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Lahti University of Applied Sciences

Developing a Sustainable Model for Urban Organic Waste in Ghana

Case Study: Ho Township, Ghana

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ABSTRACT

Biowaste is an indispensable part of urban areas and contributes immensely to socio-economic development depending on how it is looked at. In today's world, some three billion people, primarily in the developing countries, continue to struggle with their energy needs. In addition to struggling with energy needs, some of these developing countries do not have sufficient fertilisers for crop production. Urban organic waste produced in these areas poses environmental, social, economic and public health issues.

The bio-waste utilisation in the developing countries can play a major role in fulfilling the demands of the developing countries. Ghana being an agricultural country has a tremendous potential to utilise urban bio-waste for agricultural use as well.

The aim of this thesis was to find ways of utilising the organic fraction of waste in the Ho township. The participation of the Ho Municipality in the North South Local Government cooperation with the city of Lahti in Finland makes this thesis very feasible for future implementation.

In addition to Urine Diverting Dry Toilet (UDDT) pilots in the municipality, this thesis will serve as a good basis to initiate a pilot for the utilization of the urban organic waste generated especially in the light of the ongoing projects in the municipality. It seeks to highlight the present status of waste management in the Ho township, the challenges, the potential of the technology to use for biowaste utilisation, and advocates further research.

Key words: Biowaste, Energy, Organic Fertiliser, Ghana

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TIIVISTELMÄ

Kaupunkialueilla on tärkeää hallita ja hyödyntää syntyviä biojätevirtoja, millä on suuri merkitys kaupunkiseudun sosio-ekonomiseen kehitykseen. Kehittyvissä maissa noin kolme miljardia ihmistä kamppailee päivittäisen energian hankinnan kanssa. Useissa kehittyvissä maissa ei pystytä hankkimaan riittävästi lannoitteita maanviljelyn tarpeisiin. Näissä maissa kaupunkien biojätteet aiheuttavat haasteita, jotka ilmenevät ympäristön pilaantumisena, terveysongelmina sekä sosiaalisen ja taloudellisen kehityksen ongelmina.

Biojätevirtojen tehokas hyödyntäminen voisi auttaa kehittyvien maiden haasteiden ratkaisemisessa. Maatalousvaltainen Ghana voisi hyötyä kaupunkialueiden biojätteiden hyötykäytöstä lannoitteiden ja energian tuotannossa. Biojätevirtoihin tässä työssä luetaan kuuluviksi kaupunkialueen lietteet sekä kiinteät biojätteet.

Käsillä olevan opinnäytetyön tarkoituksena on löytää menetelmiä ja malleja biojätteen hyötykäyttöön Ho:n kaupunkialueella Ghanassa. Ho:n kaupunki on tehnyt yhteistyötä Lahden kaupungin kanssa osana North-South -kuntayhteistyöohjelmaa. Vastaavaa rahoitusta voitaisiin jatkossa käyttää biojätteen hyötykäytön edistämiseen Ho:ssa.

Tässä opinnäytetyössä kuvataan jätehuollon ja lietteenpuhdistuksen nykytilaa Ho:n kaupungissa sekä kartoitetaan haasteita, käytettävissä olevia jätevirtoja, mahdollisia teknologioita ja toimintamalleja biojätteen hyötykäyttöön. Käynnissä olevan kuivakäymälä -pilotin (Urine Diverting Dry Toilet, UDDT) lisäksi Ho:n kunnassa voitaisiin tämän selvityksen pohjalta alkaa valmistella toista pilottikokeilua kaupunkialueen biojätteen hyödyntämisestä lannoitteena ja energialähteenä. Opinnäytetyön lopussa esitetään ehdotuksia jatkotutkimusta varten.

Avainsanat: Biojäte, bioenergia, orgaaninen lannoite, Ghana

Contents

1. INTRODUCTION

According to UNEP (2009), 140 billion metric tons of biomass are generated every year from agricultural and industrial activities worldwide. About 1.3 billion people worldwide either have no access to electricity or rely on the use of non-commercial fuels (IAEA 2009). On the other hand, they suffer the various effects of environmental problems caused by improper waste management. This is most often a problem for developing countries where there may be a lack of adequate waste management, recycling systems and regulating environmental policies.

Uncontrolled waste and wastewater disposal can cause severe problems for health and the environment. Rotten organic biowaste is often disposed off in unsecured open landfills where it emits methane and leachate. When the waste is incinerated in common open fire small-scale incinerations, it generates high levels of carbon dioxide (CO_2) which contribute to climate change, water and soil contamination and air pollution (Green Choices 2016).

The degradation of this organic biomass may, however, be used to provide energy with the use of standard and appropriate technologies. The organic fractions of domestic wastes from cities can be valuable energy sources. Organic waste like fecal sludge can be converted to energy and fertilisers using modern treatment technologies. However, the potential for converting the organic domestic waste into bio-energy in developing countries has been inadequately studied and adopted (AETS Consortium, 2013).

Population growth, rural urban migration and industrialization cause a growing generation of urban solid and liquid waste which further complicate conservation plans and waste management. The urban waste generated possesses high value with respect to material and energy recovery. It consists of recyclable material (such as paper, glass, bottles), composite wastes such as textiles and plastics as well as biomass. Biomass is a renewable resource that causes problems when not used. The challenge, therefore, is to utilise biomass as a resource for productive uses (UNEP 2009).

1.1 Research problem

One of the current problems faced in Ghana is the continuous rise in waste generation and the lack of adequate waste management system. Most often urban waste ends up at dump sites and uncontrolled landfills, where it emits dangerous Green House Gases into the atmosphere causing health problems and environmental degradation and pollution. For instance, in the Ho Municipality where an average of 42 tons of solid waste out of 65 tons of waste generated is deposited at the final disposal site, the rest of it finds its way into drains, open spaces and heaps at inadequate sanitary sites (UN-HABITAT 2009).

Ghana depends largely on hydro and thermal power for its energy supply. However, this energy supply has not kept pace with its increasing demand. This has given rise to an Energy Crisis characterized by power rationing and rampant power cuts, which monumentally has an adverse effect on the Ghanaian population, industries and the country's present economic status (Sakyi 2014).

Agriculture is Ghana's most important economic sector, employing more than half the population on a formal and informal basis and accounting for almost half of GDP and export earnings. However, shortage in the supply of fertilisers poses another problem in agriculture. It causes low yields of crops, which eventually gives rise to issues of low income. Current research shows that supplies to the Volta region of Ghana are erratic as well as across the nation (Krausova & Banful 2010; Daily Graphic 2012).

1.2 Objective

The aim of this Master's Thesis is to research the possibility of the conversion of urban organic waste in the Ho Municipality into useful components – mainly for organic fertilisers and bio-energy.

It proposes a sustainable model for the biomass and sludge generated in the municipality. The study also seeks to mitigate some of the environmental problems caused by improper disposal of organic waste. In addition, it searches ways to generate income from the by-products – mainly bioenergy and organic fertiliser.

The scope of this study is restricted to the Ho Township area of the municipality to ensure larger localized waste volumes. Personal observation has been the most problematic area about the waste management.

A descriptive research methodology was used for this study. A survey was administered to the Authorities of the Ho Municipal Assembly (the Administrative body of the area under study

Additionally, the availability of documents such as the Medium-Term Development Plan (MTDP), Municipal Environmental Sanitation Strategy and Action Plan (MESSAP) was facilitated through my previous working period in the Ho Municipality from February 2013 to March 2015. These documents served as the main sources of information in addition to the survey administered to the authorities in the Ho Munical Assembly.

For this study, three similar case studies located in the country of study were identified. Another case study in Finland was identified for the master’s thesis. Results from the survey and case studies were harnessed to draw up recommendations as discussed in Chapter 6.

2. BACKGROUND

1.1 Case Study Area - Ho Municipality

Ghana is in West Africa. The latitudinal extent of Ghana is 4° to 12°N latitudes and 4°W to 2°E longitudes. It is divided into ten administrative regions. Volta Region is one of the country's ten administrative regions, with Ho designated as its capital. It is located west of Republic of Togo and to the east of Lake Volta (Maps of the World 2015).

1.1.1 Location and Area

The Ho Municipality is one of the 5 Municipalities of the 25 districts in the Volta Region (Ghana Statistical Service 2014). It falls between latitudes 6º 20"N and 6º 55"N and longitudes 0º 12'E and 0º 53'E. Its total land area is 2,361 square kilometers thus representing 11.5 percent of the region's total land area (MOFEP 2014).

Figure 1. Location of Ho Municipality in Ghana (World Atlas, 2015)

1.1.2 Relief and Drainage

The general relief of the Municipality is made up of both mountainous and lowland areas. The mountainous areas are mostly to the north and northeast which are part of the Akuapim - Togo Range and have heights between 183–853 metres tall. The notable areas are Awudome stretch in the southwest and Matse and Klefe in the northeast. The lowland areas are to the South of the Municipality and are between 60 – 152 metres in height. The general drainage pattern is southwards and dominated by rivers like Tsawe (Alabo) and Kalapa, which flow into the lower Volta or Avu Lagoon. These rivers are seasonal and therefore do not provide a dependable source of water supply to the communities for home use and irrigation for farming throughout the year (Ghana Statistical Service 2014).

1.1.3 Climate

Generally, the mean monthly temperature in the Municipality is from 22^0 C to about 32^0 C. The annual mean temperature ranges from 16.5^0 C 37.8 C. In effect, temperatures are generally high throughout the year, which is good for crop farming (Ghana Statistical Service, 2014).

The rainfall pattern is characterized by two rainy seasons referred to as the major and the minor seasons. The major season begins from March to June while the minor season is from July to November. The mean annual rainfall figures are between 20.1mm and 192mm. The highest rainfall occurs in June and has a mean value of 192mm while the lowest rainfall in November and averages about 20.1mm (Victoria et al., 2009).

1.1.4 Population Characteristics

Originally, Agotime – Ziope and Ho West were all part of the then Ho Municipality until 2012 when these Districts were carved from it. Based on estimates from the 2010 population census, the Ho Municipality has a population of 177,281. Females constitute 52.7 percent and males represent 47.3 percent. About 62 percent of the population resides in urban localities.

The average household size in the urban centres ranges from 4.1 to 4.7. (Ghana Statistical Service 2014). The Ho Township as part of the Ho municipality was specifically chosen for this study and has a population of 104,532.

1.2 Waste Challenges in the Ho Township (urban area)

1.2.1 Urban Solid Waste

Urban Solid Waste Management in the Ho Township is far from desirable. The Both solid and liquid waste as well as human excreta and household refuse are not disposed off properly in the municipality. Some households use open surface system and drains for their waste disposal due to lack of refuse bins (HMA 2009).

The main issues that affect the municipality is the lack of safe way of disposing waste. This issue is however more critical in the rural areas as compared to the urban areas as evidenced by rampant cases of open defecation. (CLTS 2015)

The situation in the municipality is anticipated to improve however due to the intervention of the Ghana Urban Management Pilot Programme under which a central market, an abattoir with an anaerobic digester and landfill are being constructed. After completion, these facilities would go a long way to effectively help with organic solid waste disposal in the municipality (GUMPP 2015).

Waste is often disposed of in the open streets and surroundings. The lack of refuse bins cause the random disposal of waste to streets and gutters in the city centre whch is more severe in the market area and lorry station (Siri 2010).

A final waste disposal site for solid waste has been a major problem over the years for the Ho Municipality. The original disposal site at a time was no longer accessible due to a conflict between the land owners and the Municipal Assembly. Now waste generated in the Ho Municipality is transported to a site about an hour drive (7km) away from Ho. All the solid waste is collected in skip containers and emptied at the final disposal site when full. The final disposal site is unfortunately not managed (Perttola & Juvén 2011).

