FINANCIAL FEASIBILITY ANALYSIS OF THE FORTIFER BUSINESS MODEL IN CAPE COAST METROPOLITAN ASSEMBLY IN GHANA

BY

JOSHUA ABOAH

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For quality of life

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International Water Management Institute

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Every day I remind myself that my inner and outer life are based on the labours of other men, living and dead, and that I must exert myself in order to give in the same measure as I have received and am still receiving.

- *Albert Einstein*

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A charge to keep, I have.

ABSTRACT

Waste management is seen as a financial burden for most developing countries. Hence, there is a general call for private sector participation in the sanitation sector. In Ghana, the most predominant way waste is managed is by disposal in designated and illicit places. In a bid to find a sustainable way of managing faecal sludge and solid organic waste, the fortifer business model which falls within the broad resource reuse and recovery project was started by the International Water Management Institute on a pilot scale. This led to the production of fortified excreta pellets, the so called "fortifer". In a previous study to evaluate the viability of faecal sludge and municipality waste co-composting scheme in Ghana, the willingness – to – pay versus production cost approach was used. The objective of this study is to analyse the financial feasibility including uncertainty of up scaling the fortifer business model under two different ownership scenarios in the Cape coast metropolis in Ghana using NPV and IRR. Data for these scenarios originate from pilot project in Accra, extended with expert elicitation. Results reveal that the fortifer business model is financially viable for the two ownership scenarios. Outcomes are useful for policy makers to steer urban waste management with farmers' needs in the area of sustainable waste management.

Keywords: Faecal sludge, Excreta pellets, Waste management, Agriculture

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

Human excreta have been used in many countries as a good and cheap source of nutrient to enrich the soil (Phuc et al., 2006). According to Wolgast (1993), the nutritional composition in the annual amount of human excreta generated by one person is equivalent to the amount of fertilizer to produce 250kg of cereal. Human excreta and other solid wastes can be reused after they are collected and treated. On the other hand, it could be transported and disposed of. The latter is predominant in low-income countries (Strauss et al., 1997). When wastes are reused, some benefits achieved especially in low-income countries include reduction of indiscriminate dumping; creation of jobs and addressing sanitation funding shortfall (Nkansah, 2009); and reduction in the need for expensive artificial fertilizers to increase food production (Cofie et al., 2005; Strauss et al., 1997).

In Ghana, the use of human excreta as a source of nutrient in farming dates back to the early 80s. Its prominence in recent times is seen in the peri – urban agriculture sector due to its nutritional content, cheap cost and safety of usage (Danso et al., 2006; Mariwah and Drangert, 2011). Contrary to this prominence, majority of human excreta are still treated as waste in Ghana. The management of this waste, although not effective puts a lot of pressure on government's budget (Cofie et al., 2005). As a result of the financial encumbrance, the government of Ghana is strategically seeking private participation in the waste management sector (MLGRD and EHSD, 2010). Obeng and Wright (1987) compared the cost of composting to other treatment processes and found out that composting is cheaper but not the most economically viable method. Hence, the government, city councils, and private companies face the dilemma of deciding whether or not to compost.

The fortifer business model which falls within the broader resource recovery and reuse business model is seen as a sustainable way of tackling the waste problem and at the same time as a cheap source of nutrient supply for farmers (Esrye, 2000 and World Health Organisation, 2006). Studies conducted in Ghana by Drechsel et al. (2004b), Cofie et al. (2005), Mariwah and Drangert (2011), and Murray et al. (2011a) on the reuse of human excreta have been geared towards the technical aspect of improving the nutritional composition. These studies have led to the development of fortified excreta pellets, the so called 'Fortifer' by the International Water Management Institute (IWMI) in Ghana. This is viewed as user-friendly, nutritionally enriched and economically assessable to farmers. Before this product is rolled out on a commercial phase, a comprehensive investigation into the financial aspect of running such a business model in Ghana and its social acceptability is imperative. More information about the profitability of the business model will be one of the crucial decision tools to attract both public and private investments.

1.2 Problem statement

Local planning authorities in Ghana are faced with the challenge of waste management due to the pressure on the limited sanitation infrastructure and financial resources to manage waste even though, the methods employed are usually not sustainable (Drechsel and Kunze, 2001a; Ruiz-Mier and van Ginneken, 2006). Although metropolitan and municipal assemblies in Ghana spend over 50% on solid waste management, these waste management systems are not sustainable and effective. Studies conducted by Cofie et al. (2005) and Danso et al. (2006) in some parts of Ghana indicated that farmers see soil fertility as one of their major problems in agriculture. Another revelation from these studies was that the use of faecal sludge is a cost effective way for improving farm productivity; hence, farmers are willing to use compost to enhance the fertility of the soil as long as it is of good quality, effective and also cheaper than what they are currently using. Cofie et al. (2005) concluded in their study on recycling of human excreta for urban and peri – urban agriculture in Ghana, that recycling of human excreta could be used as a component of urban agriculture development and integrated waste management in developing cities.

Contrary to farmers' willingness to use faecal sludge and compost, Rouse et al. (2008) and Kone and Strauss (2010) have shown in their studies that the success stories of planned waste collection, treatment and reuse are few and often of small scale, hardly viable and seldom surviving their pilot stage. One paramount reason ascribed to this is due to the fact that the sanitation sector predominately has been a fully subsidised public service. The impact of private sector investment in the sanitation sector has been declining especially in low and middle-income countries. This is because of the low probability of cost recovery (Budds and McGranahan, 2003; Hall and Lobina, 2008). However, many governments in low-income countries are in favour of private sector participation and support a shift towards cost recovery. This development facilitates a shift from treatment - for - disposal to treatment – for - reuse, as the latter offers options for cost recovery (Murray et al., 2011b).

In Ghana, studies conducted by the International Water Management Institute (IWMI) have been geared at improving nutrient content and safe usage of co - compost. An essential result from the technical studies has led to the development of fortified excreta pellets (Fortifer) for agricultural use on a pilot scale by IWMI. This new product is viewed as a good alternative to other organic fertilizers because it addresses concerns raised about the safety of use, bulkiness and cost of other organic fertilizer (Nikiema et al., 2013). Moreover, it contains both organic and inorganic components unlike most organic and chemical fertilizers. Studies conducted by Cofie et al. (2005) and Becx et al. (2012) in different regions in Ghana revealed that the perception of farmers and their willingness to use compost from human excreta are promising. A preliminary study conducted by IWMI reports that farmers' willingness to pay (WTP) for the new product (Fortifer) is between GH¢ 1.00 - GH¢ 2.00 for 300 – 500 grams (Ankrah and Owusu, 2012).

Information on the production cost and financial viability is little and likely to vary per location of production. Thus, investigations into the financial viability of the production of the fortified excreta pellets is needed before it is upscale on a commercial phase. But, studies targeted at the financial aspect are few. This is largely because the projects on the reuse of human excreta have been financed by government and other donor agencies. An initial attempt to assess the financial viability of solid waste composting in Ghana by Cofie et al. (2005), used a cost versus WTP analysis to conclude that financial viability of this business model was unlikely. They also asserted that without subsidies, only few farmers, mostly in compost station vicinity, could afford a viable compost production price. Although this result give a fair idea about the prospects of the viability of the business model, their assessment incorporates a wider look at municipal solid waste. This study on the other hand, focuses on the fortified co-compost from municipal solid waste and faecal sludge. In addition, this study employs widely acceptable financial methods of assessing profitability of a business like the net present value, internal rate of return and uncertainty analysis to provide a more vivid picture about the financial viability of the fortifer business model in Ghana.

1.3 Objectives

This study aims to assess the financial feasibility of up scaling the fortifer business model in the Cape coast metropolitan assembly in Ghana to help provide more information for both public and private investment in the business model.

The specific objectives include:

i. To review technical and financial parameters of the reuse of faecal sludge as compost in literature.
ii. To analyse the financial viability including uncertainty assessment of up scaling the fortifer business model.

1.4 Relevance of the study

The relevance of this study stems from the surging need for sustainable waste management, improving soil fertility in Ghana and the need for affordable soil nutrient supplement. Results from this study will provide private investors and public authorities with more information about the financial viability of the fortifer business model. Financial analysis is important for assessing the incentives for metropolitan authorities, private investors and the government involved in the project. Another objective of financial analysis which justifies this study is the provision of a basis for determining the amount and timing of investment and for setting repayment terms and conditions.

1.5 Outline of research

The remainder of the study is organized into sections 2, 3, 4 and 5. Section 2 presents the literature review of the fortifer value chain, technical and financial parameters of faecal sludge and organic solid waste co-composting schemes, the different ownership and management models available and the potential bottlenecks of the fortifer business model. The materials and methods used in this study are discussed in section 3. The results of the study are presented in Section 4. Finally, the section 5 covers the discussion, conclusions and recommendations.

