.65	14.41	4.5	0.3
I know someone who has used it before	19.6	47.29	16.27	14.5	2.41

Knowledge, attitude and perceptions of farmers towards compost

This section highlights the farmers' knowledge, attitudes and perceptions about compost from different waste sources, in particular, municipal solid waste (MSW) and faecal sludge (FS). It is believed that farmers' perceptions can positively or negatively affect the demand for compost. Similarly, a five-level Likert scale was used. The results suggest that the demand for compost is likely to increase if the product is certified by a relevant government authority. Fifty-eight percent (58%) of the surveyed respondents perceive certification by a government authority as essential for promoting and creating demand for compost made from faecal sludge. Similarly, 62% of the farmers perceive government certification of the compost product to be important. This result suggests that certification by a relevant government authority can possibly increase the demand for compost; an important strategy to build the confidence of farmers about the quality of the fertilizer product. Another attribute that the farmers perceived to be important is pelletization of the compost product. This result supports previous studies where farmers have noted the bulky nature of compost as a barrier to the transportation of the product to markets, increasing distribution costs, which are usually self-borne. This is important information for future compost businesses where they can explore opportunities to increase the accessibility and usability of compost products via product structure improvement (pellets) to improve its competitive advantage, marketability and field use.

Farmers have less reservation for compost made from either municipal solid waste or faecal sludge. Especially for faecal sludge compost, 43% of the farmers have no reservation to use faecal sludge-based compost, 23% are uncertain while 32% have reservations toward the use of this product. This result is consistent with compost made from municipal solid waste (Table 34). These results are as expected as most of the farmers are not aware of the advantages and disadvantage of the respective products. As evident, the results show that 77% of the farmers are not entirely familiar about the advantages and disadvantages of the products, contributing to their rejection rates. Overall, farmers perceive compost to contribute to the improvement of the environment and support sanitation improvements. These results tend to suggest that if certification is done by trusted government authorities and proper information on the advantages and disadvantages of pelletized compost are provided to farmers, it is possible to increase the demand of the product.

Table 34: Farmers' knowledge, attitudes and perceptions of compost

	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Evaluation questions	**%**	**%**	**%**	**%**	**%**
1. Advantage and disadvantage of faecal sludge	7.4	7.1	8.0	33.4	44.1
2. Advantage and disadvantage of MSW	10.9	22.8	24.0	23.4	18.9
3. No reservation for faecal sludge	17.2	26.7	23.1	25.5	7.4
4. No reservation for MSW	16.1	32.7	27.7	19.0	4.5
5. Faecal sludge certified by authorities	15.4	42.7	24.6	11.3	5.9
6. MSW certified by relevant authorities	16.9	48.7	21.7	10.1	2.7
7. Faecal sludge trusted if certified authority	12.5	44.2	28.8	11.0	3.6
8. MSW trusted if certified by authorities	15.1	56.4	21.7	5.9	0.9
9. Compost can be pelletized	17.8	57.0	22.6	2.4	0.3
10. Any pelletized soil input is better	16.0	35.6	35.6	11.9	0.9
11. MSW and FS if it was 20%cheaper	20.8	37.8	22.9	12.5	6.0
12. MSW and FS if it was 10% cheaper	15.1	26.1	21.1	29.4	8.3
13. Avoid buying fertilizer pellets	7.1	27.3	24.6	22.3	18.7
14. Contributes to sanitation improvements	12.8	49.6	26.7	7.1	3.9
15. Reduces environmental degradation	15.2	51.5	24.1	7.1	2.1
16. Pellet better than powder form	13.6	46.3	32.3	6.8	0.9

- **Willingness-to-pay (WTP) for MSW-based compost**

This section presents the results of the choice experiments. A conditional logit (CL) model was used to capture the effect of different attributes. Two models are presented in this section. The first model deals with the impact of the attributes on choice and the second one incorporates interactions between attributes and selected socio-economic variables as well as perception and farming characteristic variables. The first model shows the importance of the attributes in explaining respondents' choices across four different options in a choice set. The second model is an extended model which includes the socio-economic variables interacting with the attributes. To iterate, the dependent variable in the CL is the choice of compost from municipal solid waste. Respondents were given four packages of compost, with different prices, production and quality attributes and asked to choose one option. In total, there were 9 choice sets for each respondent. The key attributes considered for the CL model were: price, source, pelletization and certification. It is hypothesized that information on the source of materials used to produce compost; certification and pelletization attributes can positively affect farmers' demand for compost. The basic model focuses on these attributes. The indirect utility from the proposed compost options with quality improvement would take the following form:

$$V_i = \beta + \beta price + \beta source + \beta pellet + \beta cert \quad (1)$$

where V_i is the indirect utility for four alternatives; β refers to the alternatives specific constants and $\beta price$, $\beta source$, $\beta pellet$ and $\beta cert$ are the coefficients associated with the attributes payment for quality compost with information on source, pelletization and certification.

In the basic model, homogeneity of preferences of individuals is assumed. However, preferences may in fact be heterogeneous. Thus, to ensure an unbiased estimation of the individual preferences, heterogeneity was accounted for (Birol et al. 2005). In this study, the interaction of socio-economic variables was used to correct this issue. Socio-economic variables could not be introduced alone into the model since Hessian singularities could be encountered in model simulation (Bennett and Blamey, 2001). In this study, the socio-economic variables such as education, gender, age, household size and income were interacted with attributes in the choice set. In addition, perceptions and farming characteristic variables were interacted with the attributes in the choice set as well. The indirect utility function in this case takes the following form:

$$V_i = \beta + \beta_{price} + \beta_{source} + \beta_{pellet} + \beta_{cert} + \gamma_{source} + \gamma_{pellet} + \gamma_{cert} \quad (2)$$

Having these additive forms of indirect utility specification, the CL model is estimated for equation 1 and 2. Pertaining to the effect of perceptions and factors affecting farmers purchasing decisions, two main questions were evaluated. The first question deals with farmers' fertilizer purchasing decisions while the second question focuses on farmers perceptions about pelletized and certified compost. A Principal Component Analysis (PCA) was used to determine the questions that provide the best assessment for purchasing decisions and perceptions about compost. The PCA showed that factors such as price of the product (FAF), the brand name (FBF) and nutrient contents of the product (FCF) are relevant questions to assess farmers' purchasing decisions. Also, the PCA revealed that the ability to use the product without any reservations (FEF), certification by relevant authority (B113), certification by trusted authority (B211), pelletized soil inputs (B24b) and benefits to the environment (B26) are better determinants of farmers' perceptions about pelletized and certified compost. However, the different CL specifications showed that only FAF, FBF and FEF are relevant for the probability of farmers choosing different attributes of compost. Table 35 below presents these variables, summary statistics and definitions.

Table 35: Summary statistics of key variables used in the conditional logit model (CL)

Variables	Description	Mean	Std. Dev
AGE	Age of the respondent in years and interactions with source (AGEF), pelletization (AGEF1) and certification (AGETD).	39.32	14.58
GENDER	Gender of the respondents: 1 for males and 0 for females and interactions with source (GenderF), pelletization (GenderF1) and certification (GenderTD).	0.59	0.49
Hhsize	Household size and interactions with source (HhsizeF), pelletization (HhsizeF1) and certification (HhsizeTD).	6.36	3.4
Education	Education of farmers and interactions with source (EducationF), pelletization (EducationF1) and certification (EducationTD).	2.70	0.96
Income	Annual income of farmers and interactions with source(incomeF), pelletization (incomeF1) and certification(incomeTD)	3E+06	5470741
Religion	Religious groups of the farmers and interactions with source (ReligionF), pelletization (ReligionF1) and certification (ReligionTD).	1.60	0.811
FSIZEF	Farm size of the farmers and interactions with source (Fsize), pelletization (FsizeF1) and certification (FsizeTD).	0.962	1.19
FAF	Brand name is the most important interactions with source (FAF), pelletization (FAF1) and certification (FATD).	3.71	1.12
FBF	Price is the most important characteristics and interactions with source (FAF), pelletization (FAF1) and certification (FATD).	3.11	1.076
FEF	I do not have any reservation for accepting and using compost derived from faecal sludge and interactions with source (FEF), pelletization (FEF1) and certification (FETD).	2.00	1.2

Table **36** presents the base and full CL model results. The coefficient on price is negative and highly significant (p=0.000), which holds with prior expectations that price and the probability of compost purchase would be negatively correlated. This result is consistent across all two models. The negative sign of the payment coefficient indicates that the effect on utility of choosing a choice set with a higher payment is negative. In other words, scenario improvements with 'cheaper' alternatives are preferred to 'expensive' alternatives. The coefficient of source and certification are significant at 1% level and the signs of attributes are as expected. With the base model for compost, farmers prefer high quality compost when they know the source of materials used and are also willing to pay a premium if the product is certified and pelletized. This suggests that compost demand will be highly influenced by the provision of information on source of materials used and certification by a relevant government authority. As the socio-economic variables did not change over choice cases, they were interacted with alternative attributes. After several model specifications, the probability of choosing pelletized and certified compost is negatively affected by gender differences.

Table 36: Conditional logit (CL) model for compost choice experiment

Models	**Model 1**		**Model 2**	
Variables	Coefficient	Std. Error	Coefficient	Std. Error
Price	-0.011***	0.001	-0.011***	0.001
Source	0.625***	0.024	0.813***	0.131
Pellet	0.489***	0.036	0.471**	0.226
Cert	0.320***	0.040	0.547***	0.210
AGEF			0.000	0.002
AGEF1			-0.004	0.003
AGETD			-0.015***	0.003
GENDERF			-0.023	0.052
GENDERF1			-0.177*	0.091
GENDERTD			-0.201**	0.084
HhsizeF			0.002	0.014
HhsizeF1			0.075***	0.023
HhsizeTD			0.066***	0.022
EducationF			-0.018	0.026
EducationF1			0.068	0.044
EducationTD			0.146***	0.041
IncomeF			0.148***	0.049
IncomeF1			-0.184**	0.085
IncomeTD			-0.227***	0.079
FSIZEF			0.049**	0.021
FSIZEF1			-0.045	0.038
FSIZETD			0.062*	0.034
FAF			0.120***	0.024
FAF1			-0.070*	0.042
FATD			-0.149***	0.039
FBF			-0.093***	0.024
FBF1			-0.039	0.042
FBTD			0.125***	0.039
FEF			0.111***	0.025
FEF1			0.062	0.043
FETD			0.081**	0.040
Log likelihood	-3323.68		-2943.82	
AIC	6655.4		5955.6	
McFadden R^2	0.1387		0.1945	
Number of observations	3051		3051	

The model results show that age is a significant factor that affects the probability of choosing certified compost alternatives. As expected, older respondents were more unlikely to purchase certified compost if they were unaware of the relevant government agency responsible for certification. However, this is not an issue when pelletization or information of source is factored into the choice set of the respondents. Similarly, with education, only certification is relevant in farmers' choice decisions. Unlike age, as years of education increases, the probability of choosing

certified compost option increases, *ceteris paribus*. This result suggests that farmers with higher levels of education understand the benefits associated with the use of certified compost and are willing to pay a premium for this attribute. As farmers' income increases, they are willing to pay more for the source attribute than certified or pelletized compost. The decision to purchase certified compost is also positively affected by farmers' farm size. As farm size increases, farmers are willing to pay a premium for certified compost for farming activities as are large-scale farmers.

Estimated WTP and marginal WTP for attributes for MSW-based compost

The results from the CL models were used to estimate the rate at which farmers are willing to trade-off one attribute for the other (Table 37). In the CL model, there are monetary considerations for the attributes and the trade-off estimated is known as marginal willingness to pay for the attribute in question (Bennett and Blamey, 2001; Agimass and Mekonnen, 2011). It is important to note that the marginal willingness to pay analysis provides information on the relative importance of attributes, which play a significant role in business decision making, particularly, pricing strategies. The estimated marginal values for the 3 key attributes are presented in Table 37. The WTP is calculated as the negative ratio between the coefficients of an attribute to the price coefficient. The analysis reveals that farmers are willing to pay 58.78 UGX/kg more to know the source of the materials used to produce compost, but a relatively lower amount for pelletization and certification of compost. Given these marginal estimates, the full analysis shows that about 234.84 UGX/kg is the estimated market price for high quality compost, which is pelletized and certified by relevant government authority.

Table 37: Marginal WTP estimates for compost and estimated total price of high quality compost

					Estimates from conditional logit model(UGX/kg)			
	Current market prices(UGX/kg)				**Attributes**			
Soil input	Min	Max	Mean	Std.dev	Marginal WTP for source (UGX/kg)	Marginal WTP for pelletization (UGX/kg)	Marginal WTP for certification (UGX/kg)	Total price of compost (UGX/kg)
Compost	50	150	100	50	58.78	45.97	30.09	234.84

- **Estimated market demand for MSW-Compost**

The potential market for MSW-compost is noted to be substantial with the demand estimated at 0.78 million tons/year, with an adoption rate of 49% and application rate of 12.5 tons/ha/year. It is important to note that notable surrounding agricultural districts were considered in the market size estimation, i.e. Luwelo, Mpigi, Mukono and Wakiso in addition to Kampala. The total cultivated area under the 5 districts considered is 130,000 ha (Source: Uganda Census of Agriculture, 2008/09 Volume 4). Additionally, chemical fertilizer application rates were used as a basis for the calculation of the application rates for MSW-compost (IFPRI, 2012). It is important to note that MSW-based compost in considered as a complementary product.