Moreover, the disposal site has no foundation constructed and there has been no compression of the soil underneath making it a major risk of groundwater pollution. This clearly shows a lack of management or maintenance of this site and makes it both health and environmental hazard. It is also common to see scavengers feeding of the waste therefore contributing to the spread of diseases. The uncovered site contributes the releasing of greenhouse gas, methane and CO_2 into the surrounding air (Siri 2010).

37.8 percent of households use the public dump (container) for solid waste disposal; 29.0 percent use public dump (open space) and; 4.4 percent of households dump indiscriminately the solid waste generated. The rural–urban distribution shows that 57.8 percent of urban households use the public dump (container) while 61.3 percent rural households use the public dump (open space) to dispose of rubbish waste. In all, only 6.8 percent of households in the Municipality enjoy the services of waste collection from their homes (Ghana Statistical Service 2014).

1.2.2 Sewage and Waste Water

It is a general practice for people to defecate in the bush (free range), mainly due to lack of access to convenient toilet facilities. Where toilet facilities are provided either by households or the Assembly, there is a problem of timely and regular disposal of human excreta due to the unreliability of the only septic emptier in the municipality (HMA 2009).

According to Municipal Environmental Sanitation Strategy and Action Plan (MESSAP) only 22.4% of the households have a toilet facility. The total number of public latrines in Ho Municipality is 338, 76% of them being pit latrines. The low level of both private and public toilet facilities is an indication of the fact that people still practice open defecation. The three main toilet facilities used in the households are WC (67%), KVIP (16.4%) and VIP (9%) latrines (Ho Municipal Assembly 2012). The proportion of households that use public toilet stands at 31.5 percent (Ghana Statistical Service 2010). In the absence of in-house toilet facilities, the tendency across Ghana is the increasing use of public toilet facilities and other shared facilities.

Less than 2.6 percent of households dispose liquid waste through the sewerage system. Over one-third of households (37.2%) dispose of liquid waste by throwing it onto their compound with 56.3 percent households in rural localities and 25.9 percent of urban localities using this method. About a quarter (24.3%) of households too throw liquid waste onto streets / outside (28.9% rural, 21.5% urban) (Ghana Statistical Service 2014).

There is neither a centralized sewerage system nor a wastewater treatment plant in the municipality. Per the estimation of Municipal Water and Sanitation Team of HMA the current sanitation coverage of the municipality is 46%, which corresponds to the population of the municipality without access to a hygienic waste disposal system.

A pond for the disposal of sludge from septic tanks (now non-functional) exists on the final disposal site for solid waste described above. The disposal site originally meant for the disposal of only sludge but has been used for the disposal of solid waste as well. The sludge ponds are not big enough there is no space for further expansion. The situation is even worse everytime it rains due to heaps of solid waste overflowing. This posses a serious hazard to a There is a small stream close to the disposal site. Leakages from waste piles and ponds end up in this stream which serves as a source of water to inhabitants (Nadkarni 2004; Jarvela 2012).

1.2.3 Waste Sorting and Recycling

In Ho Municipality, as well as in a big part of Ghana, no waste sorting is done at households, public buildings or public areas. Mixed waste fractions are disposed in refuse bins, containers and subsequently at the final disposal site (Viitanen and Lappi 2012).

However, metal is generally recycled in the Municipality. For instance, per Viitanen and Lappi (2012) metal dealers buy old fridges, break them down to take out the metal components. The unfortunate thing, however, is that the left-over materials are taken to the community dump. Small scales reclaiming at dump sites has been common. Scrap metal is also collected by private people who sell them to a recycling company which in turn sells to interested buyers. Glass bottles are collected for washing and reuse by shops. Saw dust which is waste produced from the wood industry is utilised for instance in poultry farms (Siri 2010; Viitanen and Lappi 2012).

1.3 Identifying key barriers to economic development in Ho

1.3.1 Energy Shortages

The Ghanaian energy sector has been in a period of transition. Energy demand has been outstripping supply and this deficit has led to an energy crisis in the country (Eshun and Amoako-Tuffour, 2016). These issues affect the energy supply nationally, in Ho Municipality as in all other parts of Ghana as well.

About 88 per cent of gas demand in Ghana is from the power sector mainly through the West African Gas Pipeline (WAGP) from neighboring Nigeria. Ghana has however struggled to constantly get the contractually mandated quantity of gas from the plant. Supply at best has been limited to less than half of the quantity, thus preventing the thermal plants from being efficiently run. Ghana was initially meant to consume about 90 per cent of the gas but this has been reduced as Nigeria prioritizes utilizing her gas to generate electricity to drive her domestic industrialization agenda over regional integration needs (GGDP 2015).

The inadequate supply of gas has necessitated the use light cycle oil by the government to generate power which is typically at a much higher cost than gas-fired generation. The government, however, has not had the funding to buy light cycle oil to run these thermal plants either. The unavailability of gas and light crude oil to run the thermal plants has also further increased the shortage of power (GGDP 2015).

The supply of power has further been reduced by the low level of water in the reservoirs feeding the hydro plants. Below average rainfall over the past three years has reduced the water level in the Volta Lake, which in turn has reduced the water level in the Volta reservoir that feeds the Akosombo hydro station. The shortage of water has resulted in only a 60% reservoir yield at Akosombo and Kpong (GGDP 2015).

Another factor affecting the power crises is the Poor Infrastructure Planning, Maintenance and Lack of System Redundancy. The situation has been worsened by the lack of maintenance and retrofit upgrades.

Serious concerns had been raised about the underperformance of VRA's thermal plants at Takoradi and Tema; that the plants are not performing well; and that they cannot operate at full capacity on a sustained basis. Moreover, the performance of the VRA plants at Takoradi did not meet international benchmark tests for reliability, though some improvements had been made in 2009-2010 (World Bank 2014).

2.3.2 Fertiliser Supply Problems

Agriculture is the principal supply of livelihood in the Ho Municipality. About 70 percentage of the active labour force is employed in this sector. Approximately each family in the Municipality is engaged in farming or an agricultural activity. Despite its importance in the Municipality's economy, plenty of the agricultural potentials in the Municipality continue to be unutilised. For instance, out of 62,261 hectares of arable land, solely 23,167.6 hectares is currently being utilised (MoFA 2013; HMA 2014).

The need of fertilisers for improvement for higher crop yields has therefore become a necessity. Timely availability, ability to purchase and adequate usage of chemical fertilisers raises very serious challenges in Ho Municipality. Currently, the imported fertilisers first arrive to the capital Accra, where they are distributed to the rest of the country, mainly in the second-largest city, Kumasi. Volta region in the fertiliser journey from the supplier to the dealer is an average of 130 kilometers which takes about 3 hours due to very appalling road conditions (Krausova & Banful 2010).

Subsequently this directly affects the Ho Municipality which is also the capital of the Volta Region. This accounts in part for the general low yields of crops leading to low incomes for majority of farming households explaining in part the widespread poverty and poor health in the area.

1.3.2 Local Employment

The majority of the residents in Ho work in the informal sector. Most of the residents are self-employed persons and households engaged in micro- and small scale enterprises, typically involving 1-5 persons. The major economic activities are trading specifically petty trading, subsistence farming, small scale manufacturing which consists of batik, tie and dye making, meals processing, development and public service. The monetary returns from these activities are very low thereby making a vast proportion of the city dwellers stay below the poverty line

As noted earlier, the developing nature of the town has induced an equal upsurge of financial activities (i.e. shopping for and selling). It is now a frequent characteristic to see humans selling along the street facet and any reachable area agents can get (UN- Habitat 2009).

The industrial sector is not developed as there are no large industries in the Municipality. The commercial region is dominated by activities in the retail outlets. Additionally, the municipality has a few small-scale industries. These include cassava flour processing, mushroom growing, bee keeping, gari production, soap making, batik tie and dye making, carpentry and metal work (HMA 2014).

1.4 Key development priorities in Ho

As part of the Medium-Term Development Plan for 2014 to 2017 the Municipal Assembly plans to address the following pertaining issues described in sections 2.4.1-2.4.6.

1.4.1 Improvement and Sustenance of Macroeconomic Stability

The District Assemblies' Common Fund (DACF) is a resource pool set aside set aside by the Central Government for District Assemblies in Ghana. However, over dependence on the District Assembly Common Fund and other grants prevents the implementation of development projects in the Assembly especially in cases of delay.

Another issue the MTDP seeks to address is the poor revenue mobilization. Most assemblies have inadequate revenue base and no matter the modalities put in place they cannot collect enough revenue, and even those with huge revenue base have not been able to improve local revenue generation (Baffour-Awuah, 2014). To compound matters a poor access to credit facilities makes it difficult for the Municipal Assembly to carry out any projects which the assembly seeks to address (HMA 2014).

1.4.2 Enhancing the Municipal Private Sector

The need of enhancing the private sector of the Ho Municipality has been necessitated since the implementation in the development goals of the Assembly is not enough to tackle the issues affecting it. As a matter of fact, the Assembly is may be powerless to tackle some of these issues due to certain technical challenges. These challenges which exist include the following:

- Poor access to roads networks
- Inadequate grid electricity network leading to power cuts
- Inadequate distribution of potable water
- Inadequate export promotion support and services
- Inadequate market information (HMA 2014).

1.4.3 Agriculture Modernization and Natural Resource Management

One of the issues the MTDP seeks to address is the issue of agriculture in the municipality. Unpredictable rainfall patterns hamper the agricultural productivity and output. In addition to this, factors such as low access to irrigated land makes this even more challenging to cultivate crops. In cases where there is no problem of land the problem of soil suitability lurks. The issue of fertiliser distribution to the region does not make the situation any better (Krausova & Banful 2010; HMA 2014).

Credit support from Commercial Banks as loans and advances to agriculture has been very low. Since farmers in the region are normally poor and the level of productivity is low in Ghana, the agricultural sector can grow at a faster rate only if productivity- enhancing supports are introduced for example making a provision for adequate support facilities to support agricultural production. (FAO 2005, 53) Furthermore, even when the problem of crop cultivation is alleviated other problems still exist in terms of uneven access to transportation leading to post harvest losses (HMA 2014).

The issue of Natural Resource Management is another critical one. Factors contributing to the degradation of the natural environment have seen little improvements. This is much evident with regards to the solid and liquid waste management situation in the municipality as described above in section 2.2 (HMA 2009). The problem of land degradation and deforestation also arises due to agricultural use through depletion of soil nutrients, overgrazing, irrigation and overdrafting.

1.4.4 Infrastructure and Human Settlement

Planning has the fundamental goal of creating places that are economically vibrant, environmentally sustainable, and socially inclusive. (Yeboah, Obeng-Odoom 2010.) However, these expected outcomes of planning have only been achieved in Ho to a marginal extent. There is a proliferation of uncontrolled informal structures in almost every available open space in the built-up areas.

According the MTDP (2014), there is generally a weak enforcement of building regulations of building regulations, codes and permits not just in the Ho Municipality but throughout the country. The Municipal Works Department is responsible for ensuring the enforcement of these building regulations. The MTDP seeks to address this issues equipping the

Municipal works department to spearhead and ensure strict adherence to the building regulations.

Additionally, there is the challenge of a lack of vital infrastructure to tackle sanitation problems in the Municipality. The deplorable state of sanitation in the Ho Municipality has led to the implementation of an urban management and development initiative to help tackle some of these issues. This is initiative called the Ghana Urban Management Pilot Programme is being financed by a loan agreement from the Agence Francaise de Developement. The projects comprise of the construction an abattoir with anaerobic bio-digester, an engineered landfill site and the reconstruction of the Central market. (GUMPP 2015.)