2 LITERATURE REVIEW

This section delves into the technical and financial aspects of co – composting schemes in relation to the fortfier business model. The weaknesses and gaps in theoretical and empirical knowledge are identified and discussed. Topics on work done, work-in-progress and what can be done are the central foci. In light of these, the section looks at the value chain, the technical aspects of the production of the product, the potential bottlenecks along the value chain of the product, studies done on financial parameters of co-composting and the knowledge gap in these aspects. Published literature and grey literature on the issues are the bases for discussion

2.1 The fortifer value chain

The fortifer project is a pilot project being carried out by the International Water Management Institute in Accra. It falls under the broad resource recovery and reuse business model. This project seeks to serve as a sustainable way of dealing with waste (faecal sludge and solid organic waste) disposal by producing a good quality soil nutrient supplement out of the organic solid waste and faecal sludge (Nikiema et al., 2013).

According to Drechsel and Kunze (2001a), the value chain of a business model which reuse waste and faecal sludge depicts a closed loop of the nutrient cycle. In this chain faecal sludge generated in domestic households and public toilets are combined with organic solid wastes, processed and applied back as soil nutrient supplement. In a description of the chain processes, Impraim (2013) mentions that the chain starts with the sourcing and sorting of organic solid wastes to the suction of stored faecal sludge of domestic households and public toilets and then the conveyance of the faecal sludge to a disposal site. He iterated that the suction or emptying of the domestic septic tanks and public toilets is carried out by either the municipal assembly or private companies, who are charged a disposal fee for dumping the faecal sludge on the drying beds at the treatment station. Nikiema et al. (2013) describe the processes and ingredients used in the production of fortifer. They came up with different formulations for the final product. These formulations include: (i) *compost,* which is made up of matured faecal sludge only (ii) *co-compost,* which consists of a mixture of dried faecal sludge and organic waste like market waste or saw dust (iii) *fortified pellets,* which is the premium product consisting of a mixture of co-compost and ammonium sulphate. However, they argued that the fortified pellets are favoured over the other formulations because they facilitate broadcasting and application methods of fertilizing the soil, steadily release soil nutrients and are effective in decreasing soil nutrients losses.

In the preliminary market survey on the fortifer products, Ankrah and Owusu (2012) found out that the potential end users for the fortifer product are small scale farmers and few cash crop cultivators on a large scale. They found out in their survey that the distribution of the fortifer product could be carried out by wholesalers and retailers, who showed high willingness to sell the fortifer product. Distribution serves as the bridge between the producer and the end – user. It is also described by Chopra (2001) as a key driver of the profitability of a firm. In a study on fertilizer usage in Ghana, the International Fertilizer Development Centre (IFDC) found out that the proximity of farmers to the nearest fertilizer retail point influences fertilizer usage. It was also reported that the distance between the farmers and the fertilizer retail points affects the farm gate prices and transaction costs. Banful (2009) reports that the average distance of farms to the nearest fertilizer dealers in the central region of Ghana is 92 km. He concluded in this study that although this is the same as the national average of 92 km, a closer proximity of 34 km and 42 km as in the case of the Greater Accra and Ashanti regions respectively or lesser should be the goal to achieve. In IFDC's study about improving fertilizer supply chain in Ghana, it was reported that the distribution cost is the second highest cost component of the domestic supply chain. They also stated that the distribution costs were divided among importers, wholesalers and retailers. In the study, they found that on the average, the distribution cost for the wholesalers and retailers is $1.08 per 50 kg of fertilizer (International Fertilizer Development Centre, 2012). Although the studies by IFDC and Ankrah and Owusu (2012) talk about distribution by wholesalers and retailers, they do not mention potential of engaging in a direct sales approach, where the producing company can sell directly to farmers. Figure 1 shows a representation of the processes along the value chain of the fortifer, which are linked to the technical processes in tables 1.

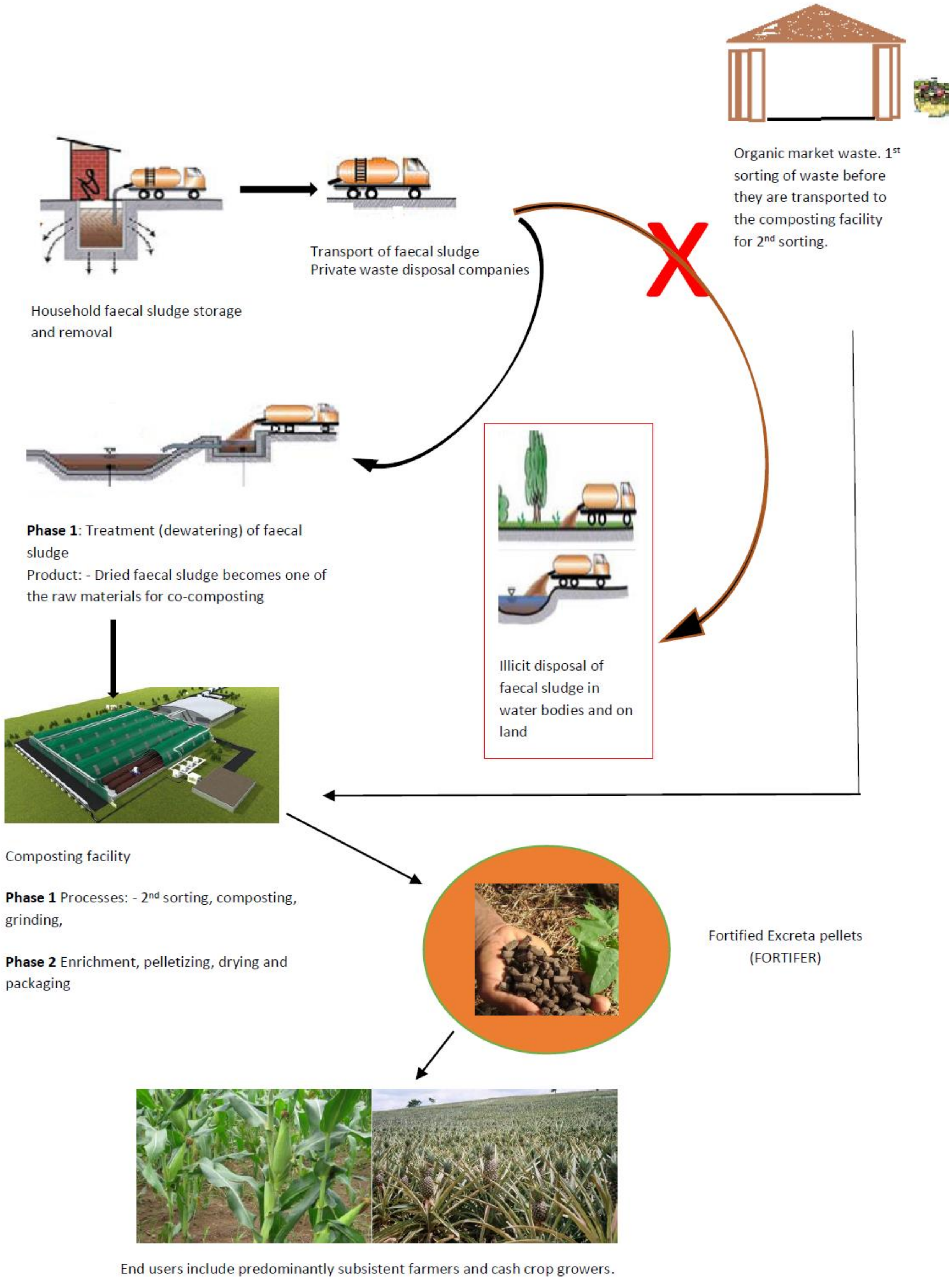

Figure 1 A representation of the value chain of the fortifer business model
Source: Author

The processes involved in the production of the fortifer in the pilot scale are shown in table 1.