B. Model 17: High value Fertilizer Production for Profit and Model 19: Compost Production for Sanitation Service Delivery (Faecal sludge to compost)

This section presents the results for the WTP and market size estimation for faecal sludge-based compost (termed here as *Fortifer*). Model 17 is similar to Model 15 in concept but in addition to MSW, this business model uses faecal sludge as an input from onsite sanitation systems which is rich in nutrients. There are opportunities for pelletization and blending of faecal sludge-based compost with rock-phosphate, urea/struvite or NPK which is an additional value proposition that can be explored under this business model, allowing the product to have nutrient levels specific for target crops and soils, and a product structure improvement (pellets) to improve its competitive advantage, marketability and field use.

3.4.2 Willingness-to-pay and Market Estimation

3.4.2.1. Background and Justification

As noted in the MSW-based compost section, agricultural production contributes immensely to the livelihoods of farmers in urban and peri-urban Kampala, Uganda. Recent changes in climate patterns has resulted in farmers facing exacerbated challenges with access to basic farming inputs such as water, land and fertilizers. Particularly, farmers have deal with increasing land degradation and related fertilizer costs. Previous research shows that the use of compost provides significant benefits to farmers and has the dual benefit of reducing public budget allocated to waste management, particularly waste collection and treatment (Danso and Drechsel, 2014). Large municipalities and towns generate vast quantities of waste that are rich in valuable resources, e.g. nutrients with great potential for agricultural production. Faecal sludge reuse, in particular, has been found to offer several benefits: a) providing options for municipalities to recover waste management costs, b) business opportunities where enterprises can produce high value organic fertilizer for sale at a profit, and c) advancing the goal of sustainably transforming agricultural production via the promotion of organic agriculture through the gradual replacement of chemical fertilizer with more sustainable and affordable options such as organic fertilizers. Like any new product, the introduction of Fortifer on the market, requires businesses to adequately assess the market so as to make strategic business decisions concerning pricing and marketing. Thus, similar to the previous business models, the introduction of Fortifer in the fertilizer market will require an assessment of the consumers' WTP and the potential market size. This will serve to better inform future investors on the appropriate pricing and marketing strategies to implement and also the optimal production capacity at which to operate. The objectives of this sub-section is to use a choice experiment (CE) approach to:

1. Estimate farmers' WTP for Fortifer;
2. Estimate farmers' WTP for attributes of Fortifer;
3. Estimate the potential market demand for Fortifer.

The subsequent sub-sections outline the research methods, data collection and analytical assumptions, results and finally the policy implications of the assessment.

3.4.2.2. Research Methods and Data Collection

The theoretical framework is as detailed out for the MSW-based compost, which uses a CE based on Lancaster's consumer choice theory and random utility theory developed by McFadden in 1974. Thus, it is assumed that in any CE, farmers will select an option from many choices, provided the selected option has attributes that provide them with the maximum utility.

The Choice Experiment Design

In addition to the estimation of the farmers' WTP and potential demand, the analysis also evaluated farmers' preferences towards diverse attributes of Fortifer. The primary step of the research was to select applicable attributes, which was based on a literature review and in collaboration with local partners. Given the difficulties associated with the exact changes in the attributes' features, the levels of choices were qualitatively presented. The **fortification** attribute is defined as a co-composted product from MSW and faecal sludge blended with rock-phosphate, urea/struvite or NPK, allowing the product to have nutrient levels specific for target crops and soils. And the **pelletization** attribute represents a product structure improvement (pellets) to improve its competitive advantage, marketability and field use. The price levels used for the choice experiment were provided by the local partners and based on current market prices. Table 38 presents all the possible combinations considered for the choice experiment. Taking the full factorial design for three alternatives (A, B, C and D), each with three attributes with three levels, two attribute with two levels, we obtain $(3^3 x 2^2)^4$ different treatment combinations.

Table 38: Selected attributes for the choice experiment

Attribute	**Levels**	**Description**
Price(UGX/kg)	4	300;600;800;1000
Fortification	2	Yes, No
Pelletization	2	Yes(pelletization), No(powder form)
Certification	2	Yes(certification), No(No certification)

Experimental design technique is used for the final design (Louviere et al. 2000) and implemented with the SAS software. Pair-wise combinations of attributes were randomly blocked to eight groups of eight choices using a blocking factor. Therefore, each of the randomly selected farmers was presented with eight choice set, as shown in the example of choice set (Table 39). The respondents were required to indicate their preferred choice on each choice set, which contained alternatives A, B, C and D (status quo) "no change" option. The respondents were provided with detailed description of the benefits and costs of Fortifer. The choice experiment survey was conducted in five main districts: Kampala city and notable surrounding agricultural districts, i.e. Luwelo, Mpigi, Mukono and Wakisoin Kampala. Selected respondents were randomly sampled from farmers with and without compost experience. The farm household heads from the selected sample were provided with different types of the Fortifer product with the attributes explained in table 38. A total of 275 farmers fully completed the survey, which included either option A, B, C or option D and thus provided a total of 2200 (275*8) valid observations for choice model estimation.

Table 39: An example of a choice set presented to the respondents

Production Attribute	**A**	**B**	**C**	**D**
Fortification	Yes fortification	Yes fortification	No fortification	If options A, B, and C were all that was available at my local farm input shop I would not purchase Fortifer from that shop.
Pelletization	Yes Pellet	Yes Pellet	No Pellet	
Certification	Certified	Not certified	Certified	
Price (UGX/kg.)	UGX1000/kg.	UGX300/kg.	UGX800/kg.	
I would choose ...	○	○	○	○

3.4.2.3. Results and Discussion

- **Socio-economic characteristics of respondents**

The majority of the surveyed respondents are within the age of 25-45 years and are mainly from medium size households (Table 40). About 43% of the farmers have secondary education, with 38% having primary level education. The analysis thus suggests that the respondents have sufficient basic education to be able to read instructions on labels and learn about fertilizer application methods.

Table 40: Socio-economic characteristics of the farmers

	Description	Frequency	Percent
Gender	Male	158	57.5
	Female	117	42.5
Age	less 25	41	15.24
	26-35	80	29.74
	36-45	71	26.39
	46-55	47	17.47
	56+	30	11.15
Household size	less than 2	17	6.27
	bet 3-6	131	48.34
	bet7-10	92	33.95
	11+	31	11.44
Education	No formal education	20	7.27
	Primary school	106	38.55
	Secondary education	120	43.64
	Technical/training college	25	9.09
	University	4	1.45
Farming experience	5	97	35.79
	between 6-12	83	30.63
	between 13-20	49	18.08
	Between 21-30	33	12.18
	31+	9	3.32
Annual gross income	200000	22	8.8
	210000-500000	16	6.4
	510000-1000000	20	8
	1100000-2000000	47	18.8
	2100000+	145	58

- **Awareness, knowledge and current use of organic fertilizers**

Background of current soil inputs

This section presents results on the characteristics and profiles of major soil inputs farmers currently being used for farming. The analysis in this section will further be used to support the discussions of farmers' perceptions and purchasing behaviors and subsequently linked to the analysis of the choice experiments. It is important to note that an emphasis is placed on the benefits of nitrate fortification in compost production. The essence is to investigate if farmers are willing to pay a premium for nitrate fortification, pelletization and certification (especially given the use of faecal sludge as an input). Out of the 275 respondents interviewed, the majority of them used different fertilizers for farming (72%) or gardening (27%). Cow dung and poultry manure are the dominant fertilizers for farming activities; and the major reasons why farmers prefer to use these soil inputs are: (1) easy

access to the inputs and ability to increase crop yields, (2) relatively ease of application, (3) nutrient value, and (4) scarcity of soil inputs in the community or availability for farming. Most of the farmers were noted to obtaining their fertilizer types from agro-chemical dealers, cattle keepers, poultry farmers and sometimes they used home-based compost. Several challenges they faced related to: crop burns, insect infestation and intensive labor demands were noted to be associated with the use of these key inputs (Table 41). Other constraints noted were: bulky nature of the product and limited knowledge on proper timing for application.

Table 41: Challenges associated with the use of dominant input

Challenges	Number of surveyed farmers	Percentage of surveyed farmers (%)
Burns crops	32	11.6
Contains insects/pests which affects crops	36	13.1
Difficulty in determining the volume to apply	2	0.7
Expensive	33	12
Heavy/bulky to transport	14	5.1
Labor intensive	32	11.6
long distance	7	2.5
Needs proper/timing application	17	6.2
None (no challenge)	55	20
Scarcity of input	22	8
Stays in soil for a short period of time	5	1.8
Stimulates the growth of weeds	1	4
Takes a longer time to decompose	13	4.7

The analysis also assessed farmers' preference for sourcing the current soil inputs they used. Similar to the assessment of model 15, the major soil inputs are mainly produced by the farmers either at home or in their farm settings. The survey results show that 66% of the these fertilizers are produced by the farmers while 16% of the farmers are supplied by an agro producer in the community, 8% by neighbors, 5% from other farmers and 3% did not know the source of the fertilizer they purchased. The farmers' responses on their preference for purchasing local inputs were also evaluated. The survey results reveal that most of the farmers prefer low quality local inputs, which corroborates the findings from the assessment for the MSW-based compost. The surveyed respondents also still preferred local inputs even if prices were higher than current market input prices and even if the quality was comparatively lower.

Factors influencing consumers' purchasing behaviour

A five-level Likert scale was used to assess 16 factors that possibly influence farmers' purchasing decisions. The survey show price to be a significant factor influencing farmers' fertilizer purchasing decisions as denoted by 48% of the farmers perceiving price to be an important factor in their purchasing decisions while 12% did not. Nutrient content of the product were also perceived as an important factors as characterized by NPK levels, organic matter levels and water holding capacity. Pertaining to water holding capacity, 80% of the farmers noted this to be an important factor influencing their purchasing decision. Interestingly, the respondents are uncertain if factors such as brand name, safety of the product and packaging types affect their fertilizer purchasing decisions. The results also suggest that farmers seek to minimize transportation costs, thus a convenient location where they can purchase fertilizer for farming activities may be crucial. In support of this

assertion, the survey results reveal that 66% of the farmers perceive a convenient location to buy fertilizer a significant factor in their purchasing decisions. Other significant factors noted by the respondents are: volumes to apply (64%) and fertilizer applications (60%). In most cases, farmers have limited to no experience with the use of fertilizer and other organic inputs. From this perspective, farmer-to-farmer promotions can enhance the adoption of Fortifer. About 56% of the farmers are likely to purchase fertilizer if it is recommended by trusted sources and a higher percentage is observed if they know someone who is already using it.

Knowledge, attitude and perceptions of farmers towards organic fertilizers

Fortifer can be produced in a powder form or in pellets, depending on the need of the farmer. A five-level Likert scale and a total of 12 questions were used to evaluate farmers' perceptions, attitudes and knowledge toward Fortifer. Attributes related to price, quality, safety and environmental issues were assessed. The results suggest that fortification of the product and certification by a relevant government authority will significantly influence demand; indicating that quality and safety of the product will need an endorsement from a trusted government authority. The results further show that the demand for the product may not necessary increase if its price is set to be the same as the price of chemical fertilizers, but rather a better strategy would be to set the set the price at least 20% lower than that of chemical fertilizer. Some farmers perceive that faecal sludge could potentially have a negative impact on crops, animals and on humans and that irrespective of the price; they would not use Fortifer. About 36% of the farmers support this assertion and also believe that this product is not safe (37%). It is possible to minimize these negative perceptions from educational programs by relevant government bodies and product certification. This would be a cost-effective approach as 20% of the respondents perceive additional educational initiative on the advantages and disadvantages of the product could increase their demand. Notwithstanding, pelletized Fortifer is preferred (52% of farmers) to powdered compost.

Table 42: Farmers knowledge, attitude and perceptions

	Likert -scale ranking				
	Agree	**Strongly agree**	**Neutral**	**Disagree**	**Strongly disagree**
Evaluation questions	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**
1. Advantage and disadvantages faecal sludge	20.07	5.47	19.71	35.77	18.98
2. Have no reservation for accepting FS	28.1	9.49	28.47	23.36	10.58
3. FS fertilizer certified by authorities	41.97	12.8	21.17	18.61	5.474
4. Fortifer certified by authorities	50.36	9.49	21.53	12.77	5.839
5. Not safe to use pellets from FS	20.07	2.55	32.85	37.23	7.299
6. FS Price same as chemical fertilizer	39.78	6.57	31.75	19.34	2.555
7. 20% cheaper than chemical fertilizer	52.19	15.3	14.96	15.69	1.825
8. 10% cheaper than chemical fertilizer	45.62	13.1	14.96	22.63	3.65
9. Regardless of price, I would buy FS	27.37	4.74	16.06	36.13	15.69
10. Benefits of sanitation improvements	52.55	15.7	17.15	13.14	1.46
11. Benefits of environmental degradation	54.38	15.3	16.42	12.77	1.095
12. Pellet is better than powder Fortifer	52.55	17.2	17.52	10.22	2.555

Faecal sludge is denoted as FS.