1.4.5 Human Development, Productivity and Employment

In this this thematic area, the Municipality seeks to:

- To development and invest into processing and adding value to traditional cash crops such as cassava
- Providing access to quality preschool education and improving the conditions of basic school infrastructure
- Making access to quality second cycle education and improving theoverall academic performance in schools
- Improve infrastructure for Technical and Vocational Education Training
- Improve ICT skills and knowledge at all levels
- Improve health infrastructure

- Improve sanitation in communities and provide adequate access to sanitation facilities and sanitation service delivery
- Promote domestic tourism and institutional arrangement for the development of the creative arts as an industry
- Make adequate support for victims of violence
- Reduce the level of unemployment e.g. by training and teaming the unemployed persons as well as facilitating their access to credit for self-employment. This could also be key to tackling the issue of rural urban migration. (HMA 2014)

1.4.6 Transparent And Accountable Governance

In the area of governance there is a general poor performance and functioning of the sub-divisions of zonal councils and unit committees. There is an ineffective communication between the District Assembly and the citizenry which is evidenced by a number of factors such as a low participation of local people in decision making. (Bebelleh, Nobabumah 2013)

In the municipality, the infrastructure for judiciary and other security agencies remains poor and this seeks to be addresses as well. In addition to these constraints there is no existence of an adequate database to inform decision making by the judiciary or security agencies. (HMA 2014)

2. CASE STUDIES

The following case studies demonstrate how organic waste has been utilised in pilot stage to generate bioenergy and organic fertiliser in Ghana. The case studies give a brief description of the projects, their Feedstocks and System of Feedstock Collection, Technology and Operational Model. Also, the challenges and success factors of these pilots are explored to learn lessons relevant to piloting solutions in Ho.

2.1 Co-composting of faecal sludge and organic solid waste, Kumasi, Ghana

This project was carried out to improve food production and public health through co-composting of Fecal Sludge and Organic fractions of Municipal Solid Waste. It was implemented as a pilot research led by International Water Management Institute (IWMI) in collaboration with Sandec, the Kumasi Metropolitan Assembly (KMA) and the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. The cost components covered land, drying bed construction, shed for co-composting, storage rooms; labour for waste delivery, inorganic fertiliser pulverization, sieving, bagging and transport to point of use. The funding mechanism was based on donor contribution for plant construction and some operations in-phase I (by France's Ministry of Foreign Affairs); operation costs in Phase II by National Centre of Competence in Research (NCCR) through a PhD research.

In 2009, the pilot phase was completed and project had some funding constraint. Since 2011 project resumed in other parts of Ghana and has now a catalogue Fecal Sludge based fertiliser formulations collectively called Fortifer which are being promoted through public-private-partnership as commercial fertiliser in Ghana. IWMI is now developing a guideline to handover the plant operation to the municipality (Cofie et al., 2009).

3.1.1 Feedstock and System of Feedstock Collection

Feedstock is faecal sludge (from septic tanks and unsewered public toilets) and biomass from municipal solid waste (MSW). The faecal sludge was collected from by vacuum trucks within the city of Kumasi and transported to the site (SuSanA 2009, 56).

3.1.2 Technology and Operational Model

Due to its high moisture content, the fresh fecal sludge had to be dried to decrease the water content to an optimum one suitable for co-composting. Sludge drying beds were built with a sand-gravel filter medium for drainage and the percolate was collected in a storage tank. It was then discharged into a stabilisation pond for treatment before final discharge into a nearby stream. The dried FS was removed from the drying beds once it had become spadable (roughly about 10 days) and was stored prior to co-composting (SuSanA 2009, 57-58).

The operation model targeted only fecal sludge and solid waste. The collection and transportation of excreta and solid waste to the project site was done by the KMA's Waste Management Department. The plant manager was responsible for the management and supervision of co-composting operation. The operational activities included loading and de-sludging the FS drying beds, sorting of SW, and co-composting. The maintenance activities consisted of changing the drying bed filter medium, after several months or years depending on the sand quality and when they clog. To reduce the risk of clogging, sand with no or a low amount of silt/clay should be used (obtained e.g. by washing) (SuSanA 2009, 58).

2.1.3 Evaluation

Kumasi has a population of over one million, producing 860 tons of solid waste and 500m^3 of faecal sludge (Cofie and Kone 2009). Approximately 70 per cent of the solid waste is organic and can be composted with the Faecal Sludge resulting in an end-product of nutrient-rich fertiliser and soil conditioner. A former Faecal Sludge Treatment Plant, a pond system at Buobai, was in operation during 2001-2003, but is currently no longer operational because the sedimentation ponds are full and yet to be emptied. The ecological benefits from recycling abundant amounts of city-wide organic waste include a solution to the Boubai's operational problems. The technology does not require an energy source avoiding the dependency/depletion of additional inputs and resources. (SuSanA 2009, 60).

Demonstration plots, urban farmers, and plant operators applied free compost in their fields for the trial. Researchers were then able to evaluate the yields to determine the productive gain from using natural excreta-based compost. Maize performed with remarkably higher crop yields. Per statistics from the FAO, Maize crops use the second largest area of land in Ghana for production (next to Cocoa) and are the most dominant crop in the drier North. Maize produces one of the highest quantities of cereals and fertiliser use is common practice. Amount of fertiliser used on cereal crops in Ghana vary and with increased production, fertiliser use will also increase (SuSanA 2009, 60).

All manufactured fertilisers used in Ghana are imported and imports account for 80 per cent of the needed fertilisers in country (FAO, 2005). Producing a locally based fertiliser with improved yields could have great economic gain for Kumasi.

The basic technology in Kumasi is drying Faecal Sludge on unplanted beds and composting dried Fecal Sludge and organic Solid Waste in an open windrow system. The simple construction, use and low-cost design is economically beneficial to this type of system (SuSanA 2009, 58).

Co-composted fertiliser tested acceptable for its germination capacity, is suitable for vegetable and crop production and improved yields of the tested maize crop (Cofie & Kone 2009). A survey from pilot program indicated that most farmers are willing to use this type of compost on their food crops and are aware that with proper safety measures this practice does not pose a health risk. Although a small percentage of farmers were concerned that consumers would not buy excreta-based compost, there is no evidence to prove such. Knowledge gained from the experimental site proved that co-composting performed well socially and can be an example for increasing awareness on the positive impact a large-scale treatment plant would have on public health (SuSanA 2009, 60).

Co-compost can be an alternative option to artificial fertilisers that replenish essential nutrients in the soil, offer a less-expensive market product for compost (as opposed to expensive imports), reduce dependency on external sources, increase food production and improve the local economy.

As with most waste management strategies there are implications that should be considered and could pose a negative impact to the project's success. In the case of Kumasi, Solid Waste requires manual sorting and compost is manually turned (SuSanA 2009, 60).

The combined process of Fecal Sludge drying and co-composting is labour intensive, since most of the main activities are executed by manual operation. This threatens the program's financial sustainability. Private companies are unable to pay this expense without a government subsidy to offset start-up costs. It should be noted that the business model only considered the supply side in their design and has yet to market the product for sales. External funding supported the program and when funding ceased so did the project (SuSanA 2009, 60).

Most notably, the pilot experienced social discontent when residents blocked

operations of the plant. The emotional reaction was a direct result of poor communication between the researchers and the local community, who complained they were not compensated for land used as the experimental treatment site. IWMI and KMA did meet with the local leaders and community members to resolve the conflict. The biggest challenge to the potential for scaling-up is financing the capital for investment. Secondary challenges include consumer and community acceptance, market demand and transport costs. Wider adoption at scale could take place if the product is fortified with some mineral fertiliser (SuSanA 2009, 61).

Producer groups became aware that the compost is a safe product for improving yields. They are responsible for building local awareness and gaining consent in their communities. Scientists and engineers are assigned with training project assistants and building the technical capacity of the workers (SuSanA 2009, 61).

3.2 Faecal Sludge to Energy in Kumasi, Ghana

This projected was implemented by Waste Enterprises (WE) with collaboration from the Columbia University, USA and Kwame Nkrumah University of Science and Technology, Kumasi through funding from the Gates Foundation. Waste Enterprisers is a Ghanaian organisation that began in 2010 which links business with poverty alleviation. It focuses on urban sanitation and the protection of ecosystems by recycling and reusing human excreta to generate industrial fuel and biodiesel feedstock. The company strives to find innovative strategies to improve the sanitation sector while finding appropriate waste management solutions (Cofie and Jackson 2013)

3.2.1 Feedstock

The feedstock used was from Municipal Faecal Sludge from households, institutions and public toilets. The faecal sludge is collected by cesspit emptier trucks fed to a sludge-to-biodiesel plant (Cofie and Jackson 2013).

3.2.2 Technology and Operational Model

The operational method in this pilot study is to extract methane from sludge and chemically converts it to methanol. Isolating methane from feces is common. However, it is the biochemical conversion to methanol what is novel in this case study. This entails collecting fecal sludge (i.e. the contents of pit latrines and septic tanks), processing it into a pelletized fuel fit for boilers and kilns, and selling the fuel to industrial clients.

Faecal sludge was dried in drying beds. Wet Faecal Sludge was poured into the partitioned beds at three different depths: 6, 8 and 10 cm. One of the sections also contained faecal sludge that had been dosed with polymer (a flocculating agent) before being poured into the drying bed at a depth of 6 cm. Once faecal sludge was poured into the partitioned drying bed, samples were taken daily to measure changes in total solids content. The samples were dried in a laboratory oven at KNUST. Total solids content of each sample was recorded before and after oven drying (Cofie and Jackson 2013).

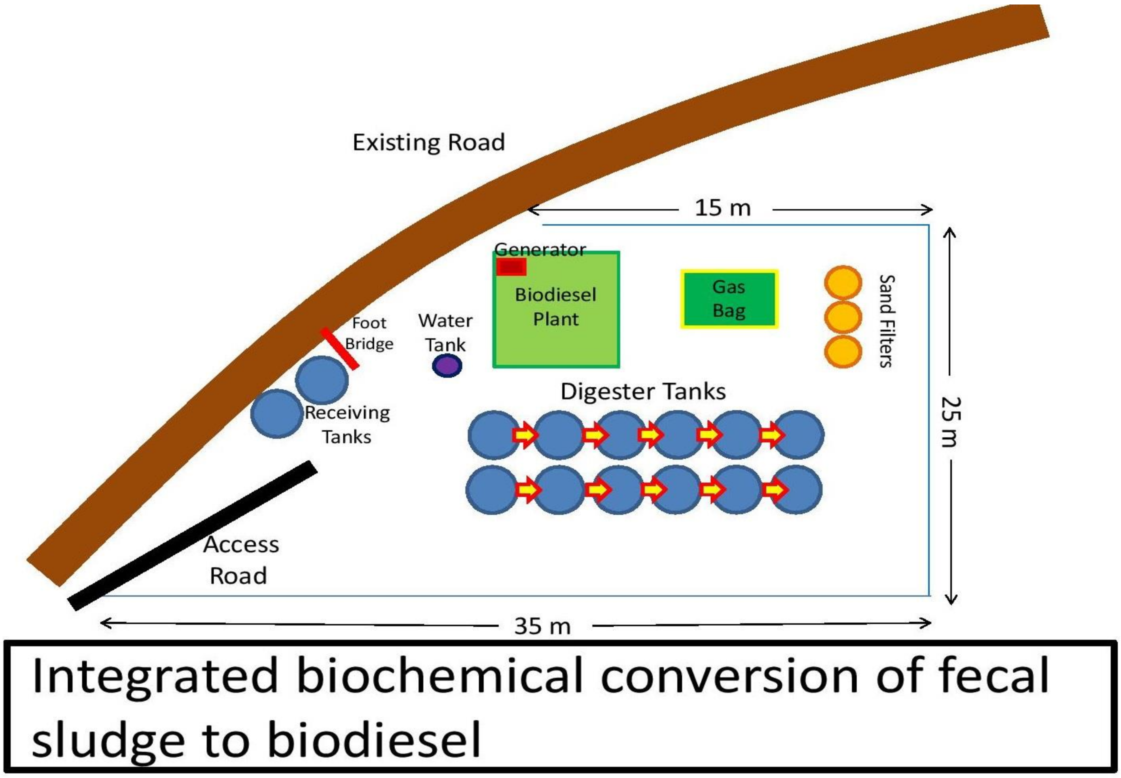

Figure 2: Layout of faecal sludge to biodiesel plant (Cofie and Jackson 2013)

3.2.3 Evaluation

The project established a business model by considering human waste as a commodity and sourcing it for economic gain. Critical to this strategy was the financial incentive which transforms faecal sludge to a commodity. The benefit is a low-cost system that pays for itself and even produces its own energy. It solves the problem of polluting waterways and dumping waste into landfills.