Table 1 Processes in producing fortifer, the potential actors and their respective roles

Processes	Description of process	Actors / roles
PHASE 1		
Drying step	Emptying of faecal sludge from public latrines and domestic septic tanks in the drying bed to get solid faecal sludge (main raw material). 3 Drying beds of 240 m^2 each can produce 2tonnes of solid faecal sludge each in 2 weeks	Municipality: Managing the disposal of faecal sludge treatment area. Truck drivers: Transporting faecal sludge and transporting solid faecal sludge to composting plant
1st Sorting	Initial sorting is carried out off - site at the refuse dumps (markets) to remove plastics and other non-degradable materials	Contracted labour for sorting and truck drivers
2nd Sorting / Shredding	Final sorting is carried on - site on the sorting platform. Big organic market waste are cut into pieces using the shredder	Takes place in the composting facility, which is owned and managed by a private investor
Co-composting	Adding the organic market waste to the solid faecal sludge in the ratio 3:1, turning, adding water and monitoring the temperature (50 -55^{0}c required). Drying the matured compost. 60 days to produce a matured compost. A 150 m^2 platform carries 3 tons of co-compost	" idea as in 2nd sorting
Grinding	Matured compost are grinded into fine particles using the grinder	" idea as in 2nd sorting
PHASE 2		"
Enrichment	Mixing starch (binder), ammonium sulphate and water to the grinded compost using the mixer. 3% starch (binder), 7% ammonium sulphate and 26% water	
Pelletizing	The mixer from the enrichment stage are put into the pelletizer to form pellets. Evenly sized pellets required. Thus more pelletizer of the same size is required in the upscale project	"
Drying	The pelletized compost are sun dried on a platform. Drying of the matured compost for 2-3 days	"
Packaging	The dried pelletized composts are sieved, weighted and packaged in size of 300 – 500 g	"

Source: Nikiema et al., 2013

2.2 Technical and financial parameters

The technical aspect of producing co-compost from human excreta hinges on the design and operation. The technical and financial parameters of schemes which reuse faecal sludge as co-compost in Ghana and two schemes which uses solid organic waste in India and Bangladesh are shown in table 2. These schemes are different in their sizes and the raw materials used. The scheme in Bangladesh and India use organic community waste. While, both schemes in Ghana use faecal sludge.

Table 2 Technical and financial parameters of co-composting schemes in three countries

	Mirpur-Dhaka Composting Scheme in Bangladesh	Buobai co-composting in Kumasi, Ghana	Anamol Krishi Udyog composting business in India	Fortifer pilot project in Accra , Ghana
Reference	Zurbrugga et al., 2005	Steiner et al., 2002	Harper, 2004	Nikiema et al., 2013
Capacity	1095 tons of collected waste per yr. [a]	500 m^3 faecal sludge per yr.	1000 tons per yr.	36 tons per yr. [b]
Method of composting	Indonesian windrow technique aerobic and thermophite composting method	Windrowing composting method	Windrowing composting method	Windrowing composting method
Raw materials	Organic waste mixed with cow dung, saw dust and urea	Faecal sludge and organic solid waste	70% solid organic waste and 30% community waste	Faecal sludge, organic solid waste enriched with ammonium sulphate
Labour	10 workers on full time base	2 full time workers and outsourced labour	12 daily wage workers and 1 full time supervisor	2 full time workers. 6 daily wage workers and contracted labour for dewatering and sorting
Revenue	Compost sales of \$9728 per yr. Collection fees of \$6087 per yr.	Compost sales = \$5 per ton	Selling price of compost product = \$ 40 per ton	Selling price based on WTP = \$495 – 990 per ton [c]
Operation cost	Collection of waste = \$3119 per yr. Composting [d] = \$7511 per yr.	\$1800 per yr. [e]	Production cost [f] = \$34.20 per ton	Production cost = \$200 per ton
Life time	10 yrs.	15 yrs.		-
Interest rate	15%	5%	12%	-

a. Based on an assumption that operation is throughout the year. Original capacity stated in study is 3 tons of collected waste per day
b. 3 drying beds produce 6 tons in 2 weeks; co-compost takes 60 days to mature. Yearly estimation is based on assumed continuous operation throughout the year
c. Exchange rate of \$1 = 2.02 Ghana cedis. WTP is 1- 2 Ghana cedis per 0.5 kg
d. Cost items comprise salaries, and expenses for electricity, water and additional feed stocks (sawdust, urea, cow dung)
e. include waste sorting, sludge removal, sand refilling, waste sorting, compost, screening and bagging, salaries
f. include biological agent (3kg/ton), packaging, marketing expenses, overheads

2.3 Ownership structure

Financing is a paramount factor for the commencement and sustenance of any operation. Governments in developing countries spend large portion of their annual budget towards managing waste. Gradually, these governments are decreasing subsidies for services such as faecal sludge emptying, transport and disposal (Mehta and Knapp, 2004). In Ghana, the private sector has been actively involved in the sanitation sector. They have been successful without financial support in faecal sludge collection and conveyance, but not in treatment plant construction and operation (Evans, 1996; Murray et al., 2011a). These studies which support the success stories of the private sector do not state if private sector will be able to function successfully if waste is reused instead of been disposed. The government of Ghana envisions a complete privatization of the value chain of the sanitation sector by 2015 (MLGRD and EHSD, 2010). This expectation does not state whether the government will be relief of their responsibility as key stakeholders in the sanitation sector. Hall and Lobina (2008) argue that the challenge is how to attract private investment in a sector which has historically been run by the public sector. They buttress this point by comparing the contribution of private sector in sanitation infrastructure in both developing and developed countries. In their book '*Decentralised composting for cities of low-and middle –income countries'*, Rottenberger et al. (2006) provide different business partnerships and management models available for a co-compost production and the role played by the government or public sector (see table 3).

Table 3 Management models for a decentralized composting

Options	Characteristics	Role of city or Government
Model 1 – Municipally owned-Municipally operated	Integrated into the existing municipal Solid waste management system and focused on reducing waste	Introduces recycling and composting into the Solid waste management (SWM) policy
Model 2 – Municipally owned- Community operated	Benefiting community is involved in the management of primary waste collection and composting. Non-profit seeking model	Introduces recycling and composting into SWM policy. Supports communities to develop proper system of waste collection and disposal. Provides support funds for constructing plants and the setting up of a primary waste collection
Model 3- Municipally owned – Privately operated	Benefiting community is partly involved. Profit seeking model is possible. At least full cost recovery (from fees and compost sales)	Introduce and implement recycling and composting policy. Investment (selects composting sites and construct plants). Contracts out the operation and maintenance. Monitors performance of contractors
Model 4 – Privately owned – privately operated	Profit seeking enterprise based on ideal compost market conditions. Income is generated through compost sale and collection fees	Introduces recycling and composting into the SWM policy. Transparent regulations. For public –private partnerships. Cooperates in supplying raw waste and disposal of residues

Source: Rottenberger et al., 2006

According to Murray et al. (2011b), the '*municipally owned – community operated'* model has been effectively practiced in a decentralised module in China with waste water reuse. In Bamako, Mali, a partnership between Peace Corp volunteer and the local community was established to manage the faecal sludge through co-composting. However, the municipality was expected to play a key role in this project (Steiner et al., 2002). Among the models outlined in table 3, studies conducted in some developing countries report that the most promising and relevant model for a low- income country is a partnership between the municipality and the private sector. Some of the projects that have been undertaken with this model are in Nam Dinh in Vietnam (Klingel et al., 2001); Buobai treatment plant in Ghana (Steiner et al., 2002) and Mirpur, Dhaka in Bangladesh (Zurbrugga et al., 2005). The need for collaboration between private and public sector was emphasized by Cofie and Kone (2009). They noted in their study on co-composting faecal sludge and organic solid waste in Ghana that combining the process of faecal sludge drying and co-composting is costly for private company.

Moss (2008) gives a different picture about the public private partnership model. He stressed on a privately owned and managed sanitation sector. He pins down the attractiveness of investment in the sanitation by the private sector to secured revenue stream, manageable risk profile, confidence and certainty in terms of engagement. Based on the difficulty of public and private operators in recovering the costs of operating wastewater treatment plants in China, he deduced that the sanitation sector in lower – income countries and could not readily generate revenue streams to recover investments.

2.4 Potential bottlenecks of the fortifer business model

Continuity of operation is key for the success of the business model. Identifying potential bottlenecks which might impede the continuity of operation is a critical subject to study. Therefore, this section delves into the bottlenecks related to the value chain of faecal sludge co-composting schemes. The discussion hinges on the following potential bottlenecks: availability of raw materials, scale of operation and the perception of the co-compost produced.

2.4.1 Availability of raw materials

The faecal sludge and organic solid waste are integral raw materials used in the production of the fortifer, hence their supply and availability is vital for successful running of production. In a study by Murray et al. (2011b) on evolving policies of public and private stakeholders in faecal sludge management in Ghana, the situational analysis of the level of faecal sludge treatment in Ghana were looked at. They pointed out that most of faecal sludge generated in Ghana are dumped off without treatment. They also observed that there is no accurate quantitative assessment of total volume of faecal sludge treatment in Ghana. An attempt to quantify sewage in Cameroon by Mougoue et al. (2012) looked at a combination of two methods to quantify sewage. These include counting trucks at the entrance of emptying sites and their classification according to the volume of the tanker and household demand for sewage services. The same method was used by Drechsel et al. (2004b) which used the logbooks of truck drivers who collect and dispose the faecal sludge. They opined that in adopting a business model which involves a partnership between the public and private sector, the implication will be that policy on the disposal of faecal sludge will be in the domain of the municipal assembly.

