Reverse logistics system and recycling potential at a landfill: A case study from Kampala City

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abstract

The rapid growing population and high urbanisation rates in Sub-Saharan Africa has caused enormous pressure on collection services of the generated waste in the urban areas. This has put a burden on landfilling, which is the major waste disposal method. Waste reduction, re-use and recycling opportunities exist but are not fully utilized. The common items that are re-used and re-cycled are plastics, paper, aluminum, glass, steel, cardboard, and yard waste. This paper develops an overview of reverse logistics at Kiteezi landfill, the only officially recognised waste disposal facility for Kampala City. The paper analyses, in details the collection, re-processing, re-distribution and final markets of these products into a reversed supply chain network. Only 14% of the products at Kiteezi landfill are channeled into the reverse chain while 63% could be included in the distribution chain but are left out and disposed of while the remaining 23% is buried. This is because of the low processing power available, lack of market value, lack of knowledge and limited value addition activities to the products. This paper proposes possible strategies of efficient and effective reverse logistics development, applicable to Kampala City and other similar cities.

1. Introduction

The rapid increase in urban population especially in developing countries, means that the rate at which waste is generated is increasing at alarming rates (Rotich et al., 2006; Alam et al., 2008; Okot-Okumu and Nyenje, 2011). This high rate of waste generation has exhausted many landfill carrying capacities and underutilisation of resources whereas the waste could be converted into energy (Gupta et al., 1998; Sharholy et al., 2008), compost, animal feeds, construction materials and other resources. On the other hand, waste management authorities are exploring for recycling opportunities and venturing into alternative technologies to reduce waste that is being landfilled via incineration, composting and material recovery (Oteng-Ababio et al., 2013). However, these technologies have some setbacks. For instance incineration is a costly venture and thus not suited for developing countries.

Waste composition in many Sub-Saharan countries constitutes about 80% biodegradable materials. This high fraction of organic degradable material is good for composting. However, small scale manually operated and non-mechanised medium to large scale composting plants in developing countries have been unsuccessful and instead turned out to become public nuisances, posing health risks and emitting foul gases due to the limited attention of the biological processes involved (Vidanaarachchi et al., 2006; Hoornweg et al., 1999).

Furthermore, some products for instance electricals and electronics (cell phones, televisions, computers and accessories) can no longer be landfilled due to regulations and therefore need other treatment or disposal ways, other than landfilling (Rogers and Tibben-Lembke, 1999; Ferguson and Browne, 2001). Such developments aimed at economic motives and environmental concerns have encouraged many firms to explore more on take-back and recovery of products hence focusing on reverse logistics as a sustainable way of managing waste. The application of reverse logistics in the developed countries is already gaining momentum.

Previously, attention in the supply chain focused on forward logistics that deals with the movement of finished goods from the suppliers to the consumers (Cooper and Ellram, 1993; Bowersox et al., 2002). Manufacturers of goods were not responsible for what happens to their products after customer use as they were only following the traditional forward logistics (Thierry et al., 1995; Fleischmann et al., 1997). With the increase of pressure from government policies of deregulations and globalisation, it became the mandate of logistic managers to find solutions to problems of location, allocation and transportation and the technique of

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integrated logistics came into course (Min et al., 1998), and the outcome of this was the emergence of reverse logistics. Since the early nineties, reverse logistics has been the topic of discussion with regard to economic gains, legislation and environmental attributes (Dowlatshahi, 2000; De Brito et al., 2005).

Rogers and Tibben-Lembke (1999) defined reverse logistics as the process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. The European Working Group on Reverse Logistics (2002) in De Brito and Dekker (2004) expanded the above authors' definition and defined reverse logistics as the process of planning, implementing and controlling the backwards flows of raw materials, in-process inventory, packaging and finished goods from a manufacturing, distribution or use point to a point of recovery or proper disposal. The issue was that in the first definition, packaging materials were left out. Reverse logistics being a new subject has been perceived to mean reversed logistics, returns logistics or reverse distribution. In all these terminologies, an element of resource recovery is contained within.