The social impact benefits the community from a cleaner safer environment perspective (Cofie and Jackson 2013).

A major factor that limits the faecal sludge to biodiesel fuel plants from becoming widespread is that conventional wastewater treatment plants continue to develop in urban cities (Cofie and Jackson 2013). It can be determined that alternative methods would face additional challenges for gaining support while local bodies continue to invest in traditional systems.

3.3 Compost, biogas and biochar in Northern Ghana

Organic waste could be utilised into a resource in the Tamale area which has problems with soil fertility and energy shortage. A research was therefore carried out to determine whether organic waste can become a resource in Tamale. This research focuses on three forms of recycling of organic waste that can be put in place to extract nutrients, energy and carbon to improve soil properties: composting, anaerobic digestion and biochar production (Galgani, 2012).

3.3.1 Feedstock

Feedstock consists of

- Biomass from MSW
- Locally sourced material i.e. Leaves, straw, food leftovers
- Industrial organic and agricultural waste flows
- Organic waste (rice husks from local rice mill) (Galgani 2012,19-20)

3.3.2 Technology and Operational Model

In the compost scenario, the organic fractions of Municipal Solid Waste are composted with other locally sourced organic waste. The compost is mixed with poultry manure to increase its nitrogen content and sold as organic fertiliser to farmers in the surrounding districts. The technology of windrow composting was selected because it does not require use of complex machinery. In windrow composting biomass is heaped into 1.5 m heights. The heaps are periodically turned, about 6-7 times during the process and lasts for about 2 months. For optimal moisture content water is added (Galgani 2012, 19).

Biowaste is used for producing biogas in anaerobic digestion. The by-product is then composted in windrows and sold as fertiliser. Electricity is produced on site and fed into the grid. A low cost dry fermentation reactor designed and realized within an ETH Zurich project at the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi, Ghana is used.

The choice of this technology is due to the fact that its cost is relatively low compared to other anaerobic digestion technologies used in developing countries (Burri and Martius 2011). Furthermore, in dry fermentation the digestion residue is solid. This means that the digestate can be processed with windrow composting, while normally the residue from anaerobic digestion is liquid and cannot be further treated aerobically (Galgani 2012, 19).

The reactor is a delivery vessel fitted with a water system where water is pumped from a tank, streams down from the roof and is gathered again on the bottom1 (Figure 2). Methane produced inside the digester can be gathered and fuel a power generator. One digester can prepare around 6 tons for every group, which takes 28 days to finish (Burri and Martius 2011).

A pyrolysis system produces biochar from the waste of the local rice mill. Rice husks are charred on site and its yield is 25% by weight. The system is thought to be a straightforward reactor where rice husks are stacked and after that combusted without oxygen. Syngas, a blend of methane, carbon monoxide and other gases, is shaped in a pyrolysis response. Here it is thought to be recycled into the broiler to fuel the ignition response. Biochar is then produced from this process. (Galgani 2012)

These technologies, however, can in fact be combined, as the residue from anaerobic digestion can be composted and used together with biochar to improve its properties. (Galgani 2012, 20)

2.3.3 Evaluation

Utilizing organic waste in Tamale through composting, pyrolysis and anaerobic digestion can bring reduce methane emissions from the landfill by producing organic fertiliser and bioenergy from the organic waste normally decomposing in landfills. (Galgani 2012, 34).

With regards to three technologies anaerobic digestion was found to have the best financial execution, when combined with composting. Biochar production was however realized to be the least effective solution especially without access to external subsidies.

4. FINNISH APPROACHES AND TECHNOLOGIES

A local example of a circular economy model in the Lahti region is discussed here to provide some insight into the potential of turning biowaste into energy and fertilisers on a city-scale. The Kujala Waste Centre is owned by twelve municipalities as shown in the figure below. Lahti, however, owns a majority stake (51.5%). This waste centre was established in 1993 and services about 202,000 inhabitants in the municipalities as shown in Figure 3 below. It takes waste from communities and production facilities for handling, storage, recycling and recovery, transfer and final disposal. The site consists of 70 hectares in total. Approximately 5.3 ha receives and stores recyclable waste. 2 hectares are allocated for the treatment of contaminated soil, 5 ha for composting with 8.3 hectares of landfill in use and 23 hetares of decommissioned landfill. The Centre receives approximately 200,000 tonnes of waste each year (PHJ 2014).

Figure 3: Municipalities owning the Kujala Waste Centre (PHJ 2014)

4.1 Waste Sorting

The Kujala Waste Centre 100 000 apartments + 16 000 cottages or summer homes. In the Lahti region, multi-unit dwellings with at least 10 apartments are obliged per municipal waste management regulations to have seven sorting bins:

- Biowaste
- Energy waste
- Mixed waste
- Paper
- Cardboard
- Metal

- Glass (PHJ 2014)

Detached houses and small properties with less than 10 apartments as well as leisure homes are obliged according to municipal waste regulations to have two waste sorting bins:

- Mixed waste
- Energy waste
- (Paper: apartments with at least three apartments) (PHJ 2014)

For the biowaste generated, composting is recommended on such properties, preferably in the backyard. Glass and metal packaging are to be taken to nearby a recycling point (eco-point) (PHJ 2014).

The Eco Points are intended for the following household waste only: Dry paper, without extra dirt, Rinsed tins, lids, bottle caps, Glass objects; jars, bottles etc. Cartons of milk, sourmilk etc.). They are located near markets or other public services in most cases.

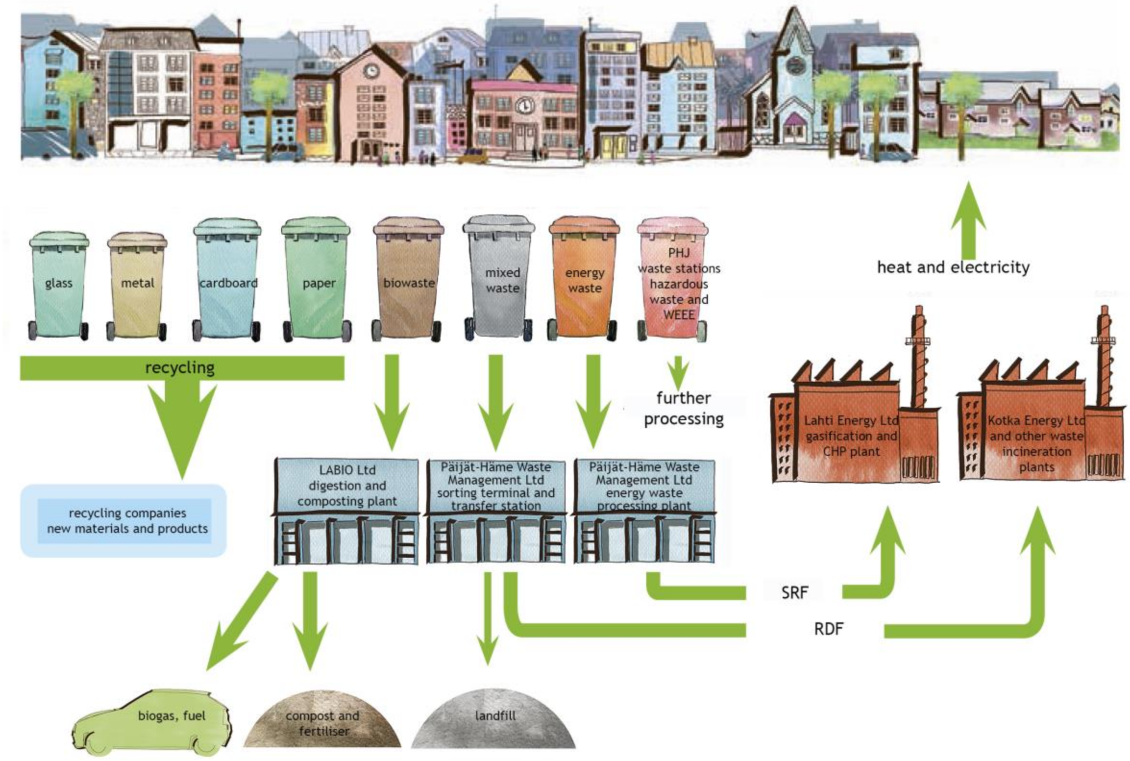

Figure 4: The municipal waste sorting system in the Lahti region (PHJ 2014)

4.2 Kujala Industrial Symbiosis

Thanks to an effective sorting system at-source, PHJ is enable to practise material recycling and energy recovery. In addition, PHJ's landfill gas is harnessed for energy by Lahti Energia and circulated directly to PHJ's premises and Hartwall (a nearby beverage producer) (FISS 2015).

The company also collects energy waste and processes it into into a strong recouped fuel comprising of wood and household waste for use at the adjacent Kymijärvi gasification plant, which produces energy (heat and electricity) for the Lahti area (PHJ 2014).

The organic waste fraction is treated in a biogas and composting facility in Labio (a biogas production and refining plant) as shown in the figure below. The biogas generated is transported via pipes to Gasum which is a natural gas and biogas operator for upgrading and distribution (PHJ 2014). The digestate is then forwarded for recycling to Kekkilä Oy. This company specialised in developing and manufacturing high-end growing mediums, plant fertilisers and mulches (Kekkilä 2016).

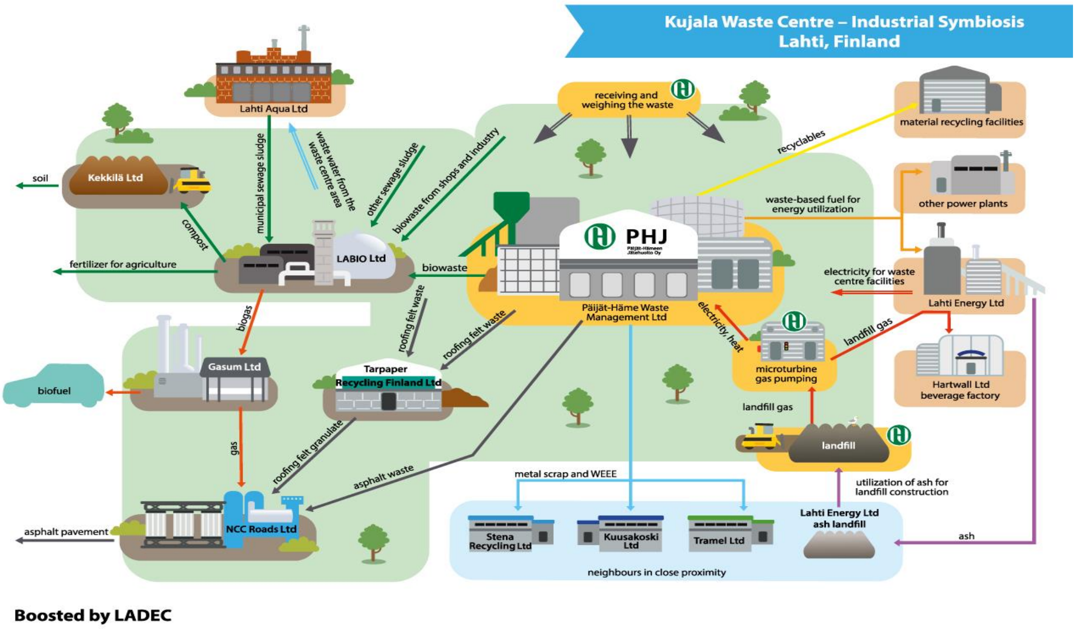

Figure 5: Kujala Industrial Symbiosis (PHJ, 2014)

Waste water from the waste centre from Labio Oy is sent to Lahti Aqua for treatment, whereas municipal sewage sludge (from Lahti Aqua) is utilised for biogas production.