The aspect of interest to the private sector is the disposal of the raw faecal sludge to generate solid faecal sludge from the dewatering process. One issue of faecal sludge disposal which are not captured in most literature has to do with open defecation. Additionally, the availability of organic solid waste, which forms the majority part of the mixture in the co-compost is vital. In Ghana, separation of waste is not popular. Thus, there is limited or no literature concerning waste separation. According to Rottenberger et al. (2006), initial sorting of organic solid waste is required. They also stated in their study that the sorting process requires a lot of time. They concluded that although there will be substantial faecal sludge and organic solid wastes generated, quantification and availability of waste will be quite challenging. Nikiema et al. (2013) mentioned availability of raw material as a factor to consider when up scaling. They recommended in their study that considerations should be given to the needs of the market and the availability of raw materials in the area where project will be sited. Because, the quantity of faecal sludge readily assessed at dumping site and the amount of organic solid waste affect the continuity of operation.

2.4.2 Scale of operation

According to Steiner et al. (2002), investment, operation and maintenance costs of faecal sludge management are influenced by their respective local conditions. Hence, they argue that these must be estimated based on each independent case. For the execution of the estimation of up scaling and comparison of treatment options, Steiner et al. (2002) considered that labour such as waste sorting and compost turning are manual. Niemeyer et al. (2001), in their paper '*The economic viability of organic waste composting'* attributed the decision to mechanize the maturation phase of composting to the following:

- planned capacity of the plant
- available space and price of land
- available funds for the investment
- level of personnel costs
- level of funding to cover running costs
- existence of legal regulations governing emission values

Thus, Niemeyer et al. (2001) and Steiner et al. (2002) in their studies, acknowledged that a mix of manual activities like sorting, turning and mechanized operations like grinding, mixing and pelletizing are suitable for an upscale project. Opting for a mechanized operation requires other investments in equipment such as an electricity generator for continuity of operation and skilled labour to run and operate the machines. This concern is emphasized by Harper (2004) who studied the "*Anamol Krishi Udyog*" composting business in India. Another critical process which could be mechanized during the up scaling exercise is the drying of the pelletized fortifer. In the pilot project of the fortifer business model, sunshine is used for drying. This requires a large platform for the drying process. Dependence on sunshine restricts operation during raining seasons in a year, thereby, affecting the scale of operation.

2.4.3 End users' perception of fortifer

A first step towards attracting private investors in the business model of using human excreta as co – compost is to find out whether the product will appeal to the prospective end users. In Ghana, the faecal sludge has been perceived as a cheap and effective source of soil nutrients. A study conducted by Danso et al. (2006) was focused on the end users' perception of the co-compost. This study looked at farmers' perception of co – compost from municipal solid waste and the potential cost of the co-compost in three selected cities in Ghana. Results from the study showed that most of the farmers perceived the cost of co-compost to be expensive, but majority of the farmers in these cities had a positive perception about the use of co-compost. Hence, low-cost but good quality co-compost is required. In a similar study conducted in the Effutu district, a predominant farming community of the Cape Coast Metropolitan Assembly, the results showed that majority of farmers are willing to use fertilizer from human excreta, although, some raised concerns about the safety of usage. This study concluded that collection and reuse of human excreta will help improve crop yield (Mariwah and Drangert, 2011). In addition to these perception studies on the use of fertilizer produced from faecal sludge, IWMI conducted a preliminary survey on end users' perception of an upgraded co-compost produced from faecal sludge and fortified with inorganic nutrients (Fortifer). The survey reports that farmers in four major regions in Ghana were willing to use the product. They also highlighted the possibility of enrolling fortifer as one of the fertilizers used by the government in the subsidized fertilizer programme.

2.5 Market value of co-compost

This section reviews works on potential market value of faecal sludge co-compost. Many studies have used different methods to determine the market value of products. Gittinger (1984) argues that a good rule in determining a market price for agricultural commodities produce is to seek the price at the point of first sale, which he suggests is the farm gate. However, this approach does not specifically address the market value for compost, although it is used as an agricultural input. A study which gives an idea on how to determine the market value of compost was conducted by Obeng and Wright (1987). They stated that some factors which influence the price of compost include availability of soil conditioners (such as livestock waste, crop residues) and the cost of agricultural inputs (like inorganic fertilizers). They also argued that the major value of compost is derived from its organic content.

Recently, other studies conducted on the market value of co-compost by Danso et al. (2006), Rouse et al. (2008) and Murray et al. (2011b) used two methods in the estimation of market value. These methods are the WTP and the replacement cost approach (RCA). The study by Danso et al. (2006) used the WTP as the market value of compost. This study considered a scenario when transportation cost and production cost was costless to farmers. However, the study does not clearly state whether the transportation cost is factored into the WTP for the compost. The WTP method was also used by IWMI as a preliminary market value of the fortifer. Results from the survey by IWMI, which did not consider costless transportation and production cost to farmers revealed that on the average, farmers are willing to pay GH¢1-GH¢2.00 for 300 - 500g of fortifer. Another study which implements the WTP method was carried out by Rouse et al. (2008). They expanded the concept of WTP, by using WTP and production cost (PC) to assess the viability of compost business. They asserted that in cases where WTP > PC, the business is likely to make profit, but when PC > WTP, a business is likely to run a loss. However, one argument against the WTP approach is that it is limited to hypothetical markets where no money or goods actually change hands (Baron and Maxwel, 1996).

The replacement cost approach is one of the methods used by Drechsel et al. (2004b) and (Murray et al. (2011b) to estimate the market value of products. In the study by Drechsel et al. (2004b), the RCA was used to estimate the value of faecal sludge as a fuel input. However, in the same study, WTP was the method used to estimate the value of faecal sludge as compost. Although Baron and Maxwel (1996) raised an argument against the WTP method, it has been widely used as a suitable method to estimate the market value for compost.

3 MATERIALS AND METHODS

This chapter outlines the methodology used to achieve the objective of the study. It involves the methods of analysis, types and sources of data used, methods of data collection and the study area.

3.1 Financial concepts

In analysing the financial viability of the business model, the net present value (NPV) and internal rate of return (IRR) are used as the valuation criteria. The NPV is the difference between the present value of the future cash flows from an investment and the amount of investment. The decision rule for applying NPV is that the project is profitable when NPV > 0 (Rottenberger et al., 2006). NPV is expressed in monetary value, hence it is sometimes considered as cognitively less efficient compared to the IRR, which is expressed as a percentage. The IRR is the discount rate for which total present value of future cash flows equals cost of investment or the discount rate when NPV is equal to zero. The IRR rule states that if the IRR of a project or investment is greater than the minimum required rate of return or the cost of capital, then the project is profitable. Whereas the NPV is an economic indicator, the IRR acts as a financial indicator (Tang and Tang, 2003; Osbourbe, 2010). The formula for the NPV and IRR are given in equations 1 and 2 respectively.

$$\mathbf{NPV} = -\mathbf{C_0} + \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \qquad \text{-------------------- (1)}$$

Where C_t = Nominal net cash flows

C_0 = Initial investment

r = Nominal rate of return

t = time (in years)

n = duration of the project.

$$\mathbf{IRR} = -C_0 + \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} = 0 \quad \text{--------------------------- (2)}$$

From these equations, the probability of making a loss can be estimated as when NPV < 0 for equation 1 and when IRR < r (discount rate) for equation 2.

The initial investment (C_0) consists of cost items such as the cost of building the composting facility, faecal sludge treatment site, land, equipment for composting, furniture and fixtures,

computer and data handling devices and initial marketing cost. The annual net cash flows (C_t) was estimated as $C_t = R - C - t$ …………………………………….. (3)
Where R is the total annual revenue, C represents total annual cost and t is the corporate tax. The corporate tax (t) is calculated as $t = t_c * (R - C - Ca)$ ………….. (4)
Where t_c is the corporate tax rate and Ca is the annual capital allowance.

According to the taxation law of Ghana, a corporate tax rate of 10% is applicable to agro related processing companies located in other regional capitals (excluding Tamale, Wa, Bolgatanga). Another aspect of taxation which was used in the estimation of the NPV is tax holiday. For waste processing companies, the government of Ghana gives a tax holiday of 7 years. Thus, taxation was deductible in the 8th year of operation. Additionally, capital allowance for building structures and works of a permanent nature other than those in mineral and petroleum exploration is 10% based on straight line basis. Plant and machinery used in manufacturing sector has a capital allowance of 30% reducing balance basis (Ghana Revenue Authority, 2013).