The concept of reverse logistics involves the movement of materials from the point of consumption back to the point of origin. Shih (2001) emphasized the importance of efficient reverse logistics planning and infrastructure design as the take-back rate of home appliances such as computers and electronics at their end-of-life. The relationship of reverse logistics and waste management involves activities in the reverse distribution channel such as reuse, recycle and proper disposal of waste. Reverse logistics can be a cost effective and environmentally friendly venture in that products life is extended. All these activities in the supply chain reduce on the environmental impact of the supply chain (Rogers and Tibben-Lembke, 2001). Generally reverse logistics involves activities of collection, transportation, reprocessing, value addition and final disposal of products. These products are moved backwards from the end user and processes include information flows associated with tracking and transaction processes.

Reverse logistics has three drivers and these are government legislation, economic value to be recovered in the returned product and environmental concerns (Srivastava, 2008). These driving factors are especially strong in the industrialised nations where government regulations are compelling firms to address recovering value and proper disposal of end of life products. Nagurney and Toyasaki (2005) noted that legislation has compelled a number of industries particularly in the electronics sector to set up a system of product recovery and safe disposal. However, the reverse logistics chain in most developing countries is informal comprising of a vast number of waste collectors, street children, waste loaders and small scale merchants. They are normally not organised and depend on recyclables collected from temporary garbage dumpsites and trucks, which deliver the wastes at the landfill (Matter et al., 2012). When the informal recyclers are present within the chain before delivery of solid wastes to the landfill, they reduce the inflow of waste to the landfill but these marginalised people are not accredited for the services they render towards waste management. For instance, waste pickers are perceived as unclean people and a public nuisance to many (Wilson et al., 2006). Waste pickers comprise of poor people who earn minimum wages for survival and hence they are at a great risk of toxic exposure to wastes, since the system they use does not address safety issues (Bleck and Wettberg, 2012).

Another setback of reverse logistics in the developing countries is information flow, making accurate recycling decisions problematic. Decision on what particular product to recycle depends heavily on tracking the costs. Additionally, reverse logistics of products in developing countries is substandard and value addition is limited to the fact that the gains accrued are little, yet the reprocessing of some products requires high investments within the reverse logistics network (Fleischmann et al., 2001). Nevertheless, reverse logistics can have environmental and economic benefits if it is done in a sustainable way, for instance, encouraging source segregation to ease sorting and grading. The expensive methods used in developed nations may not necessarily be needed in low- and middle-income countries at this stage because of the large numbers of informal workers still engaged in the separation and sorting of mixed waste at a low-cost, and yet they are much more effective than the mechanised methods used in developed countries.

Due to the economic crisis that is troubling most communities in developing countries, recycling is now seen as a sustainable approach to solid waste management. Communities have started coming up with activities that aim at material recovery in order to get some money for survival (Wilson et al., 2006). Such activities involve door to door collection of unwanted recyclable materials such as plastics, glass, metal and beverage containers.

In Uganda, data on reverse logistics is still lacking. The available data is normally on waste flows to disposal sites, normally landfills but the wastes that are recycled along the waste management chain are unknown. In the case of Kampala, currently the landfill in Kiteezi is receiving about 900 tons of waste per day (Komakech et al., 2014; Kinobe et al., 2015) but there is no documented data on the amount of waste that leaves the waste stream along the way to the landfill and at the landfill through reverse logistics distribution channel. The various functions executed under reverse logistics focus on material flow information management, relationship of value addition and proper disposal of products. With an effective reverse logistics system, operational costs would be reduced, employment of people would be availed, people's health would no longer be at risk and the environment would be kept in an ecologically sound manner (Sarkis et al., 2010).