- **Willingness-to-pay (WTP) for Fortifer**

This section presents the results of the choice experiments. A conditional logit (CL) model was used to capture the effect of different attributes on farmers' purchasing decisions. Two models are presented in this section. The first model deals with the impact of the attributes on choice and the second one incorporates interactions between attributes and selected socio-economic and perception variables. The first model shows the importance of the attributes in explaining respondents' choices across five different options in a choice set. The second model is an extended model which includes the socio-economic variables interacting with the attributes. The dependent variable in the CL is making the choice of using Fortifer. Respondents were given four packages of Fortifer, with different prices, production and quality attributes and asked to make one choice. In total, there were 8 choice sets for each respondent. Key attributes selected for the CL model were: price, nitrate fortification, pelletization and certification. The indirect utility from the proposed options with quality improvement takes the following form:

$$V_i = \beta + \beta price + \beta fort + \beta pellet + \beta cert \quad (1)$$

where V_i is the indirect utility for four alternatives; β refers to the alternatives specific constants and $\beta price$, $\beta fort$, $\beta pellet$ and $\beta cert$ are the coefficients associated with the attributes on payment for quality compost with information on nitrate fortification, pelletization and certification. Likewise in considering the heterogeneity of individual's preferences, socio-economic variables such as education, gender, age, household size and income; perceptions and farming characteristic variables were interacted with attributes in the choice set. The indirect utility function in this case is as follows:

$$V_i = \beta + \beta_{price} + \beta_{fort} + \beta_{cert} + \beta_{pellet} + \gamma_{fort} + \gamma_{cert} + \gamma_{pellet} \quad (2)$$

Having these additive forms of indirect utility specification, the CL model is estimated for equation 1 and 2. Similar to the MSW-based compost, the effect of perceptions and factors on farmers' purchasing decisions was evaluated using two main questions. The first question deals with farmers' fertilizer purchasing decisions while the second question focuses on farmers perceptions about pelletized and certified Fortifer. Principal Component Analysis (PCA) was used to determine the questions that provide the best assessment for purchasing decisions and perceptions. The PCA showed that factors such as price of the product (FAF), the water holding capacity (FDF) and nutrient contents of the product (FCF) were relevant questions to assess farmers' purchasing decisions. Also, the PCA revealed that certification by a relevant authority (FGF), use of product with no reservations (FEF), certification by trusted authority (B211), pelletization (B24b) and benefits to the environment (B26) were better determinants of farmers' perceptions of pelletized and certified Fortifer. The different CL specifications however showed only FAF, FDF, FEF and FFF to be relevant for farmers' choices concerning the different attributes of Fortifer. Table 43 below presents the variables, summary statistics and respective definitions.

Table 43: Summary statistics of key variables used in the conditional logit model (CL)

Variables	Description	Mean	Std. dev
GENDERF	Gender of the respondents; 1 for males and 0 for females and interactions with nitrate fortification (GenderF), pelletization (GenderF1) and certification (GenderTD)	0.425	0.49
Age	Age of farmers in years and interactions with nitrate fortification (ageF), pelletization(ageF1) and certification(ageTD).		
Hhsize	Household size and interactions with nitrate fortification (HhsizeF), pelletization (Hhsize4F1) and certification (Hhsize4TD)	6.67	3.64
Income	Annual farm income of farmers and interactions with nitrate fortification (IncomeF), pelletization (incomeF1) and certification (IncomeTD).		
Education	Education of farmers and interactions with nitrate fortification (H5F), pelletization (H5F1) and certification (H5TD).	2.58	0.81
fexp	Years of farming experience and interactions with nitrate fortification (H6F), pelletization (H6F1) and certification (H6TD).	11.57	10.02
Religion	Religious groups of the farmers and interactions with nitrate fortification (H9F), pelletization (H9F1) and certification (H9TD).	1.79	0.79
FSIZEF	Farm size of the farmers in acres and interactions with nitrate fortification (Fsize), pelletization (FsizeF1) and certification (FsizeTD).	0.28	0.53
FAF	Price is the most important and interactions with nitrate fortification (FAF), pelletization (FAF1) and certification (FATD)	3.427	0.93
FDF	Water holding capacity and interactions with nitrate fortification (FDF), pelletization (FDF1) and certification (FDTD).	3.93	0.716
FEF	I would buy compost if certified by relevant government authority and interactions with nitrate fortification (FEF), pelletization (FEF1) and certification (FETD).	3.7	0.83
FFF	I do not have any reservation for accepting and using fertilizer derived from faecal sludge and interactions with nitrate fortification (FFF), pelletization (FFF1) and certification (FFTD).	3.02	1.14

Table 44 presents the base and full CL model results. Using 2200 observations elicited from 275 respondents, the CL model with linear specifications in attributes is estimated using LIMDEP 9.0 NLOGIT 5.0 for the basic and full models. The coefficient on price is negative and highly significant (p=0.000), which holds with prior expectations that price and probability of compost purchase would be negatively correlated. This result is consistent across all two models. The negative sign of the payment coefficient indicates that the effect on utility of choosing a choice set with a higher payment is negative. In other words, scenario improvements with 'cheaper' alternatives are preferred to 'expensive' alternatives. The coefficient of nitrate fortification and certification are significant at 1% level and the signs of attributes are as expected. With the base model for compost, farmers appreciate a high quality product which is fortified and also prefer a product certified by a relevant government authority. This indicates that the probability of purchasing Fortifer is highly influenced by whether it is fortified and certified. In both models, farmers are willing to pay a premium for certified and fortified compost while compensations may be required for farmers to use pelletized compost.

Since the socio-economic variables do not change over choice cases, they were interacted with alternative attributes. After several model specifications, gender is a significant variable which affects the probability of choosing a Fortifer product which is certified, fortified and pelletized. It is noted that as the number of years of education increases, the probability of choosing the pelletized compost option decreases, *ceteris paribus*. The model results show that age is a significant factor in influencing the probability of choosing fortified and pelletized compost alternatives, but not certified compost. As expected, older respondents are more likely to purchase pelletized compost if they perceive the nutrient content to be relatively high. However, this is not an issue when certification of compost is factored into the choice set of the respondents. The CL model results show that as the household size increases, farmers are willing to pay a premium for fortified compost.

The decision to purchase a certified Fortifer product is positively affected by farmers' farm size. This result shows that large scale farmers' value certified compost more than compost with pelletized and fortified attributes. While it is possible for these attributes to increase the demand for compost, other factors such as water holding capacity, reservation toward the use of the product, certification and price of the product are equally relevant for business decisions. The CL model also shows that respondents' decision to purchase fortified compost is affected by the price of competitive products such as chemical fertilizer, with an expected negative correlation.

Table 44: Results of conditional logit (CL) model for Fortifer

Model	**Model 1**		**Model 2**	
Variable	Coefficients	Std.Error	Coefficients	Std.Error
PRICE	-0.001***	0.001	-0.001***	0.000
FORT	0.191***	0.043	-0.196	0.268
CERT	0.686***	0.047	0.939***	0.280
PELLET	-0.115***	0.042	0.344	0.256
GENDERF			0.335***	0.102
GENDERP			-0.350***	0.098
GENDERC			-0.237**	0.107
H3F			0.028**	0.096
H3FP			0.010	0.090
H3TC			0.021	0.101
H5F			-0.011	0.051
H5FP			-0.114*	0.047
H5TC			0.017	0.053
H6F			0.018***	0.048
H6FP			0.005**	0.046
H6TC			-0.034	0.050
H9F			0.140***	0.047
H9FP			0.034**	0.044
H9TDC			-0.122	0.049
AgeF			-0.008**	0.061
AgeP			-0.004*	0.056
AgeC			0.008	0.064
FSIZEF			-0.192**	0.096
FSIZEFP			-0.006	0.090
FSIZEP			0.230**	0.101
FAF			0.474***	0.051
FAFP			-0.171***	0.047
FATC			-0.353***	0.053
FDF			-0.060	0.048

FDFP		0.057	0.046
FDTC		0.200***	0.050
FEF		0.151***	0.047
FEFP		-0.040	0.044
FETDC		-0.115**	0.049
FFF		0.442***	0.061
FFFP		0.231***	0.056
FFTDC		0.247***	0.064
log likelihood	-2861.16	-2409.11	
AIC	5730.3	4892.2	
MacFadden R^2	0.0561	0.1995	
Number of observations	2200	2200	

Estimated WTP and marginal WTP for attributes for Fortifer

The results from the CL models were used to estimate the rate at which farmers are willing to trade-off one attribute for the other. In the CL model, there are monetary considerations for the attributes and the trade-off estimated is known as marginal willingness to pay for the attribute in question. The marginal WTP for each attribute is calculated as the negative ratio between the coefficient of an attribute to the price coefficient. The results indicate that farmers are willing to pay 161.52 UGX/kg more for fortification and an even higher premium of 581 UGX/kg for certification. However, farmers are noted to have a lower valuation for the pelletization attribute and would need compensation of 98 UGX/kg to use pelletized Fortifer. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. It is important to note that the noted premiums are slightly lower when socio-economic variables are factored into the choice set. Given these marginal estimates, the full analysis shows the estimated WTP for fortified and certified Fortifer to be 1345 UGX/kg.

Table 45: Marginal WTP estimates for compost and estimated total price of high quality compost

					Estimates from conditional logit model (UGX/kg)			
	Current market prices (UGX/kg)				**Attributes**			
Soil input considered	Min	Max	Mean	Std.dev	Marginal WTP for fortification	Marginal WTP for certification	Marginal WTP for pelletization	Estimated WTP of Fortifer (UGX/kg)
Compost	300	1000	700	360.55	161.52	580.96	(-97.58)	1345

Estimated market demand for Fortifer

The potential market for Fortifer is noted to be substantial with the demand estimated at 0.026 million tons/year, assuming an adoption of 38% and application rate of 0.5 tons/ha/year. It is important to note that notable surrounding agricultural districts were considered in the market size estimation, i.e. Luwelo, Mpigi, Mukono and Wakiso in addition to Kampala. The total cultivated area under the 5 districts considered is 130,000 ha (Source: Uganda Census of Agriculture, 2008/09 Volume 4). Chemical fertilizer application rates were used as a basis for the calculation of the application rates of Fortifer (IFPRI, 2012). The average chemical fertilizer applications were estimated at 107.5kg/ha and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product.

3.4.3 Market Structure - Business Models 15, 17 and 19

As the related products for the 3 business models under assessment do not as yet have an established market - informal (nascent sub-sector), they are all viewed from the fertilizer industry perspective. The respective market of key competitors, in this case, chemical fertilizer were considered for the market structure assessment.

3.4.3.1. Background and Justification

As noted in the WTP assessment, the increased need for organic fertilizer use is critical and beneficial on several levels: a) promotion of sustainable agriculture, b) recovery of waste management costs, and c) significant health and environmental benefits. Private sector participation in organic fertilizer production, however, greatly depends on the degree of freedom in the market structure (i.e. ease of entry and long-run sustainability). New RRR businesses can only be successful if their operations are fine-tuned to the existing market structure, which in turn influences their performance. Thus, new businesses require information on the characteristics of market structure to identify the existing opportunities to enter and further penetrate the market. Moreover, information on the existing level of competition in the market, characteristics of competitors and factors which drive the market's competitiveness or collusiveness are necessary for investment decisions. This also requires an evaluation of relevant actors' pricing and distribution strategies. The Ugandan organic fertilizer market is still informal and not well-organized or researched. Thus this assessment focuses on the evaluation of the market structure of its biggest competitor, inorganic fertilizer market in Uganda, in light of identifying key external (market) and internal factors which will drive the success of new compost and Fortifer businesses in the fertilizer market. The main objective of this analysis to evaluate the structure of the chemical fertilizer market in Uganda and its effects on the market feasibility of the selected nutrient business models.

3.4.3.2. Research Methods and Data Collection

The structure-conduct-performance (SCP) approach was used for the analysis and details of the approach are outlined in the methodology section in chapter 2. The SCP approach typically measures how the market structure of industries vary, how different market structures influence the market conduct of firms and how their conduct influence their market performance. An overview of the organic fertilizer market in Uganda, movement of organic agriculture and government policies for the fertilizer sector were evaluated. The SCP approach measures the structure of the market, the conduct and performance (profitability) of the relevant economic actors through the use of different indicators.

- **Structure:** The market structure of the fertilizer market is assessed based on the level of market concentration in the industry, for which data was extracted from already published findings due to data unavailability on market share of different actors. Additional market dimensions , such as product differentiation in the market and barriers to entry and exit were also evaluated.
- **Conduct:** The conduct of the players is studied by their price setting behaviour, factors or determinants of pricing of the fertilizer market, buying and selling practices and marketing and distribution strategies of actors.
- **Performance:** The performance along the supply chain was evaluated, via the assessment of cost incurred by key market players along the supply chain and actors' net margins.

Results of the SCP assessment was then used to draw inferences to better describe the structural feasibility of the RRR products. Data was obtained from existing secondary literature, Ugandan organizational reports and websites on the fertilizer market sector in Uganda. Information on

prevailing pricing policies was sourced from the recent organizational reports on fertilizer market and relevant newsletters and Ugandan websites. Additional information on the chemical fertilizer sector structure, organic agriculture sector and policy setting were also sourced from the above mentioned sources, IFOAM reports, Africa Agriculture Status Report, Uganda Agricultural census reports and Ugandan statistical reports.

3.4.3.3. Results and Discussion

Fertilizer consumption in Uganda

Uganda is noted as a country with very low fertilizer application rates, compared to other countries in the region. Average annual fertilizer consumption is estimated around 10,000-20,000 tons, which is far below that of other African and Asian countries. High prices, limited supply and availability of fertilizer and limited awareness of benefits (increased soil productivity), cultural beliefs and volatile crop output prices, has limited the Ugandan farmers' interest in chemical fertilizer. Low fertilizer application rates have resulted in poor crop yields and is considered as one of the key poverty drivers among rural agricultural communities in Uganda.

Nitrogen fertilizers are noted to have the highest share of the market over the time, followed by phosphorous-based fertilizers and potash fertilizers. Total fertilizer consumption rose from 7,463 to 11,600 tons from 2002 to 2010, representing a 55% growth in fertilizer consumption in Uganda. This is noted to be attributable to increased cultivated land area and the changing attitude of farmers towards fertilizer use. Ugandan fertilizer consumption is however still very low, with only 8% (2012) of farming households using chemical fertilizers, and 26% of households using organic fertilizers. Central Uganda leads in the proportion of households using both organic and inorganic fertilizers (Figure 14). It is important to note that the considered districts in the market assessment (Kampala, Mpigi, Luwero, Wakiso and Mukono) are all located in the central region.