An aggregated inflation rate based on the consumer price index (combined average of the food and non-food groups) from year 2005 – 2012 of Ghana's statistical bulletin was used for future cost and price projections. The Consumer Price Index (CPI) measures the change over time in the general price level of goods and services that households acquire for the purpose of consumption (Ghana Statistical Service, 2013). The base rate set by the Monetary Policy Committee of the Bank of Ghana was used as discount rate ***(r)***.

3.2 Data collection

A mixed of primary and secondary data were used in this study. Data were collected from pilot project in Accra, extended with expert elicitation. The pilot project facility was visited to gain a first - hand outlook of the business model. The study area was also visited to determine the baseline value chain of waste (faecal sludge and solid organic wastes). The baseline value chain describes the status – quo of wastes management in the metropolis without the fortifer business model. In the baseline value chain, waste are dumped off on a piece of land designated by the metropolitan for such purposes. Two key actors of the baseline value chain were interviewed. These actors are the public waste management authority and 'Zoomlion', one of the private companies in charge of waste collection and the suction of faecal sludge from the domestic homes. The private company and the metropolitan waste management department were asked open – ended questions to determine their willingness to partner private investors in the fortifer business model and their contribution to the partnership. These interviews were recorded using an audio recorder. Data on revenues from faecal sludge disposal were obtained from the metropolitan waste department.

Primary data on some technical parameters such as the ratio of formulation of raw materials, labour, types of equipment and the inputs used for the production process were collected through a face – to face interview with the pilot project manager with the aid of a recorder. Secondary data on both technical and financial parameters were also gathered from published literature about the fortifer pilot project and other similar co-composting schemes. Data on the cost estimates for machines and other equipment were quoted based on the commercial selling rate from the website of manufacturing and retailing companies. The selling price of the fortifer was based on the market price of a substitute good. The NPK is the most used fertilizer in Ghana (Fuentes et al., 2011). Hence, the market price of the NPK was used as the selling price for the fortifer. For projections on annual costs and output price growth, data were retrieved from the yearly consumer price index published by the country's statistical service and annual gazetted publication of the bank of Ghana.

Data sourced using expert elicitation were the specification and cost of land and the building of the composting facility. Data on the land specification and cost were gathered from Ogloo consult, a local real estate company. Data on the composting facility were sourced from Koracle consults, a local expert in building, construction and quantity surveying. The estimations of the composting facility was adapted from the building specifications for co-composting by Rottenberger et al. (2006) *(see appendix A*).

3.3 Input parameters for scenarios of the fortifer business model

This study looked at two different scenarios. The first scenario was a public – private partnership business model and the second was a completely private business model. Input parameters such as production cost, volume of dewatered faecal sludge produced and the ratio of combination of faecal sludge and solid organic matters of these scenarios were based on the data from the pilot project of the fortifer business model. Other input parameters were from primary and secondary data. In the public-private scenario, the faecal sludge treatment site is owned and managed by the public sectors while the composting facility is owned and managed by the private sector. In the second scenario, the private sector owns and manages both the faecal sludge treatment site and the composting facility. The input parameters used in these scenarios include initial outlay, initial marketing cost, and distribution cost and revenue streams. Other parameters include annual cost and output price growth and an assumption on annual sales volume. Taxation and capital allowance were also incorporated in the estimation of the NPV. An assumed capacity of 1040 tons per year was estimated based on the technical parameters of the pilot fortifer business model. Detailed input parameters for the two scenarios are presented in table 4. The difference between these scenarios are linked to the initial investment (i.e. cost of land and faecal sludge treatment site) and the disposal revenue. The two different input parameters for both scenarios can be seen in table 5.

Moreover, in making a decision on the financial viability of the project, uncertainty needs to be assessed. To capture uncertainty in this study, a model was built and a probabilistic simulation using the Monte Carlo simulation technique was run with the @Risk software. Savvides (1994) and Papadopoulos et al. (2001) argue that the Monte Carlo gives a logical conclusion by building up random scenarios which are consistent with the key assumptions made. In effect, the Monte Carlo simulation randomly samples variables' uncertainty space instead of point estimate. According to Smith (2002), the Monte Carlo simulation approach for assessing uncertainty of a variable involves the following three steps:

- Select a distribution to describe possible values of an identified stochastic variable.
- Generate data from this distribution.
- Use the generated data as possible values of the variable in the model to produce output.

To reflect the uncertainties, various probability distribution were used that are assumed to best represent the underlying data used in table 4. The selection of probability distributions when dealing with uncertainty allows for the development of a valid model for random processes. In this study, the probability distribution for the input parameters whose historical data were available was determined using the Akaike information criteria (AIC) for the goodness – of – fit. The AIC, like all the information criteria for determining goodness-of-it, checks for over-fitting. This makes it superior to most of the goodness-of-fit statistics like the chi-square and the Anderson Darling statistic. In addition, the AIC is a better information criteria for small data sample (Anderson et al., 1994). The probability distribution of other input parameters like initial marketing costs was determined based on the author's own estimation, supported by expert opinion on the parameters of the distribution. For instance, the marketing department of the Ghana Broadcasting Corporation (GBC) identified the parameters of distribution for the initial marketing cost. The triangular distribution for the assumed sales volume used in this study is based on the study by McGrowan (2008).

Table 4 Input parameters used in the NPV estimation

TECHNICAL	unit	Reference
Ratio of combination of faecal sludge and solid organic waste	1:3	Nikiema et al., 2013
Annual dewatered faecal sludge produced from five 240m^2 drying beds.	260tons	Adapted Steiner et al., 2002
Annual volume of fortifer produced (Capacity of composting facility)	1040 tons	Nikiema et al., 2013
Duration for annual recurring marketing cost (radio advertisement)	6 months	Author
RECURRING COST		
Annual marketing cost (radio advertisement are spread throughout the year for a duration of six months)	GH₵170 per month	GBC, 2013
Production cost [a]	GH₵ 404	Nikiema et al., 2013
Distribution cost	GH₵ 44 per ton	Fuentes et al., 2012
REVENUE		
Selling price (retail price of NPK)	GH₵1.43 per kg	MoFA, 2012
Disposal fees (for dumping off faecal sludge on drying beds. Weekly average of 5 trips)	GH₵20 per trip	Asabre, 2013

INITIAL OUTLAY	Unit	Most likely	Min	Max	Distribution	
LAND (7000 metres sq.) [b]	GH₵	9,310			Deterministic	Igloo consult, 2013
BUILDING						
Faecal sludge treatment site [c]	GH₵	27,836	25,210	30,462	Triangular	Steiner et al., 2002
Composting facility (see appendix A and B)	GH₵	80,914			Deterministic	Koracle consult, 2013
EQUIPMENT, VEHICLE & MACHINE						
Grinder (SL-60 Capacity of 1-1.5T/hr.)	GH₵	10,100			Deterministic	Alibaba Group, 2013
Shredder (HMC-40 compost shredder machine. ISO9001:2000)	GH₵	10,100			Deterministic	Alibaba Group, 2013
Mixer (Organic fertilizer compost mixer. Capacity of between 1T/hr.)	GH₵	12,118			Deterministic	Alibaba Group, 2013
Pelletizer (KPL-400 fertilizer pelletizer. capacity of 1.2 -2.5 T/hr.)	GH₵	10,100			Deterministic	Alibaba Group, 2013
Dryer (LGZ-12 fertilizer pellet drying machine of diameter 1200mm)	GH₵	12,118			Deterministic	Alibaba Group, 2013
Packaging Machine (TSE-G-50 compost packaging machine with a capacity of 3-5 bags/min)	GH₵	18,180			Deterministic	Alibaba Group, 2014
Tools (shovel, head pan, wheel barrow, hose)	GH₵	440	380	500	Triangular	Author

a. Production cost includes raw materials, utilities like electricity and water wages, packaging material
b. Commercial land standard specifications of 100 m*70 m. The total land size for the composting facility is 1000 m sq. (see appendix A) and 5 drying beds is 1200 m sq.
c. 5 drying beds with a bi-weekly capacity of 6 tons and an annual capacity of 260t TS FS

The exchange rate used to convert parameters from dollars to Ghana cedis is of $1 = GH₵ 2.2, based on Bank of Ghana, exchange rate in September, 2013