Additionally, wood waste and stumps are turned into chips and sold for energy generation or as support material for compost. Concrete and bricks are crushed and used for landscaping. Excavation soil is used for covering the landfill site. Metals and glass containers received at Kujala, local recycling points and waste reception stations are stored temporarily before being transferred for materials recovery (PHJ 2014).

4.3 Lessons learnt from the Finnish case

- Waste sorting starts from the kitchen
- Waste services are in easy reach
- Education and guidance is necessary to make the system work
- Waste materials have value
- Continuous development and innovation is necessary
- Municipality has a strong role but partners with the private sector to further strengthen and boost the regional economy

5. MARKET ANALYSIS

5.1 Political Factors

5.1.1 Political structure and institutions of political power

The political structure in Ghana has three divisions namely, the executive, the legislative and the judiciary. While the executive power of control is vested in the government with the president as the Head of state. The legislative performs the administrative functions of the government and consists of the parliament. The judiciary is functions exclusively of the executive and legisaltive. Thus, power is shared between the president, vice president, ministers of state, the council of state which form the executive, the independent judiciary and the unicameral parliament (legislative) (Electoral Commission of Ghana 2008).

5.1.2 The Ho Municipal Assembly Administration

The Ho Municipal Assembly is headed by the Municipal Chief Executive as the direct representative of the President of the Republic. It is made up of a total of 43 members, consisting 29 elected Assembly Members, 14 government appointees, 1 Member of Parliament and the Municipal Chief Executive of the Assembly. The Assembly additionally has few sub-departments performing under different capacities. They comprise of Social Services, Development Planning, Town and Country Planning, Works, Finance and Administration, Water and Sanitation, tourism, Agriculture and Environmental Health among others. (HMA 2015).

Inferable from absence of office space, a large portion of the Decentralized Departments are scattered from the Coordinating Directorate and this makes coordination troublesome. The poor city regulatory set influences the administration of the city considering development and urbanization inclines in Ho. The suggestion is that decisions take time to be made as it is usually centralized at the central government and poses a great challenge to development projects in the municipality (Commonfund 2015).

5.1.3 Traditional Administration

Traditionally, chiefs are the main custodians of stool lands, beliefs and customs in the Municipality. They are also the symbol of authority in the Municipality. The Ho township is made up of five main divisions namely Bankoe, Ahoe, Dome, Hliha and Heve. Each of which is administered by a divisional chief who is assisted by his council of elders (Asoglistate 2015).

5.1.4 Role of Non-governmental (NGOs) and other support organizations

NGOs are formed autonomously of the State yet enroll willfully under determined laws with a specific end goal to obtain official acknowledgment to seek after purposes that are not for profit but rather arranged towards public beneficiary (Consortium, 2016). There are distinctive sorts of NGOs, grouped by zone (global, national or local) or by core activities carried out for example, compassionate, Human rights, instructive, ecological, ladies, Children, youth, peace, and so forth).

Apparently, Non-Governmental Organizations (NGOs) have existed from the mid nineteenth century, and was later given acknowledgment by the United Nations (UN) by in 1968. The foundation of NGOs got to be conspicuous after the Second World War, likely because of outrageous need to increase the exertion of the separate governments in giving key help to individuals. From that time on, the rate at which global NGOs are been set up has expanded, numbering around 90 consistently (NGO Handbook 2008).

5.1.5 Political stability

Ghana has a decent notoriety as far as political dependability for the most part because of solid adherence to law based standards and regard for human rights. Even though, democracy does not ensure political soundness (Boafo-Arthur 2008), it exhibits a firm reason for political security to flourish.

That is not to imply that Ghana is a flat-out place of refuge as far as conflicts are concerned. There are instances of ethnic and chieftaincy debate in a few sections of Ghana which has a long history to the extent the 1960s or prior, a case is the Yendi chieftaincy conflicts (Ladouceur 1972), and other ethnic conflicts in northern Ghana (Longi, Mahama 2013, 112).

Ghana has good relations with countries in Africa and the rest of the world through different arrangements, be it economic, political, development and business partnerships, and other relationships. However, Ghana's international relations is guided by the foreign policy which is further guided by the "Pan-Africanism" and the "nonalignment policy" advocated by Dr.

Kwame Nkrumah in the 1960s. (Berry V.L 1994).

Ghana is part of the Economic Community of West African states (ECOWAS) in West Africa and African Union (AU) in the more extensive African context. Ghana unequivocally promotes cooperating to accomplish the set goals of the New Partnership for Africa Development (NEPAD) program set forward by the African Union (AU) (Commonwealth Business Council 2013).

The participation of Ghana in associations is not restricted to Africa, but rather other global associations. A portion of the significant ones are the Commonwealth of Nations, International Bank for Reconstruction and improvement (IBRD), International Criminal court (ICC), International Criminal Police Organization (Interpol), and United Nations (UN), United Nations Conference on Trade and Development (UNCTAD), and World Trade Organization (WTO) (Worldbank 2012).

5.2 Legal Factors

5.2.1 Environmental Policies

Environmental Policies Ghana has strategies and different directions for ensuring nature conservation. The Environmental Protection Agency Act 490 and the Environment Assessment regulationl, LI 1652 established the Environmental Protection Agency (EPA) in 1994. The objective of the EPA is to strategize preventive methods to deal with environmental issues or if nothing else diminish it to the barest least. Along these lines, any business element (requiring physical premises) that will be built up in Ghana must be evaluated by the EPA with and issued a permit before the initiation of business operation. The kind of evaluation would rely on upon the sort of business, the area and the expected size of business operation (Wilson 2004).

The EPA has a refinement program which welcomes non-environmental specialists to be taught on environmental issues, what constitutes environmental offenses, and comprehension of the best possible methods for managing the environment (Wilson 2004, 3-4).

Additinally, Ghana is part of many environmental agreements. Some of which are Environmental change, Climate Change-Kyoto convention, Desertification, Endangered species, Tropical Timber 83, Tropical Timber 94, Hazardous squanders, law of the ocean, ozone layer Protection and so on. (CIA-Ghana 2012). All these universal assentions possess stipulated envirnmental directions that part nations must follow, which incorporates Ghana.

Ventures Requiring Registration and Environment Permit Utilities

a) Establishment of waste disposal sites;
b) Establishment of collection and disposal facilities for
    i. Toxic and hazardous waste
    ii. Municipal Solid Waste
    iii. Municipal Sewage (EPA, 1999)

5.2.2 Renewable Energy Act, 2011 (Act 832)

The first legal framework condition for renewable energies has been established, when the Parliament of Ghana has enacted the Renewable Energy Act in December 2011. Its goal is to increase the share of renewable energy technologies in the total energy mix and achieve 10% contribution in electricity generation by 2020. The objective of the Act is to support the participation of private sector in the electricity sub-sector and to allow independent power producers access to the grid (PURC 2015).

Table 1: Feed-In Tariffs for Electricity generated from renewable energy sources (PURC 2015)

Renewable Energy Technology	**FIT effective 1st September 2013 GHp/ kWh**
Wind	32.1085
Solar	40.2100
Hydro ≤ 10 MW	26.5574
Hydro 10 MW > ≤ 100 MW	22.7436
Landfill Gas, Sewage Gas and Biomass	31.4696

5.2.3 Legal, institutional and communal settings for composting

Legal, institutional and communal factors affect the set-up and sustainable management of compost stations. The legal, institutional and administrative context within which composting and the use of compost could be feasible concerns the environmental and sanitation by-laws and policies as well as public awareness and the roles and perceptions of authorities and other interest groups, especially CBOs and NGOs in composting. Various stakeholder institutions could play the role of regulator, manager, supporter of initiatives or beneficiary. Through stakeholder analysis and role clustering, it is possible to identify which institutions play a central role or a secondary role (See Figure 6).

These institutions in two or more role clusters also play an important role inter-linking other institutions. The Ministry of Local Government and Rural Development is responsible for the ten Regional Administrations in Ghana. Each region has a Regional Coordinating Council and is sub-divided into Metropolitan, Municipal and District Assemblies (MMDAs) (Owusu 2005).

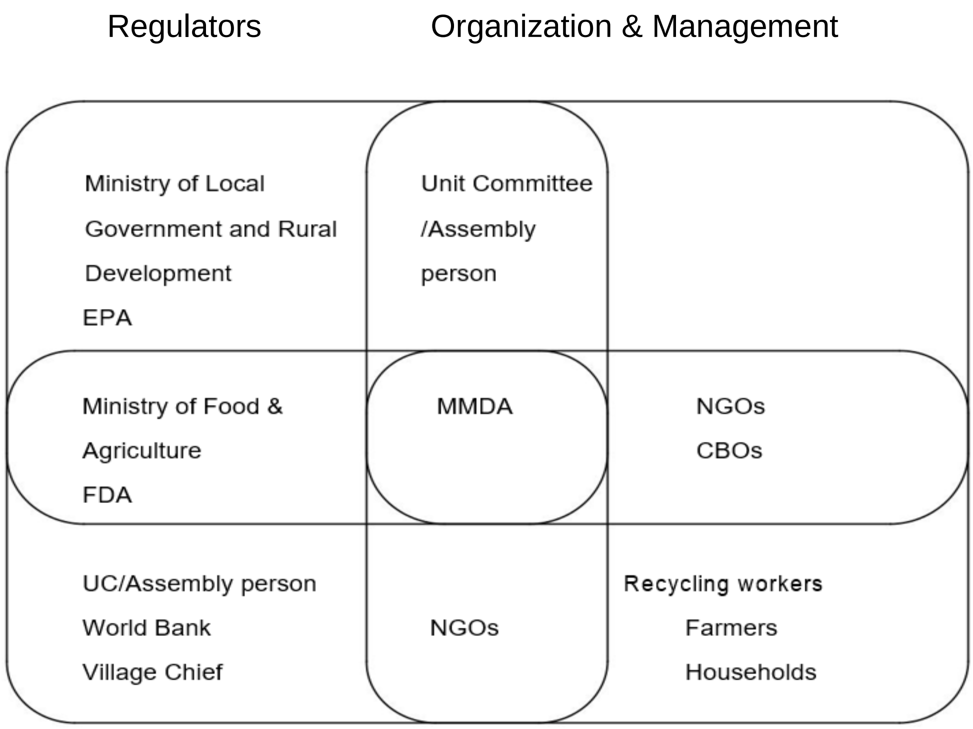

Figure 6: Institutional Platform for recycling of organic waste in Ghana

The Ministry of Food and Agriculture comes into play because it is charged with the development and growth of agriculture, including fisheries, in the country except for the cocoa, coffee and forestry sector. Its primary roles are the formulation of appropriate agricultural policies, planning and coordination, monitoring and evaluation within the overall national economic development hence its role as a regulator for composting. The Food and Drugs Authority (FDA) ofThe Ministry of Health has the responsibility regulating, monitoring and evaluation of by-products of the compost (MoFA 2015).