The main objective of this paper was to examine the status of reverse logistics activities with emphasis on, collection and distribution channels and information flow of recyclable products from Kampala City to Kiteezi landfill and to various destinations for processing. The specific objectives were to:

- establish reverse logistics organisation and chain activities at Kiteezi landfill;
- classify solid waste streams delivered at the landfill and identify recyclable products;
- evaluate the reverse logistic potential products that leave the landfill and
- develop recommendations to take efficient measures to improve reverse logistics.

2. Materials and methods

2.1. Qualitative and quantitative data collection

The data was collected from primary and secondary sources. The research was carried out using both the qualitative and quantitative methods. The qualitative approach was used to study the problem comprehensively including methods such as interviews, questionnaires, observations, surveys and document analysis. The quantitative approach was used in a formal and structured way of collecting data. It was characterised by measurable data expressed in numbers and quantities. A key informant interview of one manager (n = 1) at the landfill was carried out. A questionnaire survey was administered to waste pickers (n = 10), small scale shop merchants of recyclables (n = 5) and small scale recycling plants (n = 5). This was meant to gain an in-depth understanding of the reverse logistics and how it is done. The questionnaire addressed general information of the landfill including waste that is delivered to the landfill, types of wastes, reverse logistics in terms of returns rates, magnitudes, manpower, outsourcing, prices, market of products, actors in the business (waste pickers, recyclers, agents and traders) and knowledge of legislation applicable to waste management. The issues prior to the landfill were assessed by interviews, observations and local knowledge. In terms of secondary data, a comprehensive and extensive literature review was conducted online using key words in academic journals to investigate reverse logistics from landfills. In addition, technical reports from government and non-government agencies were reviewed.

2.2. Study area

Kiteezi landfill was opened in 1996 and is located outside of Kampala City, at 12 km north of the City. It is the only City's designated landfill. Initially, the total land area of Kiteezi landfill was 0.04 square kilometers. It reached full capacity and more land was acquired making a total of 0.11 square kilometers (KCC, 2006). The landfill receives solid wastes from the five divisions/municipalities of Kampala City/district, namely Central, Kawempe, Makindye, Nakawa and Rubaga divisions (Fig. 1) and some fringe areas surrounding Kampala City. It is an open landfill. When the waste is delivered at the landfill, it is spread out and leveled by a bulldozer. During the process of delivering and spreading the waste at the landfill, waste pickers remove materials that they deal in, leaving out what is undesired. The various waste pickers at the landfill deal in plastics, aluminum, steel, card boards and textiles. At the end of each day, the remaining waste is covered by soil and compacted by a steel studded wheeled compactor.

2.3. Waste classification and flows

The survey was carried out for a period of six consecutive months (December 2012 to May 2013). Samples were picked in the first and the last week of the month for five consecutive days with each day allocated to a division (Central for Monday, Kawempe for Tuesday, Makindye for Wednesday, Nakawa for Thursday and Rubaga for Friday). A truck schedule for that day from each of the five divisions was randomly selected and its waste was analysed. Ten trucks belonging to Kampala Capital City Authority (KCCA) were sampled per month, thereby achieving a total number of 60 trucks sampled over the entire period of six months. Samples were sorted, classified and weighed in 10 categories of waste streams. The collected amounts of the recyclable waste were separated manually. The essence of this procedure was to determine per truck, the average quantity of waste that it delivers to the landfill and quantities of recyclable materials in order to establish the waste that leaves the landfill. Differences in waste flows in the five divisions were analysed.

A piece of area at the landfill of about 7 m in length and 3 m wide was graded flat by a grader, on which truckloads of waste selected randomly from each division dumped heaps of waste approximately 1 m high at a time as directed by the researchers. The waste heaps were then spread on the flat ground using a forked hoe by the help of selected waste pickers at the landfill. A weighing scale with the capability to measure up to one ton was used to weigh the categories and the weights were recorded in a data sheet.