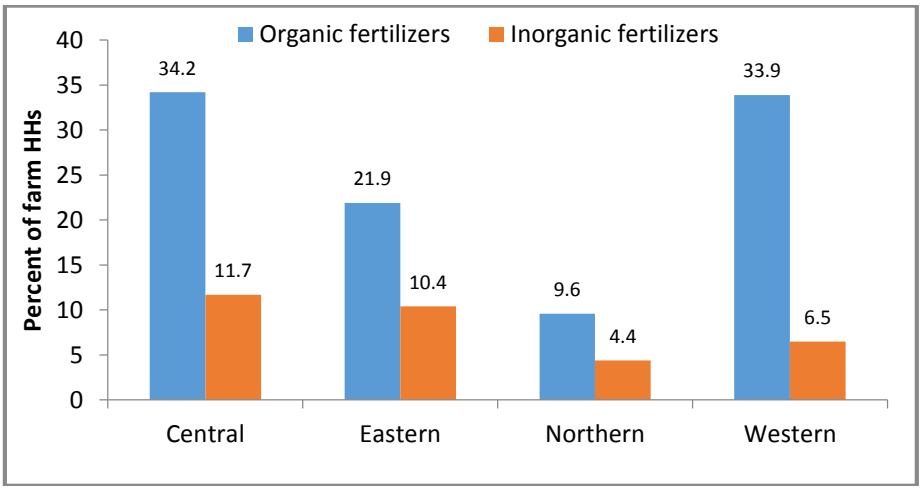

Figure 14: Incidence of fertilizer use by region.(Source: UCA 2008/2009)

Arable and agricultural land grew by 2.2% and 0.1% on average year to year, respectively; suggesting that fertilizer consumption rate increased only by 0.4kg/ha and 0.24kg/ha from 2002 to 2010. These results suggest that the growth of fertilizer consumption is not only caused by land availability for cultivation, but also changing fertilizer consumption pattern of Ugandan farmers. The demand for fertilizer in Uganda is driven mainly by the estate sector, which represents 70 percent of consumption (IFDC & CHEMONICS,2007), the remaining 30 percent assumed to be smallholder farming. These estates principally produce tea, sugarcane, and tobacco for the export market.

Business Development in Fertilizer Sector

- **Opportunities for organic fertilizer businesses as identified from competitor's sub-sector**

a) Market structure of chemical fertilizer market

Table 46 below presents the total quantity and value of inorganic fertilizers imported into Uganda and. It is observable that the majority of the country's fertilizer requirement of the country is met from imports, mainly from Kenya as there is no local production of fertilizer in Uganda.

Table 46**:** Import quantity and value(2002-2010)

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Quantity of import **(N, P205, K20)** (metric tons)	7,463	9,408	8,873	5,758	7,690	7,534	19,086	13,763	11,634
Value of imports ('000 US $)						30,114	63,796	65,396	48,523

Source: Uganda statistical abstract (2012); Africa Agriculture Status Report (2013)

The Ugandan market procures fertilizer from Kenyan-based importers, who purchase from international exporters (traders and/or producers). Direct import from producers is limited due to volume requirements and limited Ugandan demand. The national structure involves the Ugandan importer servicing distributors, who then service retailers, and finally farmers (Omamo, 2003). The largest volume of fertilizer (70 percent) is imported by independent agribusiness companies engaged in integrated production of specific crops through outgrower programs. The main players in the fertilizer market are agribusinesses involved in contract farming or out-grower schemes, often referred to as estates or plantations, these businesses work exclusively in crop-specific activities (e.g. tea, sugar, tobacco, rice, and sunflower). The remainder is imported by a group of private sector enterprises selling fertilizer in an open-market environment. The Midland Group of Companies, known locally as Uchumi Commodities, is the market and price leader in the industry. Uchumi, has an 80 percent share of the Ugandan fertilizer market (IFDC & CHEMONICS, 2007).

Kenya has become the principal source of fertilizer for importers that serve smallholder farmers in Uganda (IFRI,2013). Kampala remains the main base for fertilizer importers, where a large number of importers are located. Ugandan importer-wholesalers also function as brokers. They import fertilizer only after tendering for and being awarded a contract by commercial estates. Due to market risk and high credit cost, these brokers do not maintain significant inventories for resale. A number of NGOs are involved in fertilizer distribution to farmers via linkages with Kampala and Mbale based importer-distributors, with trade proceeding on a commercial basis (Omamo,2003) or directly procuring fertilizer and distributing it to farmers at a subsidized rate (Gasparotti, 2002). The commercial fertilizer supply system upon which smallholder farmers are dependent consists of five to seven importers, about 15 to 20 wholesalers, and 250 to 300 small-scale rural retail stockists (East Africa Agribusiness Magazine, 2012).

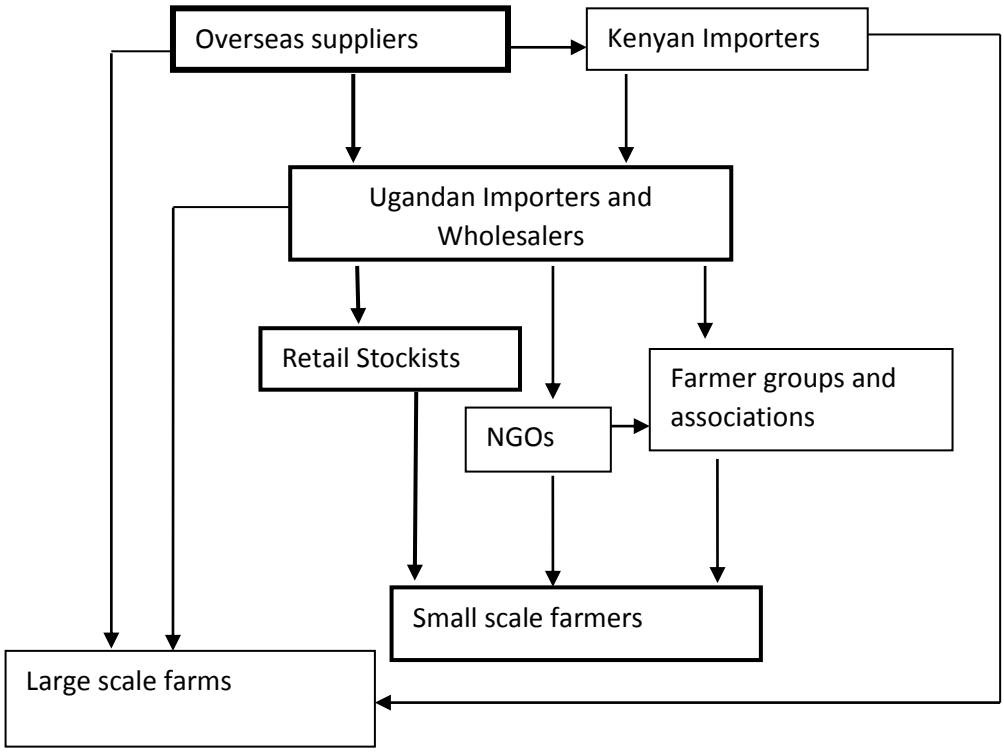

Figure 15: Principal procurement and distribution channel for fertilizer in Uganda (the principal procurement and distribution channel is shown in bold).

Source: Omamo (2003)[23]

Market concentration: The most commonly used measure of market concentration is the market concentration index. The index measures the percentage of traded volume accounted for by a given number of participants. Kohls and Uhl (1998) suggest that a four-firm concentration ratio (CR4), that is the market share of the largest four firms, of less than or equal to 33% is generally indicative of a competitive market structure, while a concentration ratio of 33% to 50% and above 50% may indicate a weak and strongly oligopolist market structures, respectively. George & Gracious (2005) found that the fertilizer market in Uganda is highly concentrated, as the top four fertilizer importers (except the commercial farms) accounted for about 92% of the market share - with the largest importer representing 56% of the fertilizer market (Figure 16). This is representative of very high market concentration, which is characteristic of a strong oligopolistic market structure.

[23]Author's survey of traders.

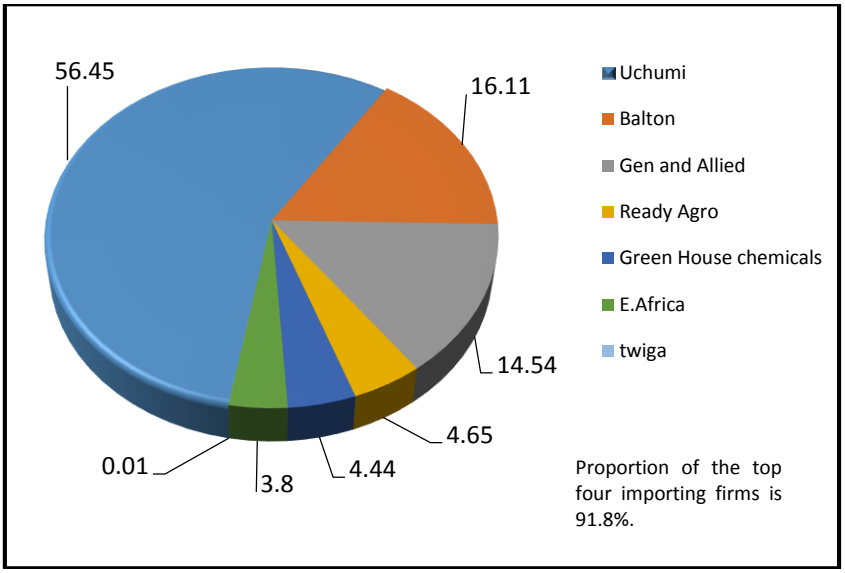

Figure 16: Market share (%) of fertilizer importers (excluding commercial farms) in 2004.

(Source : MAAIF, 2005)[24]

Product differentiation: Although the fertilizer market is of a relatively small size, the product mix available in Uganda is quite extensive[25], reflecting the grade (nutrient)-specific requirements of the commercial crop growers (estates and horticultural crop farms) (George& Gracious, 2005); and characteristic of a more developed large market and a smaller one as noted in Uganda. It is worthwhile to note that, the varied product mix of fertilizers is only limited to large commercial farms. This result suggests that new organic fertilizer (compost and Fortifer) businesses will need at start-up a highly unique and differentiated product; and continue to invest in research and development of new product features and quality improvement to buffer the effects of competitors' innovations.

b) Market conduct of chemical fertilizer market

Uganda is a price taker for fertilizer from international markets and particularly Kenyan fertilizer prices as majority of fertilizer imports are sourced from Kenya. Global commodity and transport prices are the primary determinants of the price of fertilizer in Uganda. The Ugandan fertilizer market is liberalized and there are no fertilizer subsidies for fertilizer in Uganda. Retail prices are high, with the ratio of retail-to-FOB price averaging around 2. High prices are mostly due to high inland transportation costs, small volumes, and large transaction costs (IFPRI, 2013). The majority of importers on the open market do not have sufficient purchasing power (IFDC & CHEMONICS, 2007). These importers are able to purchase fertilizer stocks in Nairobi from the depots of fertilizer firms by 28-ton truckload. Purchasing fertilizer in these smaller lots keeps their financing requirements manageable and reduces their exposure to risk of unsold inventory constraining cash flow in their business (IFRI,2013), however decreasing their market power. Most Ugandan importer-wholesalers also function as brokers. They import fertilizer only after tendering for and being awarded a contract by commercial estates. Due to market risk and high credit cost, these brokers do not maintain significant inventories for resale (George& Gracious, 2005). Retailers commonly purchase two 50 kilogram bags, and repackage them locally into 1 and 2 kilogram bags, which are preferred by small farmers as they are more affordable. Since there is a short supply of fertilizer, prices are never stable and are usually high (IFDC & CHEMONICS, 2007). Retailers are challenged by inadequate supply, low

[24]Cited from George & Gracious (2005).

[25]Although available on a sporadic basis, the following products are present in the market: urea, Ammonium Sulphate (AS), Calcium Ammonium Nitrate (CAN), DAP, Mono Ammonium Phosphate, Triple Super Phosphate (TSP), Single Super Phosphate (SSP), murate of phosphate, 17-17-17,and a broad range of specialty grades such as 25-5-5+5S and 10-20-20+B+S.

demand, and limited infrastructure and storage. This results in high prices that are compounded by auto-financing constraints since payments to distributors are made in cash. Thus, although the fertilizer market has a strong oligopolistic structure, it is inherently flawed and ridden with many market failures. Additionally, the chemical fertilizer has also never expanded to a significant level due to an ineffective fertilizer policy. Though liberalization of Uganda's fertilizer market had its own legacy to increase market competition via inducing the participation of private sector, high cost of entry and participation in fertilizer trade make the fertilizer market imperfectly competitive. There is neither a large-scale government fertilizer program that provides subsidized fertilizer to farmers nor an active private fertilizer sector that supplies fertilizer at competitive prices. This, thus, represents a great opportunity for organic fertilizer businesses who can take advantage of erratic chemical fertilizer prices and the limited number of actors in the respective market.

The majority of Ugandan importers also play the role of brokers, keeping contracts with estate sectors and do not have distinct marketing or market development strategies. This makes the Ugandan fertilizer sector unattractive to Kenyan primary importers (IFDC & CHEMONICS, 2007). Distribution of products is also very poor and inefficient with highly concentrated wholesalers in Kampala and a few in Mbale (Omamo, 2002). The lack of geographically dispersed wholesaling activities has implications for fertilizer availability in several regions, higher transportation cost, high prices and hence less competitiveness or efficiency of the fertilizer market. Thus, while chemical fertilizers represent the largest share of the market, a limited established distribution network represents a gap in supply and an opportunity that organic fertilizer producers can capture - although innovative marketing and distribution (e.g. using existing agricultural extension systems) channels will need to be adopted.