Sieve (ZSG1237 compost linear vibrating sieve. ISO 9001:SGS)	GH₵	3,030			Deterministic	Alibaba Group, 2013
Truck (K2700 /K3000 models capacity of ≤ 5 tons, 2.7 (J2) diesel engine	GH₵	44,339			Deterministic	Kia Motors Gh.Ltd., 2013
Vehicle (4WD , pickup double cabin, diesel engine , 8-valve)	GH₵	70,573			Deterministic	Toyota Ghana Ltd., 2013
OFFICE FURNITURE AND FIXTURES						
office furniture (desk, swivel office chair and side chairs, book shelf, drawer)	GH₵	4,000			Deterministic	Kingdom Books Stationery, 2013
Air conditioner	GH₵	4,000			Deterministic	Compu-Ghana, 2013
COMPUTER AND DATA HANDLING						
Printer (HP office jet - wireless duplex, print scan copy, fax, web toner)	GH₵	599			Deterministic	Compu - Ghana, 2013
Computer (PC - intel core I 3-2120, 500GB SATAIII)	GH₵	2,500			Deterministic	Compu - Ghana, 2013
INITIAL MARKETING COST						
Advertisement [d]	GH₵	60,380			Deterministic	GBC, 2013
ASSUMPTIONS						
Annual cost and output price growth rate	%	12.53	0.99		Inv. gauss	BoG, (2013)
Annual sales volume in tons	tons	104	0	1040	Triangular	Author
TAXATION						
Capital allowance						
(i)Building structures and works of a permanent nature other than those in minerals and petroleum exploration	Straight line basis		10%			
(ii)Plant and machinery used in manufacturing sector	Reducing balance		30%			Ghana Revenue Authority, 2013
(iii)Equipment, office furniture and fixtures	Reducing balance		20%			
Corporate tax rate for agro- processing companies in other regional capital (excluding Tamale, Wa, Bolgatanga)			10%			
Tax holiday for waste processing companies			7 yrs.			
Project life cycle			15 yrs.			Steiner et al., 2002
Discount rate			16%			BOG, 2013

d. 3 months TV promotional documentary and 6 months of radio adverts and 10 tons test promos – Author’s assumption based on commercial rates

Table 5 Input parameters which differ for the two fortifer business model scenarios

Input parameter	unit	Public-Private Partnership scenario	Private Scenario
Initial outlay	GH₵	335,412	372,558
Disposal fees	GH₵ per trip	0	20

3.4 Sensitivity analyses

The sensitivity analyses was carried out to determine the effects that changes in parameters had on the NPV and IRR. According to Khomenko and Poddubnaya (2011), the sensitivity analyses give a practical way of showing the effects of uncertainty on the results of the project by varying the values of the key factors. In sensitivity analyses, one parameter is changed whilst the rest are held constant to determine the impact on the output. This identifies the project's most important and sensitive parameters. Prior to performing the sensitivity analyses, a preliminary analysis was performed to identify the input parameters that may be important to explore more fully. This was done by ranking the input parameters based on their impact on the NPV and IRR using the Spearman rank. This ranking was used as the basis of selecting the input parameters incorporated in the sensitivity analyses. Afterwards, the sensitivity analyses was carried out by changing the highest ranked input parameter (the annual sales volume) to see the effect on NPV and IRR.

3.4 Study area

The study area is the Cape coast metropolitan assembly in Ghana. The metropolis is bounded on the south by the gulf of guinea, on the west by the Komenda/Edina/Aguafo district, east by the Abura-Asebu/Kwamankese district and the north by the Twifo Hemang Lower Denkyira district. The metropolis is the smallest in Ghana with a total estimated land size of 122 km^2. It is located in the centre of the Central Region of Ghana. The vegetation of the metropolis consists of shrubs, grasses and a few scattered trees. Agricultural production is mainly at the subsistence level with a cultivated coverage area of two-thirds of the available land. About seventy per cent of the people in the metropolis are farmers. Food crops grown in the metropolis include maize, cassava, cocoyam and vegetables such as tomatoes, pepper, garden eggs. Cash crops produced in the northern part of the study area are citrus, cocoa and oil palm. The average farm size is 0.5 hectares. The main soil types in the metropolis are lateritic in nature and are derived from weathered granite and schist weathered into different soil grades (Cape coast metropolitan assembly, 2012). This, coupled with the high amount of rainfall render most of the soil nutrients been leached. Hence, soil fertility is a major issue for farmers in the metropolis.

The only way waste is managed in the metropolis is by collection and disposal in a landfill as terminal end point. The metropolitan assembly has designated some acres of land in Nkamfour, where domestic solid waste, market wastes as well as faecal sludge are dumped off. The waste management department of the assembly handles most of the emptying of faecal sludge for both domestic and public toilets at a charge of GH¢80 and GH¢100 per trip respectively. However, there are other private companies which do the emptying. These private companies also dump off the faecal sludge in the designated final disposal site at a disposal fee charged by the assembly. On the average, the weekly faecal sludge disposed is 30 trips. There is no separation of domestic and market solid waste. One challenge of managing faecal sludge is related to open defecation into the sea or in the bush. This is predominant in the assembly, especially in remote district where there are no toilet facilities in the homes (Asabre, 2013). The percentage of households in the metropolis who are involved in agriculture and the poor waste management techniques been practiced in the metropolis make it a suitable location for the up scaling of the fortifer pilot project.

4 RESULTS

This section presents results on the financial feasibility of the two scenarios of the upscale fortifer business model. The results from the sensitivity analyses are also presented.

4.1 Scenario analyses

The economic results for the two scenarios of the fortifer business model are shown in table 6. All the items presented (e.g. the total revenue, total revenue and operating profit) in exception of the total investment are presented as average of 15years.

*Table 6 Economic results of the two scenarios of the fortifer business model**

	Public – Private Partnership	Private
Total investment	335,412	372,558
Annual sales revenue	1,506,155	1,506,155
Annual disposal revenue	-	13,488
Total revenue	1,506,155	1,519,643
Annual Production cost	1,073,666	1,073,666
Annual Marketing cost	52,915	52,915
Annual Distribution cost	43,522	43,522
Total variable cost	1,170,103	1,170,103
Depreciation	18,252	20,107
Total fixed cost [a]	22,360	24,837
Total cost	1,210,715	1,215,047
Operating profit [b]	295,440	291,108
Mean NPV [c]	118,855	106,847
IRR (%)	23	22

a. Fixed cost comprise of cost of land, building composting facility and faecal sludge treatment site, equipment, initial marketing cost, furniture and fixtures
b. Average of 15 years
c. Discount rate of 16% for 15 year duration
* The figures are expressed in Ghana cedis

From the table, it is evident that the private scenario of the upscale fortifer business model has a higher initial investment of GH¢ 372,558. In the Public-Private Partnership, the investment cost is GH¢ 335,412. The average operating profit of the Private scenario (GH¢ 291,108) is lower than the Public-Private partnership model (GH¢ 295,440). Both Public-

Private Partnership scenario and the Private scenarios had positive mean NPV of GH¢ 118,855 and GH¢ 106,847 respectively. Both scenarios also had IRR greater than the discount rate of 16%. However, the Public-Private Partnership scenario had a higher IRR of 23%. The simulation results for the two scenarios are presented in table 7. The table shows the minimum and maximum NPV and variations around the mean. The probability of making losses using the NPV as decision criterion are also shown in table 7. The results show that the probability of making losses for the Public-Private Partnership scenario (i.e. 52.9%) was lower than Private scenario (53.2%) when the NPV is used as the decision criterion. The results of the minimum and maximum NPV show that the Public-Private Partnership has a higher financial viability compared to the Private scenario.

Table 7 Simulation results for the two scenarios of the fortifer business model

	Public-Private Partnership	Private
NPV(GHS '000)		
Min	-2,689	-2,592
Max	4,641	4,505
Mean	119	108
5^{th} percentile	-1,944	-1,952
95^{th} percentile	3,032	3,041
Probability (NPV < 0) (%)	52.9	53.2

5000 @Risk iterations

4.2 Sensitivity analyses

A preliminary analysis was conducted to identify the input parameters which had more impact on the NPV. The input parameters were ranked based on their effect on NPV using the Spearman rank as shown in table 8.

Table 8 Spearman rank correlation coefficient between NPV and input parameters

Input parameter	Public-Private partnership	Private
Annual sales volume	1.00	1.00
Annual cost growth rate	-0.02	-0.03
Faecal sludge treatment site	-	0.01

A positive coefficient means that an increase in the input parameter will cause an increase in the NPV. On the other hand, a negative coefficient, means an increase in the input parameter will decrease the NPV. From the results in table 8, the annual sales volume was ranked as the input parameter with the highest impact on the NPV for both scenarios. The results also show that a perfect spearman correlation exist between annual sales volume and NPV (i.e. correlation coefficient of 1). The annual cost growth rate had a negative spearman correlation of -0.02 and -0.03 for the public-Private Partnership scenario and the Private scenario respectively. Hence, for the sensitivity analyses, the percentage of the assumed most likely annual sales volume was changed to 15% and 5% to see the impact on the NPV and IRR. Table 9 presents the simulation results for the NPV and the economic results for the IRR of the sensitivity analyses.