The amount of waste that left or could potentially leave the landfill was determined, basing on the willingness to pay for the separation of waste collected and the major recyclable materials that included hard and soft plastics, paper, textiles, and metals. This categorisation was arrived at based on the fact that these are the products that currently command money flows from recycled material at the landfill. At the present, vegetation, soil, glass and food waste do not command money value at the landfill. These products are taken freely from the landfill if needed, otherwise, they are left to be compacted and buried into the landfill. The outcome of this study was to document the amount of waste that leaves the landfill to other destinations in order to evaluate its potential.

2.4. Data analysis

The Microsoft Excel computer software (Microsoft Inc., USA) was used to analyse the raw data to show an overview and trend of the data. The mean values, frequencies and percentages of each variable were generated using this software. Pie-charts and bar graphs were also generated by the same computer software. A Global Positioning System (GPS) and GIS technologies were used to locate the landfill.

3. Results

3.1. Solid waste classification

Classification of solid waste for this study was categorised in terms of the ''potential use'' of the sorted waste. Based on this, each sample was sorted into the following components; plastics, paper, soft polyethylene, glass, metals, textiles and bags, vegetation and wood, soil, and other special waste (Table 1).

Soil and vegetation added up to 83%. The rest of the waste streams when added up gave a total of 17% (Fig. 2). Fig. 2 shows the waste generation percentages of the selected categories. Organics/food waste recorded the highest percentage.

3.2. Organisation of reverse logistics structure at the landfill

The structure of reverse logistics at Kiteezi landfill is influenced by the collection of products and redistribution to various destinations. The network recovery options are reuse, recycle, remanufacture and disposal with an end of life chain of subsequent products from each component (Fig. 3). There is no information on the flow of products such as medical waste, ash, batteries, glass and rotten organics at the landfill because these are normally buried. Activities of composting and incineration are not carried out at the landfill due to the high capital and operational costs involved.

3.3. Reverse logistics network chain

The reverse logistics system was complex and started before and after the material reached the landfill. The major sources of waste from Kampala include households, commercial/institutional centres, restaurants, markets and street sweepings. The distribution network is influenced by the flow of products and information from one point to another. The system is inter-mixed with activities such as collection, separation, cleaning, grading, packaging, buying and selling. The waste was dumped without segregation. The distribution networks from the source of dumping included actors such as waste collectors, street children, and waste loaders. From the dumpsites, waste was collected and transported to the landfill where waste pickers entered into the chain. At the landfill, small scale merchants, small scale recycling plants, agents, and factories enter into the chain. This brought about competition from information flow and product acquisitions (Fig. 4). The recovery system was organized with individuals performing various activities and some even involved in several of the activities (Table 2). The activities were based on conditions such as demand and supply of products and they were also affected by uncertainties.