- **Policy interventions in fertilizer markets in Uganda**

The draft Ugandan National Fertilizer Strategy and Investment Plan (NFS) aims to make a provision for guiding and promoting enhanced availability and use of fertilizer for higher agricultural productivity in Uganda. Essentially, the government anticipates the institution of this strategy to increase the rate of fertilizer use to at least 50 kgs of nutrients, per hectare per year, in the next five years and ultimately reach the recommended average of 200 kg of nutrient per hectare per year. Its main objectives to achieve this goal are to (i) create a conducive fertilizer business environment (ii) increase demand and use of fertilizers (iii) enhance the supply and distribution of quality fertilizers; and (iv) provide fertilizer related knowledge management[26]. This strategy is however not compatible with the current regulatory system for fertilizer in Uganda.

The current system is excessive both in terms of the direct and indirect costs associated with following the regulations and in terms of the benefits for public health, safety, and welfare for which the regulations have been put in place. This has resulted in limited fertilizer imports and supply and non-competitive prices for farmers. All dealers in agricultural chemicals require registration and must demonstrate a certain level of knowledge on the use of the products they sell. Additionally, all importers of agricultural chemicals require a permit. Such permits will be given only to registered dealers in agricultural chemicals who seek to import registered products. While import permits are provided by the Ministry of Agriculture to importers at no direct cost, considerable indirect costs are associated with following the regulations for importing fertilizer; as the regulations require the registration of individual fertilizer products from all international suppliers and the import permits required to then bring in the products limit access to the Ugandan market by international suppliers (IFPRI,2013). This in turn limits supply to smallholder farmers and effectively raises the price that they must pay for inorganic fertilizer. Thus although the liberalization of Uganda's fertilizer market

[26]The Draft National Fertilizer Strategy which provides a framework for enhanced availability and use of fertilizers in Uganda was to be validated through public dialogue on 14th November, 2013. Retrieved from:http://www.eprc.or.ug/data/news/105/39/NEW%20POLICY%20INTERVENTIONS%20TO%20ENHANCE%20THE%20AVAILABILITY%20AND%20USE%20OF%20FERTILIZERS%20IN%20UGANDA.html

had a legacy to increase market competition via inducing the participation of private sector, high cost of entry and participation in fertilizer trade has made the fertilizer market imperfectly competitive. Additionally, given that there is neither a large-scale government fertilizer program that provides subsidized fertilizer to farmers nor an active private fertilizer sector that supplies fertilizer at competitive prices; this represents a great opportunity for organic fertilizer businesses who can take advantage of erratic chemical fertilizer prices and the limited number of actors in the respective market.

- **Opportunities for organic fertilizer businesses as based on organic agriculture movement**

In Uganda, informal organic production has been going on for centuries. Formal (certified) organic agriculture started in 1993 as a response to the unfolding market opportunities in Europe (Opolot, Kasangaki and Charles, n.d). As early as 1994 a few commercial companies began deliberately engaging in organic agriculture. At the same time in Uganda, there was a general movement in the agricultural sector towards developing sustainable agriculture as a means of improving people's livelihoods[27]. By 2003, Uganda was already in the 13th position worldwide and in the 1st position[28] in Africa in terms of size of land under organic agriculture (Opolot, Kasangaki& Charles, n.d). Currently, Uganda has the first and second largest number of certified farmers in Africa and world over respectively[29]. Moreover Uganda has one of the fastest growing organic certified lands in Africa. By 2012, 231,157 hectares of land were under organic agricultural production with 189,610 certified farmers. This constitutes an increase of over 300% in terms of number of farmers and 27% in terms of acreage, respectively, from 2005 to 2012. Key products grown organically and sourced from Uganda include cotton (lint, yarn and finished garments), coffee (Arabic and Robusta), sesame (simsim), dried fruit (pineapples, apple bananas, mangoes, jack-fruit), fresh fruits (pineapple, apple bananas, passion fruits, avocadoes, papaya (pawpaw), ginger), jack-fruit, , vanilla, cocoa, fish, shea butter and shea nuts, bird eyed chillies, dried hibiscus, honey and bark cloth[30]. This represents a real business opportunity that can be harnessed by organic fertilizer producers in Uganda. Additionally, as exports are sold on a contractual basis, this implies a consistent demand for organic agricultural product and thus invariably a steady market for organic fertilizers.

- **Organic fertilizer market and producers**

The organic fertilizer market is still traditionally informal, with limited commercial organic fertilizer production or commercial fertilizer market up to date. Farmers use compost, cow dung, poultry manure, pig and goat waste and farm residue. The use of other organic fertilizers, such as raw solid waste is common. Other than the conventional types of compost, compost made using municipal solid waste has been introduced to Uganda recently, especially as a solution to increasing amount of municipal solid waste in urban areas. There are nine solid waste to compost plants located in nine respective municipalities in Uganda namely Mukono, Jinja, Mbale, Soroti, Lira, Mbarara, Kasese, Kabale, and Fort Portals (Omagor,2012). These plants were under corporate agreement with Uganda's National Environment Management Authority in 2015[31]. These compost plants were established under a partnership agreement with the National Environment Management Authority with the main goal of waste management and not business. With increasing and erratic inorganic fertilizer prices and increased organic farming, agricultural producers will become more dependent on organic fertilizer sources as their main nutrient source. This represents an opportunity for organic fertilizer marketers to sell their products at competitive prices and capture a share of the fertilizer market.

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[27] http://www.unep.org/greeneconomy/SuccessStories/OrganicagricultureinUganda/tabid/29866/Default.aspx

[28] Share of organic certified area in Africa was around 38% (2003)

[29] http://www.africaag.org/2014/07/18/uganda-earns-big-organic-agriculture/

[30] http://www.africaag.org/2014/07/18/uganda-earns-big-organic-agriculture/

[31] http://cdm.unfccc.int/filestorage/K/8/6/K86ZSP735QI1CFLDXVA2JOHUGE09YB/PoA%20DD%20revised%20clean%20version.pdf?t=NXh8bHpzZmJifDBEI4diRadORog24z5kD1h-

3.4.3.4. Conclusions

In summary, the market structure assessment suggests an oligopolistic fertilizer market, plagued by market distortions attributable to ineffective policies, limited infrastructure; and a growing organic agricultural sector which has created an opportunity for business development in the organic fertilizer sub-sector. The chemical fertilizer supply chain suffers from low market demand due to high prices at the suppliers' end. Given that there is neither a large-scale government fertilizer program that provides subsidized fertilizer to farmers nor an active private fertilizer sector that supplies fertilizer at competitive prices; this represents a great opportunity for organic fertilizer businesses who can take advantage of erratic chemical fertilizer prices and the limited number of actors in the respective market. Additionally, the chain structure is challenged by inadequate supply, lack of access to market information, limited infrastructure (high transportation cost) and storage(IFDC & CHEMONICS, 2007). Direct import from producers is limited due to capped import volumes and low demand. The chemical fertilizer sector is also a capital-intensive industry. Thus, limited access to financing at a large scale further exacerbates supply-related constraints (IFDC &CHEMONICS, 2007). Low profit margins, an uncertain macro environment (high exchange rate movements with devaluation of local currency), market distortions (involvement of government and NGOs in fertilizer distribution to farmers directly or indirectly) and a weak regulatory system that cannot control unlicensed suppliers, domestic and import taxes (changes in government policies) has disincentivized the interest of new investors in the fertilizer market (George & Gracious, 2005). These market distortions and barriers are representative of factors that can catalyze business development in the organic fertilizer sub-sector.

3.4.4 Market Outlook - Business Models 15, 17 and 19

And as the related products for the 3 business models under assessment do not as yet have an established market - informal (nascent sub-sector), they are all viewed from the fertilizer industry perspective. The respective market of key competitors, in this case, chemical fertilizer were considered for the market structure assessment.

3.4.4.1. Background and Justification

The market outlook assessment is particularly crucial for the nutrient business models as it has been noted that compost businesses typically in Africa have short life cycles and often socially-driven more so than having a profit/business objective. The forecasting of MSW-based compost and Fortifer is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting will aid business development management in planning into the future. Because investment toward an uncertain future is very difficult and risky, market forecasting will help alleviate the risk and obtain more accurate or reliable information. The most fundamental variable in determining an appropriate business strategy is the stage of the product life cycle as noted in the previous assessments. The product life-cycle management is the succession of strategies used by business management as a product goes through its life-cycle. The condition of the market, in which a product is sold changes over time and business strategies must be managed as it moves through its succession of stages. The goals of product life cycle management are to reduce time to market, improve product quality, reduce prototyping costs, identify potential sales opportunities and revenue contributions, and reduce environmental impacts at end-of-life. Thus, successful new organic fertilizer businesses will need to understand its customers, markets and competitors. Thus, the objective of this analysis is to forecast market growth behavior of MSW-based compost and Fortifer.

3.4.4.2. Research Methods and Data Collection

As with the other business models, the Bass model (1969) was used to assess the market outlook for MSW-based compost and Fortifer given data limitation. The model took into consideration the probability of purchase given that no previous purchases were made and the total number of potential buyers as parameters reflecting the rate of diffusion and the initial probability of first-time purchases (Proctor, 2000). A variant of the discrete time bass model function was applied. Satoh (2001) justified the adoption of the discrete time model when data used is discrete, as the Bass model is a continuous-time model. Satoh (2001) further noted that the discrete Bass model conserves the characteristics of the Bass model because the difference equation has an exact solution. Therefore, the discrete Bass model enables us to forecast the innovation diffusion of products and services without a continuous-time Bass model.

$$f(t) = \frac{\frac{(p+q)^2}{p} e^{-(p+q)t}}{\left(1 + \frac{q}{p} e^{-(p+q)t}\right)^2}$$

$$F(t) = \sum_{i=0}^{t} f(i)$$

$$A(t) = M\ F(t) \text{ and } a(t) = M\ f(t)$$

The optimal time to peak sales is given by:

$$\frac{\ln\left(\frac{q}{p}\right)}{p+q}$$

Other variables in the Bass Model which are calculated from M, p, q and t, are:

f(t): the portion of M that adopts at time t.
F(t): the portion of M that have adopted by time t,
a(t): adopters (or adoptions) at t and
A(t): cumulative adopters (or adoptions) at t.

The most critical determinants of the model are innovation and imitation coefficients p and q and the potential market size of the market for MSW-compost and Fortifer. In the absence of already available data on the p and q for these products, the study made use of an average estimation of those coefficients as per the findings of Sulthan at al. (1990). Accordingly, the assumed estimate of p used was 0.03 and q, 0.38. Low diffusion rates (low switching behaviour) were assumed because although Ugandan farmers already use organic fertilizers quite extensively, their knowledge and use of human waste-based organic fertilizers is quite limited. Additionally, the total (p + q) is assumed to lie between 0.3 and 0.7. The potential market size for MSW-based compost and Fortifer are estimated at 33.7 million tons/year and 1.1 million tons/year, respectively, based on the WTP assessment. Data for the parameter estimation of the Bass model was sourced from NASAA (National Association for Sustainable Agriculture, Australia) and Memon et al., 2010. Additional data was obtained from FiBL-IFOAM survey, Ugandan Census of Agriculture, World Bank data reserves, Africa Agricultural Status reports,country statistics/institutional databases of the Ugandan Bureau of Statistics, household surveys and World Bank databases.

3.4.4.3. Results and Discussion

A) Market outlook of Products

- **MSW-based Compost**

Figures 17 and 18 show the behavior of new and cumulative product sales over the years with 0.38 and 0.03 average coefficients of innovation and imitation. The results indicate that peak sales can be achieved between 6 - 7 years. A lower peak time, however, can be reached with strong business strategies including promotional and awareness programs for farmer communities and other potential industrial users. The estimated quantity of sales at the peak will be 86,000 tons. Businesses can adjust their production capacity and other financial requirements to target a higher average peak volume at the average peak time. According to the figures of both scenarios, it will take approximately 17 -18 years for new businesses to capture the total market size.