Table 9 Results of the sensitivity analyses

	Public-Private Partnership		Private	
% most likely sales volume	15%	5%	15%	5%
NPV(GHS '000)				
Min	-2,572	-2,515	-2,483	-2,514
Max	4,656	4,696	4,654	4,753
Mean	234	2	224	-9
5th percentile	-1,821	-2,077	-1,839	-2,098
95th percentile	3,086	2,997	3,083	3,005
Probability (NPV < 0) (%)	50.3	55.5	50.5	55.6
5000 @Risk iterations				
IRR (%)	30	16	28	15

The NPV obtained from the percentage change in the annual sales volume in table 9 reaffirms the Spearman correlation. The results of the sensitivity analyses show that the financial viability of the Public-Private Partnership scenario is higher compared to the Public-Private scenario. The IRR from the sensitivity analyses show that with an average annual sales volume of 5%, the Private scenario will not be financially viable.

5. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

In this section, the results are discussed, conclusions drawn and recommendations made to the findings.

5.1 Discussion

The call for a cost recovery orientation towards waste management in developing countries has necessitated the search for sustainable methods of managing waste. This call has also aroused the discussion on active private sector participation in the waste management sector. Thus, the fortifer business model is seen as a double - edged sword to tackle the problem of managing waste in a sustainable way and at the same time achieve cost recovery from investment.

This study looked at the uncertainty in the outputs using the Monte Carlo simulation method. The input parameters used in the financial viability analysis were pivotal in determining the results obtained. The components of the initial outlay were mostly obtained based on commercial selling rates. Although, some of the input parameters (e.g. initial marketing cost, annual marketing cost) were assumed, their estimations were also based on the commercial cost quotations. Some of the input parameters were quite optimistic. However, the correlation coefficient of these parameters in the Spearman rank showed that the changes in these parameters will not have much impact on the financial viability of the business model. The input parameter which plays a key role in the financial viability of the business model is the annual sales volume. To be financially viable, the Private scenario of the fortifer business model should target above 5% mean annual sales volume. The Public-Private Partnership scenario will be able to recover costs at 5% mean annual sales volume. Apart from the sales volume, one important factor which influenced the financial viability of the business model is the selling price of the fortifer product. In this study, the market price of a substitute good (i.e. NPK) was used instead of the price reported in the willingness-to-pay study. This gives management more room for exploring the different price options, which will be a competitive tool for a new product such as the fortifer.

The two different scenarios of the fortifer business model used arise from the level of public authority involvement in the business model. The public authority's involvement considered in this study are the provision of land and the ownership of the faecal sludge treatment station. For instance, in a study on various composting schemes, Steiner et al. (2002) considered the provision of land as one of the major public sector involvement. Rothenberger et al. (2006) also considered investment in the composting facility as an involvement of public authority. The results from this study showed that both Public-Private Partnership and Private scenarios of the fortifer business model were financially viable. However, the Public-Private scenario had higher chances of being financially viable than the Private scenario.

The result resonates with the conclusion drawn by Harper (2004) that individuals and municipalities seeking to venture into the composting business could cover their operating costs and earn some surplus for a production capacity of 1000 tons a year. The results of this study show that both scenarios were financially viable. However, there are potential bottlenecks which might impede the success of up scaling the fortifer business model. The scale of operation with respect to the level of investment and the operation (either manual or mechanized) is one of the potential bottlenecks identified by Steiner et al. (2002). Another potential bottleneck is the availability of raw materials. This will be an impediment to the success of the venture especially, when the private company is dependent on the public authority for the provision of dewatered faecal sludge (Drechsel et al., 2004b). Moss (2008) sums it all up by his assertion that the success of the venture will depend on the factor of managing the risk profile.

5.2 Conclusions

The conclusions drawn from the results of this study are that:

- The overall shift towards a cost recovery orientation in the waste management sector is attainable.
- Up scaling the fortifer business model is financially viable, however the public sector involvement increases the chances of viability.

5.3 Recommendations

From the conclusions, it is recommended that the policies on waste management should be geared at reusing waste in a more sustainable way. Additionally, the public sector should not relegate the management of the sanitation sector entirely to the private sector. The public sector should be actively involved in cost recovery schemes in collaboration with private investors. Finally, regulations on waste separation is highly recommended.

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APPENDICES

Appendix A Required space for composting plant processing 3 tons of waste per day

COMPOSTING AREA	SIZE	REMARKS
Sorting Area	40m^2	Concrete platform with no roofing. Thickness of 20 inches
Storage of rejects	30m^2	These are rooms within the composting facility.
Storage of recyclables	10m^2	(covered with roofing sheet)
Composting pad	400m^2	This is a platform with a thickness of 20 inches with roofing. Similar to a shed
Maturation area	150m^2	This is a platform with a thickness of 20 inches with roofing. Similar to a shed
Screening and bagging area	35m^2	This is a room within the composting facility. (covered with roofing sheet)
Compost storage area	25m^2	These are rooms within the composting facility. (covered with roofing sheet)
Machine area*	200 m^2	This is a big space within the composting facility. (covered with roofing sheet)
Sub-total Area	890m^2	
FACILTIES		
Office	16m^2	These are rooms within the composting facility.
Sanitary facilities	10m^2	(covered with roofing sheet)
Water supply point	4m^2	
ADDITIONAL SPACE		
Vehicle parking area	30m^2	Space outside the composting facility covered with roofing sheet.
Green buffer zone	50 m^2	This is a space outside the composting facility which is not covered with roofing sheet.
TOTAL AREA	1000m^2	

Source: Adapted from Rothenberger et al., 2006.

Appendix B

Cost estimate for construction of composting facility by Koracle construction Ltd.

Description	Qty	Unit	Rate	Amount (GH¢)
<u>APPROXIMATE BILLS OF QUANTITIES FOR PROPOSED SHED</u>				
<u>ELEMENT NO. 1: SUBSTRUCTURE</u>				
<u>Site Preparation</u>				
<u>Excavation and Earthwork</u>				
Excavate trenches to receive strip foundations average depth not exceeding 1.5m,starting from stripped level	38	m^3	18.00	684.00
Excavate pits for column bases depth not exceeding 1.50m starting from stripped level	14	m^3	18.00	252.00
Backfilling selected excavated material around foundations	24	m^3	8.00	192.00
Remove surplus excavated material from site	28	m^3	8.00	224.00

<u>Hard core filling</u>				
Approved imported laterite hardcore filling to make up levels under floors and compacted in 150mm thick layers	44	m^3	44.00	1,936.00
To Collection				3,288.00
<u>Concrete work</u>				
<u>Plain in-situ concrete grade 15 as described in:</u>				
50mm Blinding layer	15	m^2	15.00	225.00
Foundation	14	m^3	285.00	3,990.00
150mm Thick floor Bed	167	m^2	42.75	7,139.25
<u>Reinforced in-situ concrete (1:2:4-19mm aggregate) as described in:</u>				
Column bases	7	m^3	350.00	2,450.00
Footing columns	2	m^3	350.00	700.00
<u>Reinforcement</u>				
<u>Mild steel round bar reinforcement to BS 4449 cut, bent and fixed into position as described in:</u>				
12mm Diameter bars in column bases	388	kg	3.00	1,164.00
12mm Diameter bars in column	201	kg	3.00	603.00
10mm diameter ditto	93	kg	3.50	325.50
<u>BRC Mesh</u>				
6mm BRC Mesh on floor bed	167	m^2	12.15	2,029.05
<u>Formwork</u>				
<u>Sawn Formwork to:</u>				
Vertical sides of columns	14	m^2	18.00	252.00
Cut to profile of steps	1	m^2	18.00	18.00
Risers 150mm high	7	m^2	2.70	18.90
Edges bed and ramp 150mm wide	58	m	2.70	156.60
To Collection				19,071.30
<u>MASONRY</u>				
<u>Solid sandcrete block in cement and sand (1:4)</u>				
150mm thick walls	145	m^2	39.60	5,742.00
To Collection				5,742.00
<u>COLLECTION</u>				
Page No. - 1				3,288.00
Page No. - 2				19,071.30
Page No. - 3				5,742.00
ELEMENT NO.1:SUBSTRUCTURE - To Summary				28,101.30
<u>SUPERSTRUCTURE</u>				
<u>ELEMENT 2: REINFORCED CONCRETE FRAME</u>				
<u>Reinforced insitu concrete(1:2:4-20mm aggregate) in:</u>				
Column	1	m^3		350.00