5.2.4 Business/trade regulations

Regulatory bodies that make sure organizations act lawfully. Depending on a particular industry where a firm or investor wants to operate, there are specific authorities responsible for activities of businesses. The Ministry of Trade and Industry is the highest authority in terms of trade, industry and Private sector investment issues in Ghana. This ministry is also responsible for advising the government on policies concerning the growth, development and participation of private sector in certain areas of the economy (Ministry of Trade and Industry 2010).

The Ministry of Foreign Affairs and Regional integration plays a very important role to help create an enabling environment for foreign investors in Ghana. Additionally, it also helps create cordial relationships between

Ghana and external Governments (Ministry of Foreign Affairs and Regional Integration 2012).

The Ghana Investment Promotion Center (GIPC) likewise gives helpful information to potential investors with respect to what openings exist and how the entire procedure can begin and direction on how it should be possible most adequately and proficiently.

Other organisations that help or play out certain key capacities regarding interest in Ghana. They are Ghana Export Promotion and the Ghana National Chamber of commerce (Ghana Investment Promotion Centre 2012).

5.3 Feedstock and Environment

The tables below form the basis of the Categorization of Organic Waste for this study.

Table 2: Categorization of Organic Waste suitable for composting (NSW Department of Environment and Conservation, 2004)

<table>
<tr><th colspan="4">Typical General Waste</th></tr>
<tr><th>Suitable for Composting</th><th colspan="3">Not Suitable for Composting</th></tr>
<tr><th>Biodegradable materials</th><th>Hazardous material</th><th>Residues</th><th>Recyclables</th></tr>
<tr><td>Garden Waste
- Grass; leaves; plants; cuttings; branches; tree trunks and</td>
<td rowspan="4">- cleaning products
- automotive products
- Pesticides
- healthcare risk waste
- expired medicines
- batteries
- treated timber
- chemicals
- inflammable products</td>
<td rowspan="4">- soiled polyethylene
- Bones
- Painted woods</td>
<td rowspan="4">- glass
- metal
- aluminum
- paper
- plastics
- cardboard</td></tr>
<tr><td>Food Waste
- Vegetables;
- fruit and seeds
- processing sludge and wastes;
- winery, brewery and distillery wastes;</td></tr>
<tr><td>Wood Waste
- Untreated timber Sawdust
- shavings
- timber offcuts
- crates
- pallets</td></tr>
<tr><td>Others
- Bio solids and manures
- Mulch
- seed hulls/husks
- straw
- bagasse and other natural organic fibrous organics
- paper-processing sludge</td></tr>
<tr><td>Composting Process</td><td colspan="2">Transport to Landfill site</td><td>Sell to Recycling Industry</td></tr>
</table>

Refer to Appendix 2 for further categorization of Organic Wastes and their Environmental Impacts

Organic Waste that has a higher potential impact (Category 3 or the like), that may be co-composted or co-treated with general organic wastes, include the following:

Animal carcasses: This category of organic wastes may include abattoir waste, animal carcasses, marine animal carcasses (seals, whales, etc.) (Department of Environment and Conservation 2004).

Alien vegetation: This category may include alien trees, shrubs, roots and seeds, water plants such as hyacinths, sea-weed, etc. Some plant species require the high temperatures that veld fires produce in order to trigger the germination process. This also results in significant amounts of pollutants being released into the atmosphere, as well as 'heat patches' being produced which result in rapid infestation of alien vegetation. Therefore, this burning may promote the germination of alien invasive seeds which have just been cut, thus promoting the consideration of composting as an alternative (Department of Environment and Conservation 2004).

Sewage Sludge: Sewage sludge is considered to be organic waste, but this material must meet the requirements for total metal and inorganic content as prescribed in the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (No. 49 of 1996). Composting of sewage sludge furthermore needs to meet the requirements as stipulated in the "Guidelines for Utilisation and Disposal of Wastewater Sludge"

(WRC Report No. TT 261/06) (Department of Environment and Conservation 2004).

5.4 Technical Feasibility

This section deals with the technologies possible for resource recovery from waste. Several technologies are commercially available for energy recovery from waste, such as incineration, biochemical conversion (e.g. anaerobic digestion), which can bring other additional benefits (e.g. fertiliser from anaerobic digestion) and LFG collection. The figure below shows viable pathways for resource recovery from waste (Trois and Jagath 2011, 2520–2531).

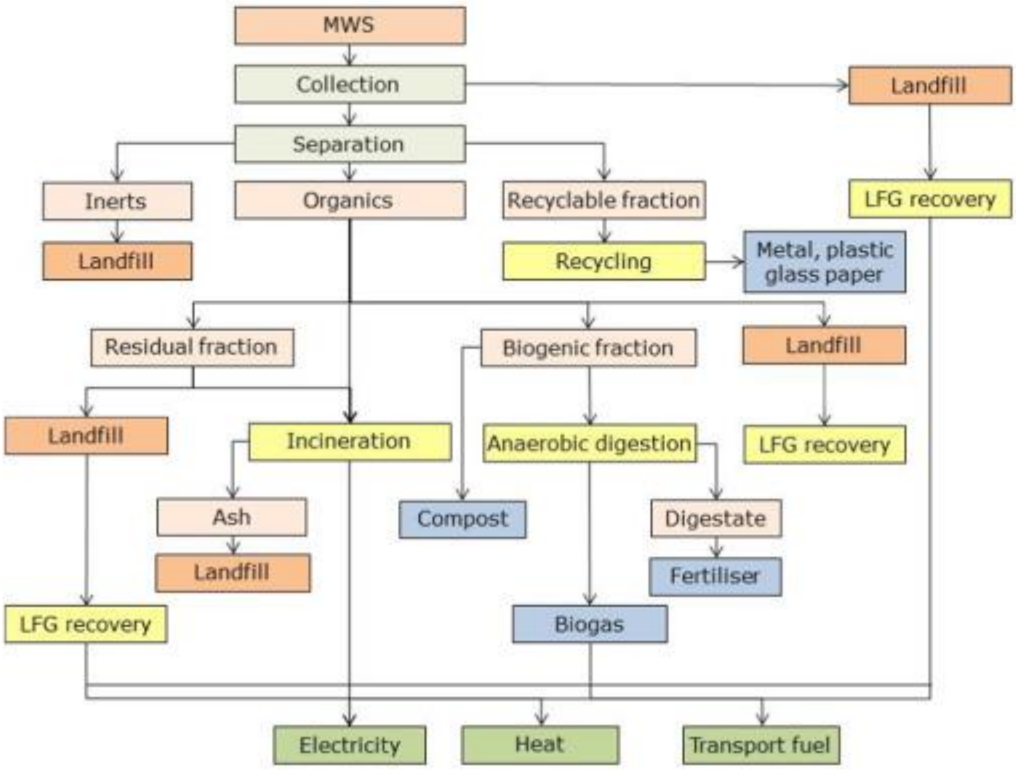

Figure 7: Pathways for resource recovery from waste (Trois, Jagath, 2011)

5.4.1 Incineration Plants

The most commonly known waste to energy (WtE) facilities are incineration plants. Incineration plants burn waste that is combustible at high temperatures in the range of 1000 degrees Celsius to reduce the waste to ashes. The benefits of these include the treatment or processing of the trash to make it non-hazardous, non-infectious and less harmful to humans and the environment and reducing the total waste volume requiring final disposal, thereby reducing the amount of land needed for landfills (Minnesota Resource Recovery Association, 2011).

Waste incineration is common practice in the developed countries (EU, US, Japan) where waste-related policies limit waste disposal on land. Even using waste minimisation, recycling and recovery practices as it is the case in the EU or US, some non-recoverable waste will remain, making landfills necessary. (UN-HABITAT 2010; UNEP 2013).

Recovering the energy embedded in waste is considered preferable to landfilling assuming emission control is adequately addressed. Open burning of waste is particularly discouraged due to harmful emissions and severe air pollution. (UN-HABITAT 2010; UNEP 2013).

In a developing country like Ghana, the high capital and maintenance and operation costs of waste incineration plants have prevented the large-scale application of this technology as an energy recovery option, making it an option even less attractive (UN HABITAT 2010; UNEP 2013).

Moreover, the highly variable composition and high moisture content of waste make continuous and optimal plant operation difficult to achieve, requiring additional fuel support as well. Without proper controls, waste incineration can be highly polluting, generating harmful emissions, such as dioxins and heavy metals (Scarlat et al 2015,1269-1286).

5.4.2 Landfilling

Landfilling offers a simpler and more affordable solution and has been the common practice for a long time, but poses significant challenges in the Ghanaian context. Although landfilling of waste should be avoided as far as possible, this practice will continue especially in Ghana due to financial reasons. Proper landfilling, in modern sanitary landfills, is also often lacking due to complex logistics, the lack of financial capabilities and technical know-how, coupled with poor environmental policies. Building sanitary landfills with leachate and gas recovery may be too expensive for most Ghanaian cities (UNEP 2013). The few existing sanitary landfills are limited to major cities (Achankeng, 2003).

5.4.3 Landfill Gas Capture and Flaring

When wastes on landfills undergo the process of anaerobic digestion, gases will be emitted. The released biogas or landfill gas is composed of approximately 50% carbon dioxide, 50% methane and trace amounts of other gases. To prevent these GHGs to be emitted to the atmosphere, the landfills must be properly closed to combust the gas by oxidation, as air contains 21% of oxygen. The disposal site can easily be tapped with a plastic foil. Closed sites without a methane gas recovery project usually cover the landfill with a substantial soil layer, so that the methane emissions can be consumed by methanotroph bacteria that use methane as a source of carbon and energy. Three types of liners typically are used: mineral, geomembranes and composite liners. Mineral liners are made of clay, mudrocks, and soil bentonite admixtures, geomembranes are thin polyethylene layers and composite liners are a combination of a geomembrane with some form of mineral lining (Williams 2008).

There are several materials that can be used were found to be suitable. High density polyethylene (HDPE) is a tough plastic film that has the disadvantage that it can be degraded by chemicals. Flexible Membrane Liners (FML) is a single liner made of two parts, a plastic liner and compacted soil, usually clay that is often fractured and cracked. Here it has to be made sure that the soil is permeable to liquids or gases. Evapotranspiration (ET) Landfill Cover Systems use water balance components to minimise the percolation, which also costs (MIKTSE 2006).

Once a landfill is properly closed, the activity of microorganisms generating biogas during the degradation is favoured and can be extracted in chimneys from the landfill. The easiest solution to avoid the release of dangerous GHGs is flaring those gases with an excess gas burner at the top of the gas pocket (MIKTSE 2006).