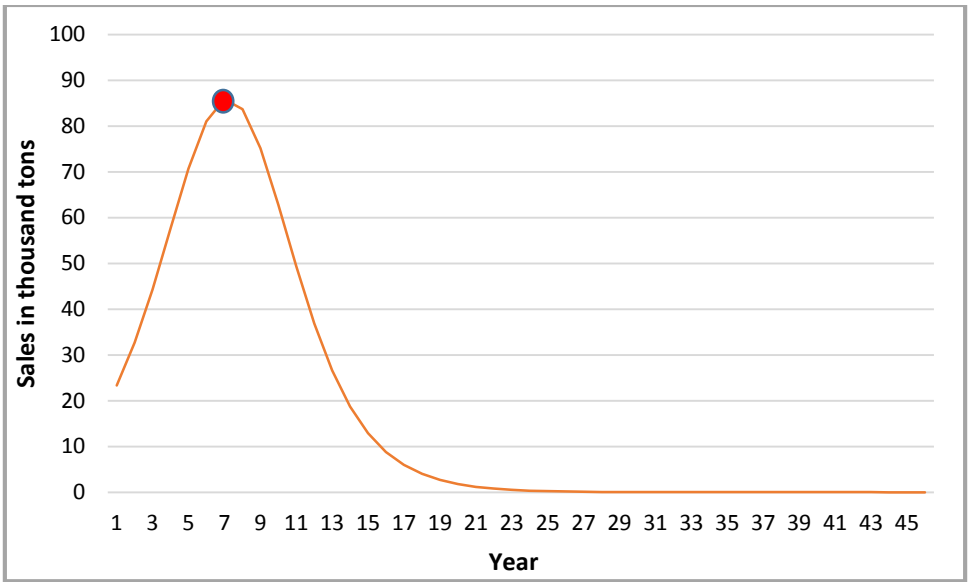

Figure 17: Volume of new sales over the years

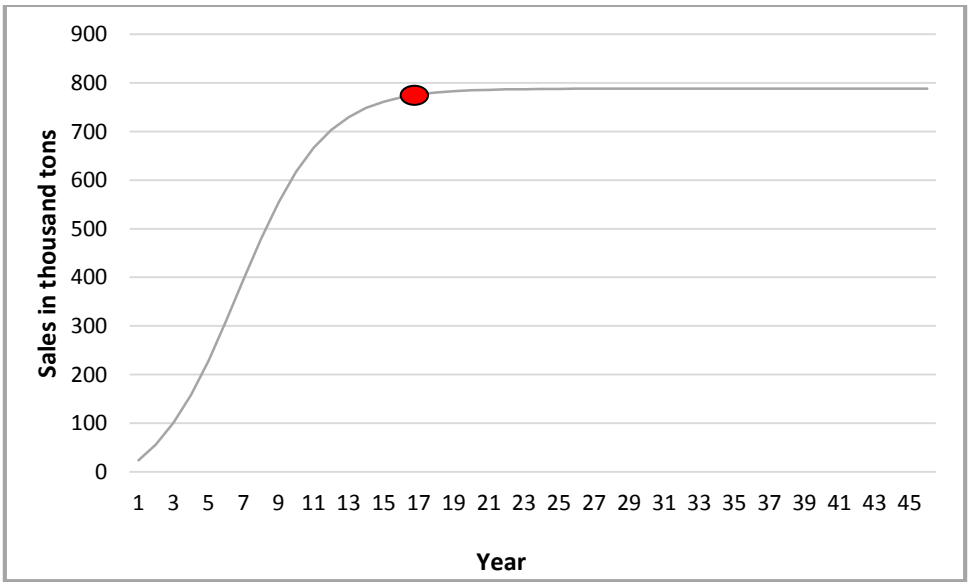

Figure 18: Cumulative sales over the years

- **Market outlook of Fortifer**

Figures 19 and 20 show the behaviour of new and cumulative product sales over the years with 0.38 and 0.03 average coefficients of innovation and imitation. The results indicate that peak sales can be achieved between 6 to 7years. A lower peak time, however, can be reached with strong business strategies including promotional and awareness programs for farmer communities and other potential industrial users. The estimated quantity of sales at the peak will be 2,800 tons. Businesses can adjust their production capacity and other financial requirements to target a higher average peak volume at the average peak time. According to the figures of both scenarios, it will take approximately 17 -18 years for new businesses to capture the total market size.

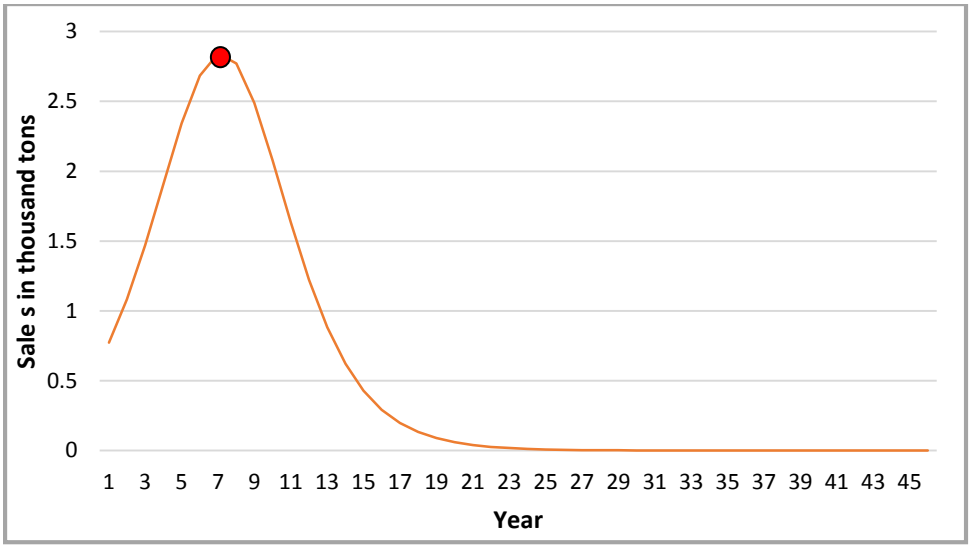

Figure 19: Volume of new sales over the years

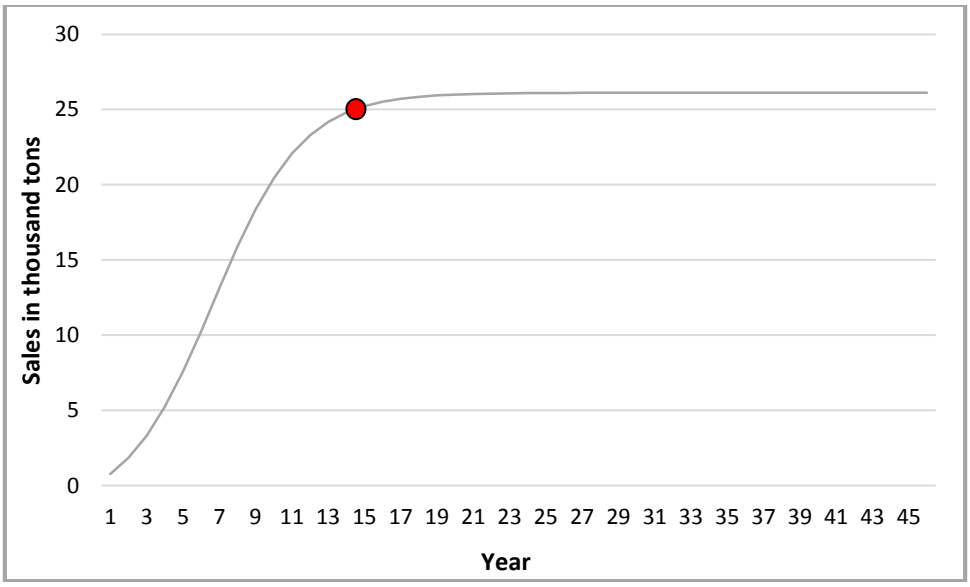

Figure 20: Cumulative sales over the years

B) Product Life Cycle

- **Introduction stage**

Generally introduction of a new product is facilitated when the competitive products are at the stage of maturity. Interest in existing products is generally declining and consumers are seeking new products with new features. In Kampala, the organic fertilizer market is still in a nascent stage and there is ample opportunity for new compost and Fortifer businesses to enter the market. It is important to note that although chemical fertilizer producers have the largest share in the industry, market distortions inherent in their supply chain mitigates the effects of their market power - of which compost and Fortifer businesses can take advantage of. Effective pricing strategies will be crucial to ease market entry for the compost and Fortifer businesses. Limited farmers' knowledge and use of human waste-based organic fertilizers may cause low adoption rates in the introduction stage. Strong awareness programs coupled with actual field experiments will increase product recognition and eventual adoption. Contract farming with growers may be a good option to explore in order to establish farmer relationships and ensure demand. This strategy is increasingly been adopted by chemical fertilizer suppliers in Uganda. This implies that cost of research and development (sunk cost) and negotiations may be higher and lead to lower profit overall at business start-up.

- **Growth stage**

Based on the average diffusion coefficients, both the MSW-based compost and Fortifer product show a fair growth rate during the growth stage and takes between 6 to 7 years to reach its peak sales. This is mainly attributable to the assumed and conservative lower diffusion coefficients due the traditional nature of low adoptability of Ugandan farmers and their current level of knowledge and use of human waste-based organic fertilizers. Product growth sales can thus be increased via the adoption of innovative marketing and pricing strategies and strongly positioning the product in the market in the introduction stage. Businesses can also adjust their production capacity and other financial requirements in order to target a higher average peak volume at the estimated average peak time. To achieve a comparatively higher (steady) growth, businesses can also adopt new strategies to reach new customer segments, new marketing and distribution strategies. In addition, regular customer testing and evaluation is necessary to further tailor product features, in particular for Fortifer, such nutrient ratio requirements, pelletization to consumer preferences. Promotional and awareness programs may still be important at this stage to reach additional customer segments.

- **Mature stage**

Figures 18 and 20 indicate that it will take 17 -18 years for new businesses to capture the total market size. This is the stage where firms maximize profit and recover all cost of operation and development where sales grow at slower rates and finally stabilize. The main goal of this stage is to maximize the production capacity. Prices can be increased or matched with competitors' price. Although the cost of research and development will be lower at this stage, experiments for development of new product features is important so as to buffer the potential decrease in demand in the declining stage. Product promotion will still be necessary to avoid possible brand switching. Competition for market share is stiff in this stage and strategic pricing and quality adjustment will be necessary depending upon the behavior of the competitive products. It is important to note that given that MSW-based compost is considered a substitute to chemical fertilizer, it is anticipated that Fortifer is the only product assumed to be able to capture the entire market.

- **Declining stage**

During this stage, sales are expected to fall for both MSW-based compost and Fortifer due to loss of consumer interest in products and consumers start to switch to new competitive products. Thus, focus should be placed on the development of new product features and quality improvement to buffer effects of competitors' innovations. Generally, costs of operations are minimized in this stage in order to increase profit levels. Accordingly, a reduction of distribution outlets, means of distribution (selective means of distribution) and promotional costs can be observed during the

declining stage. More specifically, prices will need to be set lower to attract more price sensitive consumers and increase sales.

3.4.5 Conclusions - Models 15, 17 and 19

The overall market assessment suggests that there is demand for both MSW-based compost and Fortifer in Kampala, and surrounding notable agricultural districts (Luwero, Mukono, Wakiso and Mpigi). The results show that consumers' WTP, for compost is significantly higher than the average market price for substitute products at 100 UGX/kg. A statistically significant difference was noted between the WTP estimates of the key customer segments - households and farmers. The results indicated that the farmers were willing to pay more to know the source of the input materials used to produce the compost (i.e. MSW, faecal sludge and/or animal waste). The marginal WTP analysis shows that farmers are willing to pay 58.78 UGX/kg more to know the sources of materials used to produce compost, 45.97 UGX/kg for pelletized compost and 30.09UGX/kg for certified compost. This suggests that high quality compost product if labelled with information on source of the inputs, has 3rd party certification and is pelletized will command a market price of 234.84 UGX/kg - which is almost 2.5 times higher than the current market price.

Likewise the demand for Fortifer (faecal sludge-based compost - models 17 and 19) was significant with an average WTP value of1345 UGX/kg. The marginal WTP analysis shows that farmers are willing to pay 161.52 UGX/kg more for fortification and an even higher premium of 581 UGX/kg for certification. However, farmers are noted to have a lower valuation for the pelletization attribute and would need a compensation of 98 UGX/kg to use pelletized Fortifer. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. It is important to note that the noted premiums are slightly lower when socio-economic variables are factored into the choice sets.

The potential market for MSW-compost is noted to be substantial with the demand estimated at 0.78 million tons/year, with an adoption rate of 49% and application rate of 12.5 tons/ha/year. The potential market for Fortifer was estimated at 0.026 million tons/year, assuming an adoption of 38% and application rate of 0.5 tons/ha/year. It is important to note that notable surrounding agricultural districts were considered in the market size estimation, i.e. Luwelo, Mpigi, Mukono and Wakiso in addition to Kampala. The total cultivated area under the 5 districts considered is 130,000 ha (Source: Uganda Census of Agriculture, 2008/09 Volume 4). Additionally, chemical fertilizer application rates were used as a basis for the calculation of the application rates for MSW-compost and Fortifer (IFPRI, 2012). The average chemical fertilizer applications were estimated at 107.5kg/ha and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product. MSW-based compost, on the other hand, is considered to be a complementary product to chemical fertilizer.

Whilst the current production level of organic fertilizers is unknown, it is clear that it is a burgeoning industry with some entry barriers but supportive and existing policies encouraging business development. The organic fertilizer market is less commercialized and the related market structure and business dynamics are very informal. Given data limitations, the inorganic fertilizer market, which is more formal, commercialized and well-researched during past decades was used as the basis to the extent possible for the market structure and outlook assessment. A market condition that would potentially impact the development of organic fertilizer (i.e. compost and Fortifer) businesses is the market power held by chemical fertilizer producers. The fertilizer market in Uganda is highly concentrated – the top four fertilizer importers (except the commercial farms) accounted for about 92% with the largest importer taking 56% of the fertilizer market. This suggests a very high concentration that is characteristic of strong oligopolistic market structures. The chemical fertilizer market has however never expanded to a significant level due to an ineffective fertilizer policy. And

although liberalization of Uganda's fertilizer market had its own legacy to increase market competition via inducing the participation of private sector, high cost of entry and participation in fertilizer trade make the fertilizer market imperfectly competitive. Barriers to entry indicate an important determinant of market concentration of the fertilizer markets. Although chemical fertilizers represent the largest share of the market, a limited established distribution network, market distortions attributable to ineffective policies, limited infrastructure; and a growing organic agricultural sector has created an opportunity for business development in the organic fertilizer sub-sector. Additionally, there is neither a large-scale government fertilizer program that provides subsidized fertilizer to farmers nor an active private fertilizer sector that supplies fertilizer at competitive prices. Thus, this represents a great opportunity for human waste-based organic fertilizer businesses who can take advantage of erratic chemical fertilizer prices and the limited number of actors in the respective market. On the other hand, the product mix available of chemical fertilizer products is rather extensive, reflecting the grade (nutrient)-specific requirements of the commercial crop growers (estates and horticultural crop farms). This suggests that new compost and Fortifer businesses will need at the start-up a highly unique and differentiated product; and innovative marketing strategies to mitigate the effects of the currently limited marketing and distribution channels available in the fertilizer market. In summary, it is noted in Table 48 below that Models 17 and 19 have a high feasibility and model 15 - medium feasibility from a markets' perspective.