			350.00	
Tie beams/lintels	2	m^3	350.00	700.00
<u>Mild steel round bar reinforcement in:</u>				
12mm diameter in Column	223	kg	3.00	669.00
10mm ditto links	98	kg	3.50	343.00
12mm diameter in beam or lintel	185	kg	3.00	555.00
10mm ditto stirrups	103	kg	3.50	360.50
<u>Formwork</u>				
<u>Sawn Formwork to:</u>				
Sides Column circular in shape	12	m^2	18.00	216.00
Sides and Soffit of Lintel/beams	21	m^2	18.00	378.00
<u>ELEMENT 2: REINFORCED CONCRETE FRAME - To Summary</u>				3,571.50
<u>ELEMENT NO.3: MASONRY</u>				
<u>Solid sandcrete block in cement and sand (1:4) mortar</u>				
125mm wall	77	m^2	30.80	2,371.60
100m Partition wall	18	m^2	25.80	464.40
<u>Door/window frame</u>				
<u>Erect, plumb, level and build in the following 50 x 100mm hardwood frames as block work proceeds</u>				
Door frame size 750 x 1800mm high	3	No.	39.15	117.45
Ditto, size 900 x 2100mm high	4	No.	45.90	183.60
Window frame size 875 x 600mm high	3	No	26.55	79.65
Ditto size 1200 x 1200mm high	5	No	26.55	132.75
ELEMENT 3:MASONRY - To Summary				3,349.45
<u>ELEMENT NO.4: ROOFING</u>				
0.50mm pre painted long span aluminium roofing sheets laid with two corrugations side laps and fixed to hardwood purlins at 1050mm centres with aluminium drive screws and washers in accordance with manufacturer's instructions.	232	m^2	32.40	7,516.80
0.50mm Pre-formed corrugated aluminium ridge cap. 450mm girth and fixed to hardwood with drive screws and washers	26	m	14.58	379.08
<u>Timber Members</u>				
<u>Sawn Treated Hardwood:</u>				
50 x 150mm Rafters	166	m	9.00	1,494.00
50 x 50mm Purlins	220	m	3.85	847.00
50 x 50mm Noggins	420	m	3.85	1,617.00
50 x 50mm Hangers	88	m	3.85	338.80
25 x 225mm Fascia board	118	m	9.15	1,079.70

ELEMENT NO.4:ROOFING - To Summary					13,272.38
ELEMENT NO.5: JOINERY					
Wrot Hardwood					
DOORS					
44mm thick (finished) Panelled door, comprising 250mm top rail and stiles, 150mm middle and bottom rails, open rebated and divided into four panels:					
Ditto, 800 x 2050mm x 40mm thick	3	No.	350.00		1,050.00
44mm thick skeleton framed flush door covered both sides with 6mm plywood and lipped all round with hardwood strips:					
Door size, 650 x 1750mm high	2	No.	95.60		191.20
Fillets, Glazing beads and Grounds					
Wrot Hardwood					
12 x 38mm Planted door stop	17	m	2.85		48.45
19 x 19mm Window fillets	26	m	1.50		39.00
12 x 50mm Cover battens	33	m	2.85		94.05
Ironmongery					
Supply and fix the following ironmongery to hardwood with screws to match:					
Pair: 100mm Brass butt hinges	5	No.	8.00		40.00
Approve mortice lock with set of Anodized Alumimium lever handles	5	No.	50.00		250.00
ELEMENT NO.5:JOINERY - To Summary					1,712.70
ELEMENT NO.6: METALWORK	-				
STANDARD UNITS	-				
Aluminium 'Naco' louvre Carriers	-				
Pair: 8-Blade carrier 1124.5mm long with single control and screwed to hardwood	5	No	42.35		211.75
Pair: 4-Blade carrier 584.2mm long with single control and screwed to hardwood	2	No.	18.65		37.30
Sundries	-				
Nylon mosquito proof woven plastic guaze cut to size and fixed to hardwood frames with battens (measured separately)	8	m²	3.85		30.80
Burglar Proofing	-				
20mm Diameter mild steel bars cut to required lengths and threaded through hardwood frames as burglar proofing	22	m	4.50	99.00	
ELEMENT NO.6: METALWORK - To Summary					167.10
ELEMENT NO.7: ELECTRICAL INSTALLATION	-				

Include the Provisional sum of Gh¢ 3,000.00 for electric works, fittings and accessories				3,000.00
ELEMENT NO.7:ELECTRICAL INST.-To Summary				3,000.00
ELEMENT NO. 8: PLUMBING INSTALLATIONS				
Internal Pipe work	-			
Include the Provisional sum of Gh¢ 500.00 for internal pipework and accessories in connection with plumbing installations		Item		500.00
Sanitary Appliances	-			
Supply and install the following sanitary appliances	-			
Vitreous China heavy duty low level W.C.suite with	-			
S-trap complete with plastic seat and ceramic cistern	2	No.	350	700.00
550 x 400mm white glazed wash hand basin (Twyford) complete with 31mm diameter chromium plated waste fitting, plugged, cain and stay and one 12mm chromuim plated valve and one glazed stopper and appliance mounted on pair of brackets plugged and screwed to blockwork	2	No.	150.00	300.00
Chromium plated toilet roll holder	2	No.	25.00	50.00
PLUMBING INSTALLATIONS - To Summary				1,550.00
ELEMENT NO. 9: WALL, FLOOR AND CEILING FINISHINGS				
-				
13mm Thick smooth terazzo (1:4) finish on:				
Walls (Internal & external)	122	m²	16.50	2,013.00
Tiles, slab or block finishings				
450 x 450 x 6mm Porcelains non-slip ceramic floor tiles of approved colour laid with adhesive or equivalent according to manufacturer's instructions on screeded bed (measured separately)				
Polished porcelan floor tiles as described	120	m^2	38.00	4,560.00
250 x 400 x 6mm ceramic wall tiles of approved colour laid with approved adhesive in accordance to manufacturer's instructions on screeded backing (measured separately) on:				
Wall tiles as described	22	m^2	28.00	616.00
Plain Sheet Finishes				
Tongue and grooved plastic "Panelit" horizontal ceiling lining fixed to soffit Joist/Noggings(m/s)				
Horizontal ceiling lining	120	m^2	25.60	3,072.00
BEDS AND BACKINGS				
Cement and sand (1:3) mortar as described in:				

19mm Thick floated backing on walls to to receive wall tiles (measured separately)	22	m^2	9.85	216.70
38mm Thick screeded bed to receive floor tiles (measured separately)	120	m^2	15.00	1,800.00
ELEMENT NO. 9: WALL, FLOOR AND CEILING FINISHINGS - To Summary				12,277.70
ELEMENT NO. 10: GLAZING	-			
Mirror	-			
600 x 750mm Bevelled edge polished plate mirror fixed with chromium plated dome-headed screws	2	No.	85.00	170.00
6mm x 150mm Wide clear/obscure glass louvre blade with long edge slightly rounded and ends fixed in clips of carriers (exceeding 750mm but not exceeding 900mm long)	48	No.	4.00	192.00
-	-			
ELEMENT NO. 10: GLAZING - To Summary				362.00
ELEMENT 11: PAINTING AND DECORATION				
Primer				
Prime back of joinery before fixing	6	m^2	3.25	19.50
Knot, Prime, Stop and Paint two undercoats and one finishing coat of gloss oil paint on:				
General surfaces (Doors)	12	m^2	6.70	80.40
Door frames not exceeding 300mm girth	14	m^2	6.70	93.80
PAINTING AND DECORATION - To Summary				193.70
SUMMARY				
ELEMENT 1: SUBSTRUCTURE				28,101.30
ELEMENT 2: REINFORCED CONCRETE FRAME				3,571.50
ELEMENT NO.3: MASONRY				3,349.45
ELEMENT NO.4: ROOFING				13,272.38
ELEMENT NO.5: JOINERY				1,712.70
ELEMENT NO. 6: METAL WORK				167.10
ELEMENT NO. 7: ELECTRICAL INSTALLATION				3,000.00
ELEMENT NO. 8: PLUMBING INSTALLATION				1,550.00
ELEMENT NO. 9: GLAZING				362.00
ELEMENT NO.10 WALL, FLOORS AND CEILING FINISHINGS				12,277.70
ELEMENT NO. 11 PAINTING AND DECORATING				193.70

BILL No. 2 **PROPOSED SHED - To General Summary**		67,557.83
<u>ELEMENT NO. 12: SEPTIC TANK/SOAKAWAY</u>		
Include the Provisional sum of Gh¢ 3,000.00 for the construction of septic tank and soakaway pits	Item	3,000.00
ELEMENT NO. 12: SEPTIC TANK/SOAKAWAY		3,000.00

<u>GENERAL SUMMARY</u>

<u>BILL NO.1</u> - PRELIMINARIES AND METHOD RELATED ITEM		3,000.00
<u>BILL NO.2</u> - COMPOST FACILITY		67,557.83
<u>BILL NO.3</u> - EXTERNAL WORKS		3,000.00
SUB –TOTAL		73,557.83
<u>ADD</u> FOR CONTINGENCY SUM (10%)		7,355.78
TOTAL ESTIMATED COST OF WORKS	GH¢	80,913.61