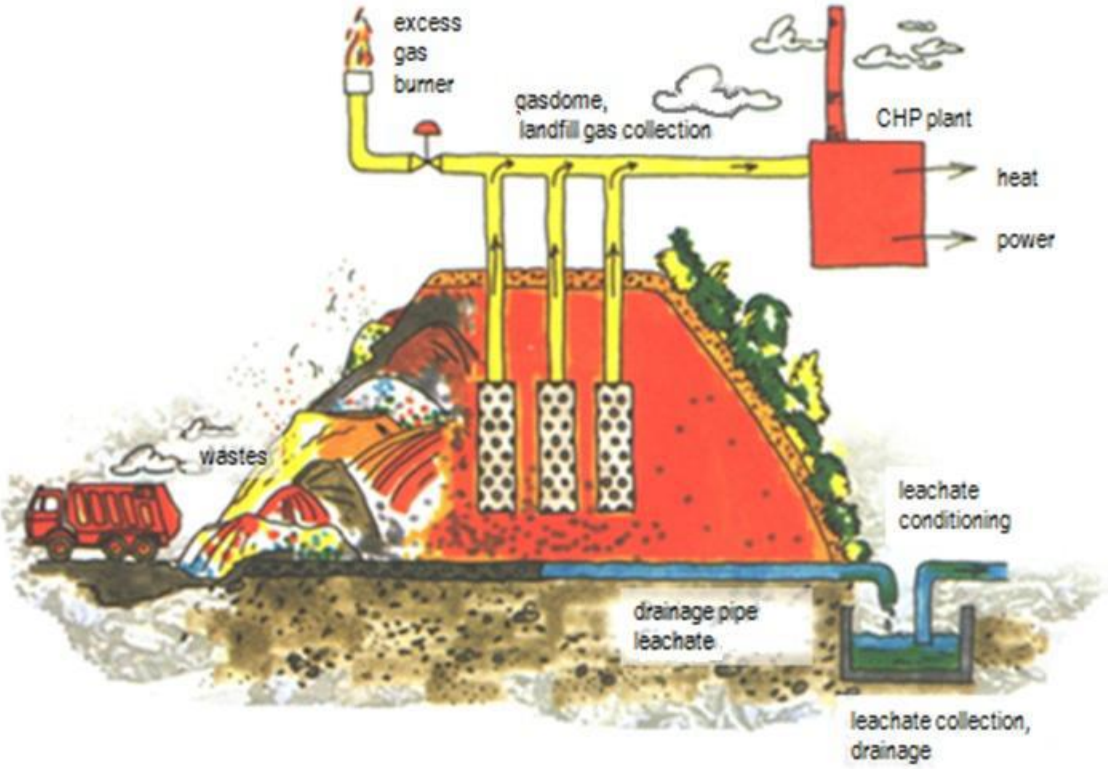

Figure 8: Schematic diagram of a landfill (MIKTSE 2006)

To make usage of the biogas, operators dig a series of wells into the landfill and can capture between 60 per cent and 90 per cent of the gas emitted, depending on the system design (EPA, 2009). The captured gas is then pumped to a central facility where the methane can be refined to pipeline-quality renewable natural gas, flared, or used for heat or electricity generation on the site (Guzzone and Schlagenhauf 2007).

5.4.4 Biogas Plant

Wastes can be turned into several types of biofuels, biofertiliser and biogas that generates electricity or heats homes. Biogas usually contains 50-75% methane, carbon dioxide and traces of other gases and is the chemical equivalent of natural gas (Fachagentur Nachwachsende Rohstoffe 2010).

The process of generating biogas contains several steps. Firstly, the waste, that can be MSW or come directly from wastewater treatment plants, farms, slaughterhouses or restaurants, will be delivered to the biogas plant either by tubes or by trucks and will be mixed together, preferably with water. Anaerobic digestion of municipal waste frequently incorporates the partition of fluid from both the biowaste fed into the digester and the residue. The partition enhances biogas efficiency and creates a solid organic fertiliser for aerobic treatment prior to and at the end of anaerobic digestion. The fluid portion is further processed in a methane reactor and the effluent is utilised as fluid manure. The solid portion is subsequently composted (Schäfer, W. et al. 2006).

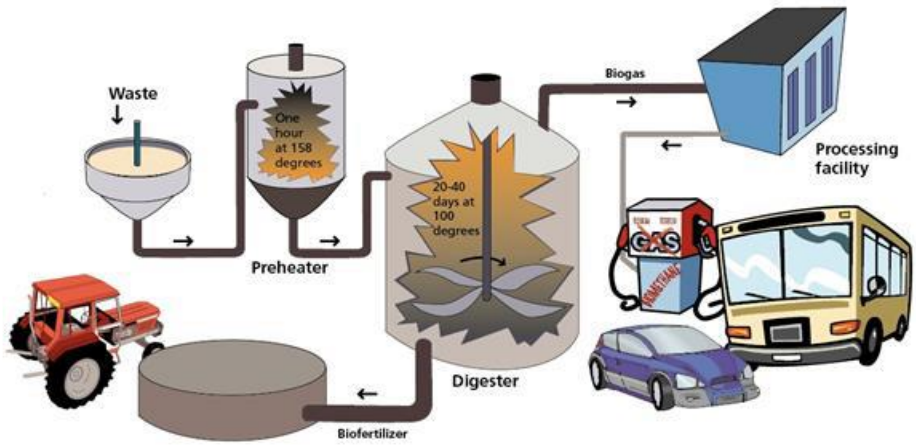

Figure 9: Biogas Conversion (Swedish Biogas International 2010)

Biofertiliser can also be upgraded to a higher methane concentration of about 97 per cent, the quality of natural gas, which is then called bio-methane by decreasing the proportion of carbon dioxide and contaminants in the gas by a separation process (Swedish Biogas International, 2010). Studies on the materials best implemented for the generation of biogas have shown that the biggest potential biogas yields, measured in the content of carbon and methane (Ceeres 2010) are in fact wastes rather than energy crops.

5.4.5 Economic and Social Impacts

With proper waste management, municipal organic waste can become a precious sustainable resource for the urban areas. The confined way of utilizing biowaste into energy offers an approach to conquer the issue of constrained access to power (Ackom 2013; Mohammed et al. 2013, 15–22; IEA 2006, 2007).

The bioenergy created can also be utilised for irrigation, subsequently, improving crop yields. All these are routes through which destitution among provincial occupants can be diminished.

Biogas can be utilised as a vehicle fuel. For this purpose, it should be rid of all debasements to make it easy to be compressed into cylinders (Murphy et al. 2004, 294–310; Afrane & Ntiamoah 2011, 539-549; Ofori-Boateng et al 2013, 94–102).

Overall as a sustainable waste management system urban organic waste can produce energy that can be utilised for economic gains. Composting plays a huge economic role in the waste management since organic materials constitute the largest fraction (about 60%) of the municipal solid waste stream in developing countries. It reduces the quantity of waste for disposal leading to lower operating costs (Guerrero; Maas & Hogland 2013, 220-232).

The collection and transportation of solid waste for disposal represents a high fraction of the total cost profile of waste management in developing countries (Alagoz & Kocasoy 2008, 1461–1471). Therefore, the recovery and composting of the high fractions of organic solid wastes can have significant benefits on waste minimisation and in cost reduction. This implies composting has high economic potentials and hence very relevant in achieving sustainable waste management in developing countries.

Production of compost manure also reduces demand for chemical fertiliser, saves foreign exchange and improve economic productivity in developing countries. It serves as a substitute to chemical fertiliser which yields savings in production cost of agriculture and consequently improve farmer’s income. This enhances poverty reduction in developing countries considering that 70% of the world's poor earn their main income from agriculture; and the majority about 69% are from the least developed countries (World Bank 2014). More so, improving agriculture is one of the most important ways to alleviating rural poverty (Khan 2000).

Not only does bioenergy and composting serve as a method for overseeing waste (Ofori-Boateng et al. 2013, 94–102; Menikpura et al. 2016, 576-584) yet it can have other monetary and social advantages, for example, creating jobs (IRENA 2015). Bioenergy offers numerous opportunities through its usage. While it is thought that such projects are highly technical and often require imported skilled labour and technology from developed countries, local people, especially “waste scavengers,” can be employed and use their skills.

The process of composting manufacture and marketing involves a chain of economic activities that engages labour for production, sales and transport and others which creates employment and generate income. It seems unlikely that municipalities themselves or international corporations can deal with waste. Additionally, it can integrate local entrepreneurs in the process and can be extended to entrepreneurs from informal settlements as well (Bawakyillenuo 2014; UN-HABITAT 2014).

6. ANALYSIS OF THE POTENTIAL OF PILOTING BIOENERGY GENERATION AND FERTILISER PRODUCTION IN HO TOWNSHIP

This chapter deals with the findings of the survey administered to the Ho Municipal Assembly. The purpose was to analyze the general interests and status quo in Ho. This information is complemented with information from official documents from municipal administration including past and ongoing projects in the municipality.

6.1 Analysis of Feedback Availability and Potential

Common feedstock types that are available in the area under study and can be used are:

- Food-processing residues,
- livestock manure
- slaughterhouse waste
- municipal solid waste (organic fraction), MSW
- municipal sewage sludge.

However, some of the before named possible feedstock types are technically challenging and need a special pre-treatment. MSW is one of the feed stocks used for composting. When using MSW, the final product should not contain dangerous levels of contaminants, for example, substantial traces heavy metals spilling from batteries in the waste. Therefore, utilization of MSW often required source separation of waste and/or effective pre-treatment. The nature of the feedstock might not be ideal for anaerobic digestion due to its high cellulose and lignin content. Although this material allows the percolate to penetrate the feedstock uniformly, it is not easily degraded by methane-forming bacteria.

General waste composition in Ghana per Miezah et al, 2009 is 61% organics, 14% plastics, 6% inert, 5% miscellaneous, 5% paper, 3% metals, 3% glass, 1% leather and rubber, and 1% textiles. As the Ho Municipality generates 21 600 tons of solid waste annually (Siri, 2010) this translates to 13 176 tons of organic waste. Now the Ho township forms approximately 59 per cent of the Ho municipality. Hence the estimated amount of solid biowaste available in the Ho township is 7769 tons annually.

In 2006, the estimated total amount of wastewater (domestic- grey and black waters, produced in urban Ghana was estimated to be approximately 280 million cubic meters (Agodzo, 2003). Comparing that to the population of the Ho township means about 2 million cubic meters is produced annually.

In Ghana, 58% of the solid waste generated is dumped by households in designated dumping sites, 25% is dumped elsewhere in non-designated sites and only 15% is uncollected (GSS, 2000). This accounts for about a 15% loss of solid bio-waste. For liquid waste disposal, throwing waste onto the compound (37.2%) and onto the street (24.3%) account for the two most common methods used by households in the municipality. This means only about 40 per cent of the liquid waste produced is accessible at the moment. Enforcing by-laws as a means to ensure proper disposal of biowaste seems to be the most effective solution to maximizing the accessible amount in the township.

6.2 Recommended Technology Options to Consider

About the available feedstock in the Ho Township (easy access, quality of feedstock), the estimated technological option for bioenergy and fertiliser production would be a biogas plant. The feedstock is well endowed with a great variety of organic material that can be used as a feedstock for generating biogas. The biogas could be either a dry one or a wet one, but the dry biogas system is highly recommended. Wet biogas plants have improved energy balance and economic performance compared to dry biogas plants. However, dry biogas plants offer several benefits, including greater flexibility in the type of feedstock accepted, shorter retention times, reduced water usage and more flexible management of, and opportunities for marketing, the end-product (Angelondini, Smith 2015, 549–557).

Based on the data from a survey made to the Ho Municipality (Fugar 2016), this recommendation represents a very feasible waste to energy solution with expressed interest in Ho as a waste management solution. There is an expressed need and interest for waste-to-energy solutions in the Municipality.

Composting is not done in any organized form except some individuals doing it at their homes/farms. However, Urine Diversion Dry Toilet (UDDT) facilities have been constructed in the Ho Municipality through the North-

South cooperation with co-funding from the Ho Municipal Assembly. As the name implies, the UDDT model is based on urine diversion and onsite-composting. The on-site composting of fecal matter is based on alterative use of the two squatting pans connected to different compost vaults. The urine collected serves as urine fertiliser used on farms for field demonstrations.

In 2014, two farms were chosen from each of the eight Ministry of Food and Agriculture (MoFA) farming zones in Ho Municipality for field demonstration sites. Demonstration farms were established in each zone and farmers were given the opportunity to participate in the application and observance of the growth and yield trends between urine fertilisers and chemical fertilisers during the major farming season (May to September). The results revealed that urine and chemical fertiliser application significantly affected growth parameters positively during the two seasons. The urine treatment, however, seemed to have some level of advantage over the chemical fertiliser treatment in its impact on the growth parameters. Furthermore, the field demonstrations showed that the farmers have a major interest in the use of the organic fertilisers. So far, these pilots represent the only form of composting done in the municipality although there is a plan to expand on these activities focusing on the rural area of the municipality.