4. Summary and Conclusions

4.1 Summary and Key Implications of Findings

A key component of the feasibility studies is the market assessment of the RRR business models as functioning markets, an enabling institutional environment and positive economic and financial conditions are essential for sustainable business activity in any sector including the waste reuse sector. The set-up of any RRR business and the commercialization of a new product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends among other factors particularly on market demand. Specifically, the question of whether a demand actually exists and the price end-users are willing to pay for this new product needs to be explored. "Demand, even among those with limited resources, is not automatic." (Phillip et al., 2003; page 194). For this reason, the market assessment set out to evaluate the current and potential market for the recovered resource and the effect of different factors (e.g. socio-cultural aspects and perceptions, price of substitute products, etc.) on market demand. Information on market segments, potential clients of the RRR product, their actual and potential number and resource absorption capacity and their willingness-to-pay (WTP)were assessed.

Additionally, the adoption of effective marketing and pricing strategies to ensure business sustainability require entrepreneurs to comprehensively understand the dynamics inherent in the relevant sub-sectors. This translates into the need for evaluating the structure (i.e. competition, differentiation of substitute products, barriers to market entry, among others) of the product market they operate in, i.e. how the behavior and performance of other businesses influence their decision making. Another important facet to the market assessment is demand forecasting – i.e. market outlook. Market forecasting is a crucial element for business owners in assessing future capacity requirements, evaluating their decisions in the implementation of new business strategies and pricing decisions. Businesses need to adopt different strategies ranging from establishing key partnerships and price markups to maintain a competitive advantage and ensure sustainability. An assessment of the above listed aspects provides entrepreneurs with a solid market information base crucial for business start-up and sustainability. In that regard, the specific objectives of the market assessment were:

1. To assess the market value of the RRR products under consideration –
    a. To assess consumers' willingness-to-pay (WTP) and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
    b. To estimate the potential market size for the RRR product;
2. To assess the extent and characteristics of the market structure;
3. To evaluate the market outlook of the RRR products and to what extent the RRR products would be viable over time in the market.

As noted earlier, a total of 8 RRR business models were selected for the feasibility studies in Kampala. For the purposes of the market assessment, an end-use typology of the business models was employed as although the underlying concept of the business models were different, a number of the end-products were the same across different business models. Thus for some business models, the related customer segments and relevant actors along the value chain considered would be the same. In that regard, for the selected business models, the following 5 value-added products were considered: 1) briquettes, 2) electricity, 3) treated wastewater, 4) MSW-based compost and 5)

faecal sludge-based compost. Untreated wastewater is not considered a marketable commodity as it is considered to increase human health risk and environmental pollution and thus potential users' valuation was not assessed.

- ***Model 1: Dry fuel manufacturing: Agro-waste to briquette***

The results indicate that there is a growing and substantial market demand for briquette in Kampala. Overall, the results suggest that most of respondents are aware of the benefits and costs of briquettes and are willing to pay over and above the current market price of 1000 UGX (Ugandan shillings)/kg. The WTP estimates for businesses and households are 1.5 – 2 and 2 – 3 times higher than the current market price of competitive products, respectively. Subsequent scenario analyses to assess the impact of trade-offs associated with different government policies on consumers' WTP for briquettes indicated that households, in particular, were willing to pay a price 3 times higher than the current price of substitute products with the institution of an enforceable law which prohibits the use of non-renewable energy sources with a fine equivalent to the current market price. A similar effect on WTP estimates was observed for businesses although the marginal price increase was lower than that of the households. The potential market demand for briquette for is significant and estimated at 55,400 tons/year and 240,000 tons/year for households and businesses, respectively (taking the demand from surrounding districts into consideration). The difference in potential quantity demanded with the implementation of an enforceable law (S4) is fairly notable but not significant for both households and businesses.

The briquette industry is a nascent with minimal entry barriers, and supportive and existing policies encouraging business development. There are several factors that will help catalyze the development of new businesses including: a) instituted government policies on renewable energy and b) better efficiency on energy value. Specific marketing strategies are however necessary as there are no established retail distribution networks as yet (only super markets and institutions); and there is a level of difficulty in linking up with the existing charcoal retail network. While there are currently limited financial incentives (e.g. VAT exemption; higher upfront production cost than for charcoal and firewood production), there are special lending schemes for briquette businesses. Additionally, it is important for entrepreneurs to consider a segmented pricing strategy for its different customer groups to capture any existing consumer surplus. In terms of the market outlook of the product, the penetration of RRR briquettes products will be facilitated by the prevailing market conditions. A lower market price than the prevailing price of charcoal is expected to increase consumers' adoption rate. Strong awareness programs coupled with promotional approaches will be important to eventually increase market demand due to the strong positioning of the charcoal market and further shorten the growth stage.

- ***Model 2a: Energy service companies at scale: agro-waste to energy <u>and</u> Model 4: Onsite energy generation by sanitation service providers***

The results of the study indicate that businesses have a WTP for waste-generated electricity (ranging between 319.07 – 355.94UGX/ kwh) lower than that of the current unit prices charged by the Uganda Electricity Transmission Company (UETCL) at a rate of 450UGX/kwh. Similarly, the WTP estimates for households are significantly lower than the current tariff set by UETCL. Generally, there is a significant and growing demand for electricity in Kampala and opportunities for waste-to-energy entities to fill this gap based on the anticipated rapid rural electrification program; foreseeable increasing trend in electricity prices; structural and legal feasibility for private sector involvement (structural unbundling of the Ugandan power sector, vertically integrated monopoly and privatization of the generation and distribution); a lesser vertically integrated market; and supportive renewable energy policies among others. The WTP estimates however suggest that although there are incentives to catalyze investment, there is limited demand, which is predictive of

the potential pricing strategy to be implemented. The increasing number of independent power producers (IPP) in the energy sector in recent years is also indicative of the structural feasibility of the Ugandan electricity sector. Electricity producers are however currently price takers and restricted to the price ceiling set by the state-owned transmission entity – UETCL (limited negotiation ability – monopolistic market). Thus, in actuality, the level of market concentration, price setting behavior and potential net profit margins (business performance) will determine the sustainability of a waste-to-energy business, which for the first two factors are significant limiting drivers. The opportunity for waste-generated electricity can only materialize when offered prices in the power purchase agreement (PPA) can substantially cover production costs. Additional limiting factors to business development and sustainability in the sector are: a) continued interest and large hydro-power potential; b) significant interest in small hydro-power projects and c) waste-to-energy projects currently viewed as high-risk ventures by financial investors. While producer prices can be increased, additional market failures inherent in the energy sector can only be rectified with the institution of sound policies.

- ***Model 9: On cost savings and recovery and Model 10: Informal to formal trajectory in wastewater irrigation***

Models 9 and 10 were assessed based on one product (i.e. treated wastewater) as we assume that incentives are what is needed to catalyze the adoption of safety measures under model 10. Additionally, untreated wastewater is not considered a formally marketable commodity given the associated human health risks. About 98 percent of the enterprises surveyed expressed a high level of satisfaction with the current quality of water supplied by the National Water and Sewerage Corporation (NWSC) and 96% noted facing no shortages with water supply. Only 7% of the respondents expressed interest in using treated wastewater, particularly for washing purposes, and also noted willing to pay higher prices than the current fees at UGX 500/m^3. The results however indicated that this subset of enterprises did not have a strong preference for certification (i.e. had no valuation for 3rd certification that the wastewater delivered was treated to an acceptable level). However, it is quite clear that enterprises have a strong preference for connections provided by NWSC and that quarterly payments seemed more suitable. Farmers , on the other hand, showed a higher interest in wastewater reuse for irrigation. About 74% of the surveyed farmers were willing to pay for reliable supply of treated wastewater services at the farm. The total payment elicited by the farmers for treated wastewater supplied by NWSC is UGX 530/m^3. It was also noted that the farmers would prefer supply from NWSC and interestingly are willing to pay more for certification. While 70% of the respondents preferred operation, maintenance and delivery by NWSC, 12% preferred KCCA and 10% opted for farmers' organizations. The results also indicate that farmers are willing to pay higher if the treated wastewater is delivered through canals and payments are made on a quarterly basis.

The total number of agricultural households in the urban and the peri-urban areas of Kampala was estimated at about 44,962 households (Makita, 2009). Assuming a total agricultural land estimate of 31,473 hectares, the total water requirement in the urban and per-urban area of Kampala is estimated to be about 250 million m^3 in a year. This demand estimate clearly exceeds the total wastewater generated. It is important to note however that the estimated demand may be limited by costs related to delivery especially for farmers located far off from the wastewater treatment plants. As noted earlier, additional incentives may be needed to motivate wastewater use particularly in areas where farmers are facing water scarcity.

- ***Model 15: Large-scale composting for revenue generation (compost), Model 17: High value fertilizer production for profit and Model 19: Compost production for sanitation service Delivery (faecal sludge-based fertilizer)***

The results indicate that there is a significant demand for compost as measured by the consumers' WTP, which is significantly higher than the average market price for substitute products at 100 UGX/kg. A statistically significant difference between the WTP estimates of the key customer segments - households and farmers suggests the potential for new businesses to implement a segmented-market pricing strategy. The results indicate that farmers are willing to pay more to know the source of the input materials used to produce the compost (i.e. MSW, faecal sludge and/or animal waste). The marginal WTP analysis shows that farmers are willing to pay 58.78 UGX/kg more to know the sources of materials used to produce compost, 45.97 UGX/kg for pelletized compost and 30.09UGX/kg for certified compost. This suggests that high quality compost product if labelled with information on source of the inputs, has 3rd party certification and is pelletized will command a market price of 234.84 UGX/kg - which is almost 2.5 times higher than the current market price. Likewise the demand for faecal sludge-based compost (models 17 and 19) was significant with an estimated WTP of 1345 UGX/kg. The marginal WTP analysis shows that farmers are willing to pay 161 UGX/kg more for fortified compost and 580 UGX/kg more for certified compost. However, 97UGX/kg will be needed to compensate farmers to use pelletized compost.

Whilst the current production level of compost is unknown, it is clear that it is a burgeoning industry with some entry barriers but supportive and existing policies encouraging business development. The organic fertilizer market is less commercialized and the related market structure and business dynamics are very informal. A market condition that would potentially impact the development of compost businesses is the market power held by chemical fertilizer producers. The fertilizer market in Uganda is highly concentrated – which is characteristic of strong oligopolistic market structures. Although chemical fertilizer producers represent the largest share of the market, a limited established distribution network represents an opportunity that organic fertilizer producers can capture. Additionally, there is neither a large-scale government fertilizer program that provides subsidized fertilizer to farmers nor an active private fertilizer sector that supplies fertilizer at competitive prices thus, this represents a great opportunity for waste-based organic fertilizer businesses to take advantage of erratic chemical fertilizer prices and the limited number of actors in the respective market. On the other hand, the product mix available of chemical fertilizer products is rather extensive, reflecting the grade (nutrient)-specific requirements of the commercial crop growers (estates and horticultural crop farms); suggesting that new organic fertilizer businesses will need at the start-up a highly unique and differentiated product; and innovative marketing strategies to mitigate the effects of the currently limited marketing and distribution channels available in the fertilizer market.

4.2 Ranking of the feasibility of the business models from a market perspective

The overall feasibility of the individual business models was evaluated based on the different aspects assessed (i.e. consumers' WTP and potential market size, market structure - level of market competition and ease of entry into industry, and market outlook). Specific indicators were used for each criterion. The indicators of the WTP and market size; and market structure were the overriding indicators in the evaluation of the overall feasibility assessment of the business models, as it is noted that limitations related to the product life cycle can be more easily mitigated, for example, with the implementation of key pricing and marketing strategies. For the WTP assessment evaluation, for a specific business model to be considered of a medium or high feasibility, the estimated consumers' WTP had to be equal to or higher that the current market price of the substitute product. The

market structure evaluation considered several indicators: a) ease of market entry, b) level of market concentration, c) level of product differentiation; d) whether the main competitor is a price taker or price setter and where possible e) the level of potential net profit margins. Different constellations were used in deriving the feasibility ranking system for the business models. Table 47 below presents the methodology used to rank the business models.

Based on this assessment, we observe in table 48 below that business models 1a, 15, 17 and 19 have the highest feasibility for successful implementation from a market perspective. Depending on the objective of the municipality, in particular, for the wastewater business models, incentives can be put in place to motivate wastewater use such as the provision of price subsidies or other subsidies (e.g. agricultural input subsidy, crop price subsidies).