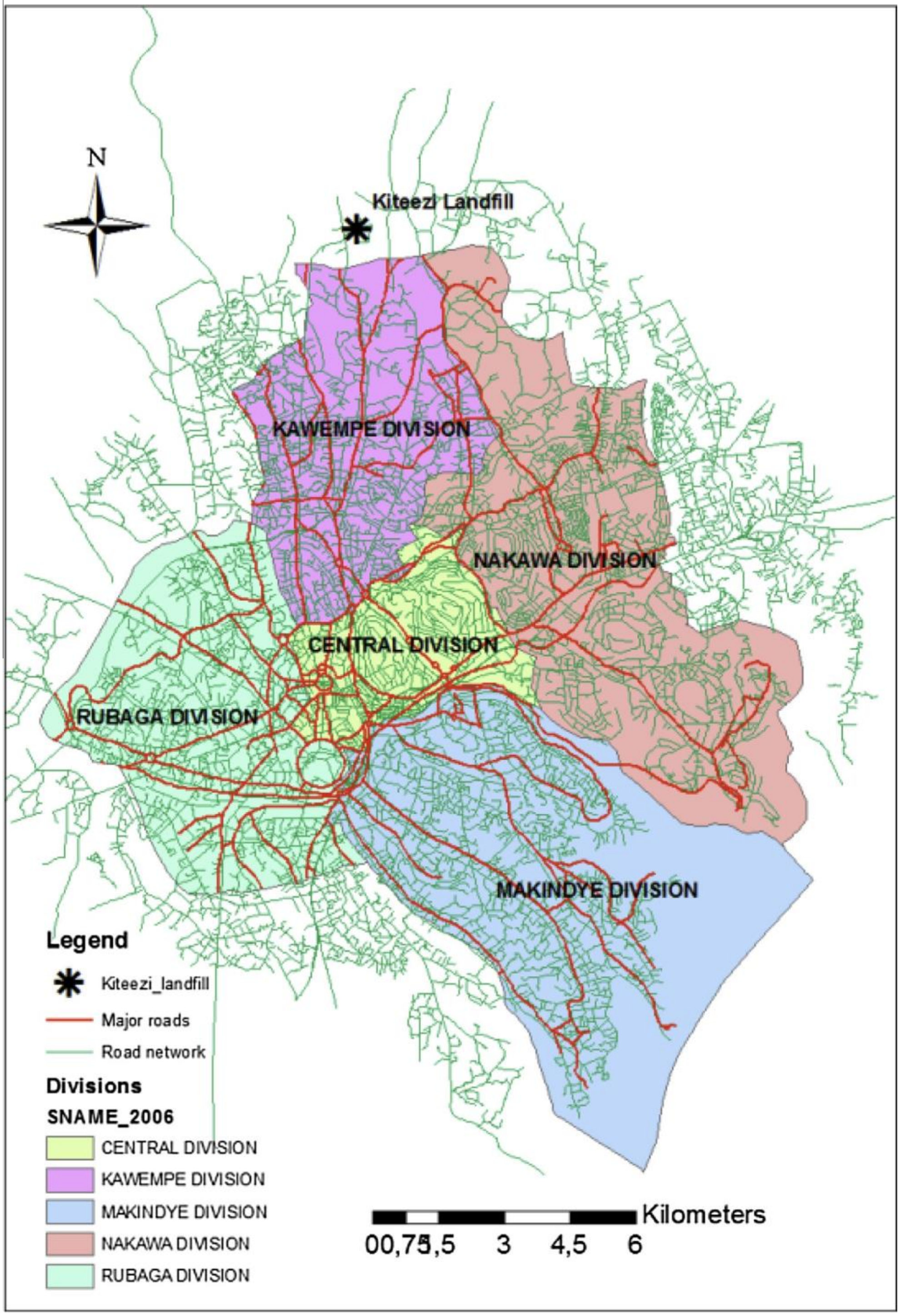

Fig. 1. Location of Kiteezi landfill and the five divisions of the city.

3.4. Potential products to be reversed

Five categories of waste with reverse logistic potential were identified, because these products command high money value. The potential reverse logistics products selected included plastics, soft polyethylene, paper, textiles and metal (Fig. 5). The rest was buried. Among the buried material, included glass, whose recycling initiatives in Uganda were lacking hence its end of life at the landfill. Polyethylene constituted the highest generation from the landfill with an average tonnage of 0.7 followed by 0.6 plastics, 0.3 textiles, 0.2 paper and 0.1 metal. Generally, polyethylene and plastics represented the highest fractions of recyclables from all the five divisions with the Central division generating the highest tonnage and Makindye delivering the lowest.

The percentage of reversed products from the survey is presented in Fig. 6, where the largest generators of polyethylene and plastics stand at 37% and 31% respectively of the total. The plastics sector included the polyethylene, hard and soft plastics. Paper and textiles trailed, with 12% and 15% respectively and the metals contributed only 5%.

Table 1
Categories and components of the waste delivered at Kitezi Landfill.