6.3 Recommendations for Organization and Planning

As per the information gathered from the questionnaire the problems being faced with regards to waste management are:

1. Logistics for waste sorting
2. Lack of proper final disposal site for both solid and liquid waste generated
3. Lack of education on waste sorting
4. Lack of recycling centers/factories

There are several ongoing waste management projects in the municipality namely

1. Engineered landfill site
2. Central market complex
3. Abattoir with a combined anaerobic digester

The engineered landfill under construction is yet to be completed and expected to serve as a safe means of solid waste disposal.

Now, the only project utilizing waste for useful components is the abattoir with a combined anaerobic digester. No measures have been put in place to sort waste into organic/inorganic components at the newly constructed central market facility. Additionally, no composting or any form of recycling has been envisaged to accompany these projects at least for now.

Issues to be considered when planning a pilot include

- Establishment of a waste management department tasked with the implementation of activities specifically waste sorting, operation and maintenance of biogas plants, operation and maintenance of newly constructed waste management facilities and existing ones.
- Planning a pilot to accompany a facility for example composting of organic waste sent to the landfill.
- Creating awareness especially with regards to waste sorting and outlining the benefits of embracing it. This can be done with help of the already existing staff of the Environmental Health Department of the Ho Municipal Assembly as well as the School of Hygiene.
- Waste management in the municipality is solely handled by Zoom Lion Ltd. Xatti and Felli is another company tasked with the handling of waste in the community although using equipment belonging to the municipality. Involvement of the companies tasked with handling of the municipal waste is crucial in that the waste remains the resource to be utilised when planning a pilot.
- On the topic of potential funding options investment capital is however a tricky situation because the municipality depends on external funding for most development projects. Private sector partnerships should be considered as it can be effective and boost the economy as well. Additionally, external funding sources such as the Ghana Climate Innovation Centre funded the World Bank provide support for green projects.

7. CONCLUSIONS

The aim of this thesis was to study the possibility of converting urban organic waste in the Ho Municipality into useful components, mainly for composting and bioenergy, and to establish a sustainable business model for the utilization of urban organic waste.

The findings of the thesis show that there is a lack of adequate waste management system in the study area. Handling and disposal of biowaste (both solid and liquid), are inadequately carried out in the study area. There is neither a centralized sewerage system nor a wastewater treatment plant. Urban waste mostly ends up at dump sites and uncontrolled landfills, where harmful emissions are emitted, including Green House Gases, into the atmosphere and waterways thereby causing health problems, environmental degradation and localized pollution as well as contributing to the climate change. Sorting of waste is not done at any level in the Ho Township.

In the light of the waste challenges, a few interventions were made through the Municipal Assembly, the Government of Ghana as well as the North South Cooperation. These interventions include the ongoing construction of an engineered landfill site, a new central market complex and an abattoir with a combined anaerobic digester. Urine Diversion Dry Toilet (UDDT) pilots which provide treated compost and urine as organic fertilisers were also provided through the North-South Local Government cooperation.

This research study was limited to the Ho Township of the Municipality. The focus was mainly on bio-waste and sludge generated from this urban area. The urban area was chosen as there are larger localized waste streams in the densely populated areas. Bigger waste volumes allow for more utilization opportunities.

Information on suitable solutions and business or operating models was gathered by considering relevant case studies. The case studies were selected based on similar operating environments (population figures, climate, social amenities, culture, economic situation). Solutions that combine both biowaste and sludge, and products that include but are not limited to energy were given a preference. Additionally, solutions from Finland (Kujala Waste center) were considered to give a broader view of how the management of biowaste streams could be organized on a larger scale in a town approximately the size of Ho.

Additionally, local content from the Municipality was used to gather information; The Municipal Environmental Sanitation Strategy Action Plan (MESSAP), Stakeholder Interviews, Ghana Statistical Service, Medium Term Development Plan as well as information from the North-South Local Government cooperation.

Findings of the study suggested the sorting of waste into organic and inorganic components, first at the central market and afterwards at the household level. Subsequently the establishment of a biogas gas plant (a combined solution) which produces both energy and organic fertiliser should follow. This, in its turn, should be accompanied by the establishment of a waste management department in the municipality to spearhead operations of the pilot to be established and to manage the existing waste management operations.

The overall aim of this study was achieved, but a few challenges were encountered. The data available from the Ho municipal assembly was in some cases very scanty. For further studies, I would recommend the systematic steps to be taken to establish a pilot biogas plant in the Ho township based on the studies carried out here.

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APPENDICES

Appendix 1: Interview

STRUCTURED INTERVIEW FOR ENVIRONMENTAL HEALTH AND SANITATION DIVISION/PLANNING DEPARTMENT OF THE HO MUNICIPAL ASSEMBLY AND ZOOMLION

The research is mainly for academic purpose. Therefore, answers given will be treated confidentially.

Thank you

Position of Respondent: ....

Date of Response: ....

SECTION A

Waste collection and disposal

Q1. What is the quantity of solid waste generated in a day in tonnes? (In figures): ………………………………………………………………………………......................................

Q2. What is the quantity of solid waste generated per capita in a day in tonnes? (In figures)

…………………………………………………..……………………………………………

Q3. What are the common types of solid waste generated in the Municipality? (List them)

1.. 2..

3.. 4................................ ……………….

5.......................................

Q4. Do you separate the waste before disposal? (Either into plastic, wood, metals, glass, food waste among others) Yes [ ] No [ ]

Q5. If yes, indicate the reasons.

1…………………………………………………………………………………………

2…………………………………………………………………………………………

3…………………………………………………………………………………………

Q6. What are the percentages of the following waste types generated in Ho? (Can be provided in a percentage range)

1. Plastic……………………………………..

2. Food waste………………………………..

3. Wood………………………………………

4. Glass……………………………………....

5. Metal……………………………………….

6. Other……………………………………….

Q7. How was the data gathered and on what basis?
……………………………………………………………………………………………

Q8. Has there been any study on the waste content types generated in the Municipality
……………………………………………………………………………………………

Q9. What is the mode(s) of collection of waste in the Municipality?

……………………………………………………………………………………………

……………………………………………………………………………………………

Q10. What is the number of times waste is collected in a week from the various communities of Ho

…………………………………………………………………………………....................

Q11. What is the cost of collection per week? Indicate the amount in

GH¢...

Q12.Where do you dispose of the waste collected from the various sections? (Final disposal site)...

Q13. How much liquid waste is produced in the Municipality?

……………………………………………………………………………………………

Q14. Is there any waste water treatment plant?
……………………………………………………………………………………………

……………………………………………………………………………………………

Q15. If not what happens to the liquid waste generated in the municipality?
……………………………………………………………………………………………

……………………………………………………………………………………………

SECTION B
Waste Management

Q16.What methods do you use in managing the solid waste generated in the area? (If more than one indicate them)

1. Composting [ ]

2. Recycling [ ]

3. Engineered Landfilling [ ]

4. None [ ]

5. Other, (specify):...

Q17. In the case of composting what is composted and how much?

…………………………………………………………………………………………

…………………………………………………………………………………………

Q18. In the case of recycling what is recycled and how much?

…………………………………………………………………………………………

Q19. Why do you choose to use any of the method(s) for managing solid waste above? (Indicate the reasons in the spaces provided below).

1...

2...

3...

4...

Q20. Do you have the needed equipment for waste collection in the Municipality?
Yes [ ] No [ ]

Q21. Do you have the needed equipment for waste disposal in the Municipality?
Yes [ ] No [ ]

Q22. Do you have the needed personnel for waste collection in the Municipality?
Yes [ ] No [ ]

Q23. Do you have the needed personnel for waste disposal in the Municipality?
Yes [ ] No [ ]

Q24. What equipment is available for waste collection and disposal in the Municipality?
…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Q25. What personnel is available for waste collection and disposal in the Municipality?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Q26. Is there an available waste disposal and management site in the Municipality?
Yes [ ] No [ ]

Q27. In your view what are some of the problems facing the department in terms of managing waste?

1………………………………………………………………………………………………

2………………………………………………………………………………………………

3………………………………………………………………………………………………

Q28. State briefly how these problems can be solved?

1………………………………………………………………………………………………

2………………………………………………………………………………………………

3………………………………………………………………………………………………

Q29. Are there any local partners or organisations involved in waste management in Ho?

…………………………………………………………………………………………………

Q30. If yes, how many and what are their respective roles

Institutions Role in waste management

…………………………….. …………………………………………….

…………………………….. …………………………………………….

…………………………….. …………………………………………….

…………………………….. …………………………………………….

…………………………….. …………………………………………….

Q31. Are there any ongoing waste management projects in the Municipality?

…………………………………………………………………………………………………

Q32. What are the details of these projects and their anticipated date(s) of completion?
…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Q33. Will any of the following methods accompany any of the projects? (If more than one indicate them)

1. Composting [ ]

2. Recycling [ ]

3. Landfilling [ ]

4. None [ ]

5. Other, (specify):...

Q.34 In the case of composting what will be composted and how much?
…………………………………………………………………………………………………

…………………………………………………………………………………………………

Q.35 In the case of recycling what will be recycled and how much?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

SECTION C
Waste and Energy
Q36. Is any of the waste generated converted by any means to energy for use in the Municipality?

………………………………………………………………………………………………

Q37. If yes who are the players in this waste to energy sector?

………………………………………………………………………………………………

Q38. What is the energy generated used for?

………………………………………………………………………………………………

………………………………………………………………………………………………

Q39. Is it possible to generate energy to supplement the electricity grid?

………………………………………………………………………………………………

Q40. If yes are there any constraints?

………………………………………………………………………………………………

………………………………………………………………………………………………

Q41. In your opinion what would be the best waste to energy solution for the municipality? i.e. the best output
1. Biogas [ ]

2. Electricity [ ]

3. Biofuel (liquid) [ ]

4. Other, (specify): ....

Q44 Explain further

………………………………………………………………………………………………

………………………………………………………………………………………………
Thank you for your assistance

Appendix 2: Categorization of Environmental Impacts of Organic Waste

Potential to have environmental impact	**Category**	**Types of organics permitted in categories**	
		Type	**Examples of organics**
Lowest potential environmental impact	Category 1	Garden and landscaping organics	Grass; leaves; plants; cuttings; branches; tree trunks and stumps.
		Untreated timber	Untreated timber Sawdust; shavings; timber offcuts; crates; pallets; wood packaging
		Natural organic fibrous organics	Mulch; seed hulls/husks; straw; bagasse and other natural organic fibrous organics
		Processed fibrous organics	Paper; cardboard; paper-processing sludge; non-synthetic textiles
Greater potential environmental	Category 2	Other natural or processed vegetable organics	Vegetables; fruit and seeds and processing sludge and wastes; winery, brewery and distillery wastes; food organics

impact		Bio solids and manures	Sewage bio solids, animal manure and mixtures of manure and biodegradable animal bedding organics.
		Meat, fish and fatty foods	Carcasses and parts of carcasses; blood; bone; fish; fatty processing or food (Excluding category 3)
Greatest potential environmental impact	Category 3	Fatty and oily sludge and organics of animal and vegetable origin	Dewatered grease trap; fatty and oily sludge of animal and vegetable origin
		Mixed residual waste containing putrescible organics	Wastes containing putrescible organics, including household domestic waste that is set aside for curbside collection or delivered by the householder directly to a processing facility, and waste from commerce and industry

Source: NSW Department of Environment and Conservation 2004