Table 47: Methodology for ranking of business models

WTP and Market Demand	Market Structure	Market Outlook	Feasibility Ranking
WTP < Current market price of substitute product	1. Difficult market entry 2. High level of concentration (monopolistic/ oligopolistic market) 3. High level of product differentiation of competitive products 4. Price taker 5. Potential negative profit margins (without subsidies)	10 years and beyond to reach growth stage	No feasibility
WTP < Current market price of substitute product	1. Medium to difficult market entry 2. Medium to high level of concentration (monopolistic/ oligopolistic market) 3. Medium to high level of product differentiation of competitive products 4. Price taker 5. Potential negative profit margins (without subsidies)	10 years and beyond to reach growth stage	Low feasibility
WTP > Current market price of competitive/ substitute products	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	5 - 9 years to reach growth stage in business life cycle	Medium feasibility
WTP > Current market price of competitive/ substitute products	1. Easy market entry 2. Limited level of market concentration 3. Limited to no product differentiation 4. Price setting market 5. Potential net profit margins –positive	5 - 9 years to reach growth stage in business life cycle	High feasibility

Table 48: Summary of the feasibility of the selected RRR business models from a market perspective

Business model	WTP and Market Demand	Market Structure	Market Outlook	Cumulative feasibility score	Value-added product/recovered resource
Model 1a – Dry fuel manufacturing: agro-waste to briquettes	WTP > Current market price of substitute product	1. Easy market entry 2. Low-to-medium level of concentration 3. Limited to no product differentiation 4. Price setter 5. Potential net profit margins	6 – 7 years to reach growth stage in business life cycle	**High feasibility**	**Briquettes**
Model 2a – Energy service companies at scale: agro-waste to energy (electricity)	WTP < Current market price	1. Difficult market entry 2. High level of concentration (oligopolistic market) 3. No product differentiation 4. Price taker 5. Potential negative profit margins (without subsidies)	Limited data to evaluate business life cycle	**Low feasibility**	**Electricity**
Model 4 – Onsite energy by sanitation service providers	WTP < Current market price	1. Difficult market entry 2. High level of concentration (oligopolistic market) 3. No product differentiation 4. Price taker 5. Potential negative profit margins (without subsidies)	Limited data to evaluate business life cycle		
Model 9 – On cost savings and recovery (wastewater reuse)	WTP < Current market price	With an inexistent formal wastewater market, the assessment of its structure would be limited to a base reference of the freshwater market, which in this case would result in a flawed assessment.	Not applicable	**Low feasibility**	**Wastewater**
Model 10 – Informal to formal trajectory in wastewater irrigation	WTP < Current market price	Same as for Model 9.	Not applicable	**Low feasibility**	
Model 15 – Large-scale composting for revenue generation (MSW to compost)	WTP > Current market price of competitive/ substitute products	1. Medium level of difficulty for market entry 2. Limited level of concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 – 7 years to reach growth stage in business life cycle	**Medium feasibility**	**Compost**
Model 17 – High value fertilizer production for profit	WTP > Current market price of competitive/ substitute products	1. Easy entry 2. Limited level of concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 – 7 years to reach growth stage in business life cycle	**High feasibility**	**Faecal sludge-based organic fertilizer**
Model 19 – Compost production for sanitation service delivery					

5. References

1. Bensah EC, Antwi E, Ahiekpor JC. (2010) Improving sanitation in Ghana – role of sanitary biogas plants. J EngApplSci5(2): 125–33
2. Diener, S. et al. (2014) A value proposition: Resource recovery from faecal sludge- can it be the driver for improved sanitation? *In: Resources, conservation and recycling* 88: 32-38
3. Dodane P-H, Mbéguéré M, Sow O, Strande L. (2012) Capital and operating costs of full-scale faecal sludge management and wastewater treatment systems in Dakar, Senegal. Environ SciTechnol46(7): 3705–11
4. Koné, D., Cofie, O. O. & Nelson, K. (2010) Low-cost options for pathogen reduction and nutrient recovery from Faecal Sludge *In: Wastewater Irrigation and Health* Assessing and Mitigating Risk in Low-Income Countries (P. Drechsel, C. A. Scott, L. Raschid-Sally, M. Redwood & A. Bahri, eds) Earthscan, London, pp. 171–188
5. Muspratt, A.M. et al. (2014) Fuel potential of faecal sludge: Calorific value results from Uganda, Ghana and Senegal *In: Journal of water, sanitation and hygiene for development* 04(2): 223- 231
6. Murray A. and Ray I. (2010) Commentary: back-end users: the unrecognized stakeholders in demand-driven sanitation. J Plann Educ Res 30(1):94–102.
7. Network for water and sanitation (NETWAS) (2011) Market study on demand for use of wastewater, excreta, and faecal sludge and other related by-products, Final report by NETWAS UGANDA
8. NWSC (2004) Sanitation strategy and master plan for Kampala City, Kampala: National Water and Sewerage Corporation
9. Schroeder E. (2011) Marketing human excreta – a study of possible ways to dispose of urine and faeces from slum settlements in Kampala Uganda. GIZ p. 59.
10. UBOS (2006) Uganda National Household Survey 2005/2006, Socioeconomic Module, Uganda Board of Statistics, Kampala
11. Uganda Bureau of Statistics(2002) Uganda population and housing census –population size and distribution. Kampala, Uganda; 2006. p. 72.
12. UNICEF, WHO (2012) Progress on drinking water and sanitation: 2012 update p. 66.
13. Africa Energy Policy Research Network (AFREPREN) Secretariat, (2004) Data and Statistics on Renewable and Rural Energy Sub-Saharan Africa. Part VIII, Nairobi, Kenya
14. Bhat P. R., Chanakya H. N., Ravindranath H. N., (2001) Biogas Plant dissemination: success story of Sirsi, India, *Energy for Sustainable Development*1: 39-46
15. Byekwaso, B. (2009) Biogas: The untapped resource in Uganda *In:* New Vision [online] Available at: http://www.newvision.co.ug/D/8/459/700781
16. Ekere, W. (2009) Assessment of waste situation and potential for reuse in urban and peri urban areas of Lake Victoria crescent. PhD Thesis, Makerere University, Uganda.
17. Erdogdu E., (2008)An expose of bioenergy and its potential and utilization in Turkey. Energy Policy 36: 2182-2190

18. Gautam R., Baral S., Herat S., (2009) Biogas as a sustainable energy source in Nepal: Present status and future challenges, Renewable and Sustainable Energy Reviews 13: 248–252
19. Hoornweg, D.T.L. (1999) What a Waste: Solid Waste Management in Asia. The International Bank for Reconstruction and Development. The World Bank
20. MAK (2010) Chapter one: Crop and animal waste in Uganda [online] Available at:http://news.mak.ac.ug/documents/Makfiles/theses/FinaldraftDec%209-2010.pdf
21. Sabiiti, E. et al. (2004) Urban market garbage: a hidden resource for sustainable Urban/Peri-urban agriculture and the environment in Uganda. The Uganda Journal. 50: 102 – 109
22. Sabiiti, E. (2011) Utilising agricultural waste to enhance food security and conserve the environment *In: AJFAND online* 11(6): 1-9
23. Sabiiti, E. and Katongole, C. (n.d.) Evaluation of the urban solid waste management system in Kampala, Uganda [online] Available at:http://www.ewmce.com/Resources/Documents/Prof_Elly_Sabiiti_and_Dr_C_B_Katongole_-_Eval_of_Urban_Solid_Waste_Mgmt_Kampala.pdf
24. Sayin C., Mencet M. N., Ozkan B., (2005) Assessing of energy polices based on Turkish agriculture: current status and some implications. Energy Policy33, 2361–73
25. Taleghani G., Kia A. S., (2005) Technical–Economical analysis of the Saveh biogas power plant. *Renewable Energy* 30: 441–446
26. Yadvika A., (2004) Enhancement of biogas production from solid substrates using different techniques—a review
27. Agimass, F. and Mekonnen, A. 2011. Low-income fisherman's willingness to pay for fisheries and watershed management: An application of choice experiment to Lake Tana, Ethiopia. Ecological Economics 71:162-170.
28. Agyekum, E. O., Ohene-Yankyera, K. Kerita, B. Fialor, S.C. and Abaidoo, R. 2014. Willingness to pay for faecal compost by farmers in southern Ghana. Journal of Economics and Sustainable Development 5(2).
29. Arene, C.J. and Mbata, G.I. O. 2008. Determinants of profitability and willingness to pay for metropolitan waste-use in urban agriculture of the federal capital territory, Abuja, Nigeria. Journal of Tropical Agriculture, Food and Environment and Extension 7(1):41-46.
30. Arnot, C., Boxal , P. C. and Cash, S.B. 2006. Do ethical consumers care about price? A revealed preference analysis of fair trade coffee purchases. Canadian journal of Agricultural Economics 54:555-565.
31. Bennett, J., Blamey, R. (Eds.), 2001. The Choice Modelling Approach to Environmental
32. Valuation, New Horizons in Environmental Economics. Edward Elgar Publishing, Inc., Massachusetts, USA.
33. Danso, G and Drechsel, P. 2014. Nutrient recycling from organic wastes through viable business models in peri-urban areas in Sub-Saharan Africa. Maheshwari et al (Eds): Securing water, food, energy and the liveability of cities. Published by Springer.

34. Danso, G., Drechsel, P. Fialor, S. and Giordano, M. 2006. Estimating the demand for municipal waste compost via farmers' willingness-to-pay in Ghana. Waste management 26:1400-1409.
35. Drechsel et al. 2004. Waste management report submitted to IDRC
36. Dadson, A.V., Ishak, S. And Jasaw, G.S. 2013. Urban households' willingness to pay for improved solid waste disposal services in Kumasi Metropolis, Ghana. Urban studies Research 8.
37. Greene, W.H. 2002. Econometric analysis. Fifth Edition. Upper Saddle River, New Jersey: Prentice Hall.
38. Hanley, N., Wright, R.E. and Alvarez-Farizo, B. 2006. Estimating the economic value of improvements in rover ecology using choice experiments: an application to the water framework directive. Journal of environmental management 78; 183-193.
39. Karousakis, K. And Birol, E. 2006. Investigating household preferences for Kerbside recycling services in London: A choice experiment approach. Environmental Economy and Policy research. Discussion Paper Series Number: 18.2006. University of Cambridge, Department of Land Economy.
40. Lancaster, K. 1966. A new approach to consumer theory. Journal of Political Economics, 74:217-231.
41. Louviere, J.J., Hensher, D., Swait, J. and Adamowicz, W. 2000. Stated choice method: analysis and applications. Cambridge: Cambridge University Press.
42. Lim, K.H., Hu, W. Maynard, L. J and Goddard, E. 2013. U.S. consumers' preference and willingness to pay for country-of-origin labelled beef streak and food safety enhancements. Canadian Journal of Agricultural economics 62: 93-118.
43. McFadden, D. 1974. Conditional logit analysis of qualitative choice behaviour. In: Zarembka, P. (Ed.), Frontiers of Econometrics. Academic Press, London, pp. 105-142.
44. Maddala, G.S. 1999. Limited dependent and qualitative variables in econometrics. Cambridge: Cambridge University Press.
45. Ndunda, E. and Mungatana, E. 2013. Evaluating the welfare effects of improved wastewater treatment using a discrete choice experiment. Journal of environmental management 123:49-57.
46. Palatnik, R., Ayalon, O. And Shechter, M. 2005. Household demand for waste recycling services. Environmental Management 35(2):121-129.
47. Valerian, J., Domonka, E. Mwita, S. And Shirima, A. 2001. Assessment of the willingness to pay for organic products amongst households in Morogoro Municipal. Sustainable agriculture, Tanzania.
48. Uganda National Report (2010);For the Implementation of the Programme of Action for the Least Developed Countries for the Decade 2001-2010, Ministry of Finance, Planning and Economic Development, Republic of Uganda.
49. Uganda statistical abstract (2012)
50. Africa Agriculture Status Report (2013)
51. EPRC Fact sheet No 1 (2012) ;Why a fertilizer policy for Uganda.
52. IFDC & CHEMONICS (2007).Fertilizer Supply and Costs in Africa.

53. International Food Policy Research Institute Policy notes (2013). Uganda Strategy Support Program: The Supply of Inorganic Fertilizers to Smallholder Farmers in Uganda.
54. George, O. & Gracious, D. (2005). Rationalization and Harmonization of Fertilizer Policies, Regulations and Procedures in Uganda. First Draft report: A Study Report Prepared for the Association for Eastern and Central Africa Program for Policy Analysis (ECAPAPA) of the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA).
55. Musiime, E., Keizire, B. and M. Muwanga. 2005. Organic Agriculture in Uganda: The Need For A Coherent Policy Framework. *ACODE Policy Research Series No. 11.*
56. Kato E. And E. Nkonya, 2002. "Information Asymmetry among Output Traders, Processors and Farmers in Uganda, and IFPRI's Experiences in Agricultural Marketing Data Collection"
57. WANZALA M (2001). *Fertilizer markets and agricultural production incentives: Insights from Kenya*. Background document for the Tegemeo Institute Agricultural Monitoring and Policy Analysis Conference on Poverty, Technology and Competitiveness, September 6th, Nairobi, Kenya.
58. Omamo, S.W(*2003).Fertilizer Trade and Pricing in Uganda*. Agrekon, Vol 42, No 4
59. Omagor, N. (2012). Environmental And Social Audit Of The Second Environmental Management And Capacity Building Projects: Composting, Reforestation, Wetland Restoration, And Community Sub-Projects, Report prepared for National Environment Management Authority (NEMA),Uganda.
60. http://www.eprc.or.ug/data/news/105/39/NEW%20POLICY%20INTERVENTIONS%20TO%20ENHANCE%20THE%20AVAILABILITY%20AND%20USE%20OF%20FERTILIZERS%20IN%20UGANDA.html
61. http://www.unep.org/greeneconomy/SuccessStories/OrganicagricultureinUganda/tabid/29866/Default.aspx
62. http://www.africaag.org/2014/07/18/uganda-earns-big-organic-agriculture/
63. Danso et al. (2002) Income of farming systems around Kumasi *In*: Urban Agriculture Magazine
64. Diener, S., Semiyaga, S., Niwagaba, C.B., Murray, A., Gning, J.B., Mbéguére, M., Ennine, J.E., Zurbrugg, C., Strande, L. (2014) A value proposition: resource recovery from faecal sludge-can it be the driver for improved sanitation? Journal of Resources, Conservation and Recycling
65. FaMe (2014) Financing sanitation- resource recovery from faecal sludge in Kampala, Uganda: Workshop Factsheet- Faecal Sludge Management Enterprises Project
66. Faruqui, N.I.; Niang, S.; Redwood, M. (2004) Untreated wastewater use in market gardens; a case study of Dakar, Senegal. In *Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities*
67. Kakembo, F. (2012) Socio-economic and policy factors in wastewater disposal in Uganda: Constraints and opportunities, Uganda Christian University, Mukono, Uganda
68. Ministry of Water and Environment (MWE) (2010) Water sector performance report 2010
69. NETWAS (2011) Market study on demand for use of wastewater, excreta and faecal sludge and other related by-products, Final Report by NETWAS Uganda