Category	Components included
Organic	Food remains, kitchen waste
Earth	Rock, soil, silt, ash, sand, construction and demolition
Vegetation	Tree cuttings, leaves, garden waste Market residue waste
Other waste	Medical waste, e-waste, batteries
Hard plastics	HDPE, LDPE, PET,
Soft plastics	Polyethylene bags, films,
Glass	Glass, melamine
Paper	Paper products, cardboards, boxes
Textiles	Clothes, old shoes, rugs
Metals	Ferrous, non-ferrous, aluminum

Similarly, further analysis of data presents average potential waste of reversed products (Fig. 7). In this figure, the products are grouped to give a clear picture of the waste that would have been recycled from the landfill at full capacity. The figure excludes the soil and other special waste. The analysis was aggregated to give simpler results. The data in Fig. 7 shows a high percentage of organics (food wastes and vegetation), thereby reflecting a great potential of recovery of organic waste at the landfill from all the divisions.

At the landfill in Kiteezi, the reversed products dealt in included plastics, polyethylene, paper, textiles and metal. Products such as organics, vegetation and glass were landfilled because of lack of money value. Products like soil and other special waste were covered by soil, compacted and buried in the ground at the end of each day. The currently reversed products at the landfill constituted 14% of material delivered. From the data computed, the potential products that can be utilised, including those already utilised comprise of food waste, plastics, polyethylene, paper, glass, textiles, metals and vegetation and these amount to 10.5 tons giving 63% of waste arriving at the landfill. The material that would have to be buried constitutes other special waste and soil and amounts to 3.1 tons, representing 23% of the waste delivered at the landfill (Fig. 8).

4. Discussion

4.1. Waste classification at Kiteezi

This study separated the waste streams to get an accurate quantity of the inflow to the landfill. The results of the survey indicated organics, vegetation and soil, with the largest percentage of 39%, 21% and 23% respectively. The high quantities of soil was observed, and this was because most of the streets were unpaved, meaning that whenever it rains, soil erosion prevails and this contributes large volumes of soil to the waste stream. Added to this was silt from the de-silted blocked channels, as well as construction and demolition waste that contributes large volumes of soil and stones. Vegetation quantities were due to the pruning of trees, compound cleaning and market residues. The high content of organics (in terms of volume and weight) was as a result of the nature of the food commonly consumed in Kampala, the form in which it is delivered to markets and preparation for consumption. Vegetables are delivered to markets in Kampala with roots con- taining soil as well as non-eatable stalks and leaves. Bananas are peeled before consumption and the peelings constitute a large pro- portion of the waste. Also, non-edible banana leaves are trans- ported from rural areas into Kampala, only to be used to wrap bananas during the cooking process. All of these result into large quantities of organics comprising of moisture content, making them heavy to transport. Indeed, at the Kiteezi landfill, large vol- umes of waste were delivered with the greatest proportion being organics. Similar findings have been reported, for example, Komakech et al. (2014) and Kinobe et al. (2015) measured organics at the landfill to represent 92.1% and 92.7% respectively of the total waste arriving at the landfill in Kiteezi.

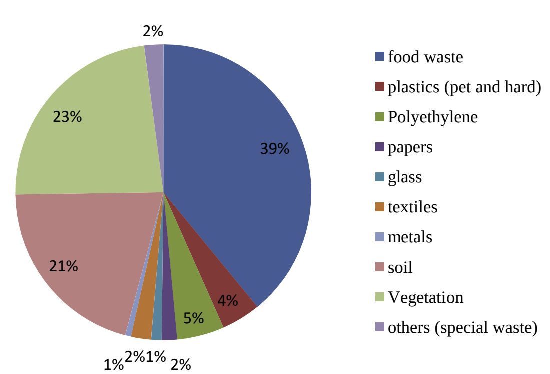

Fig. 2. Selected waste stream categories at the landfill.

In this study waste products with potential reverse logistics were selected. Organics were left out because they command no money value upon arriving at the landfill, and the same applied to vegetation matter and soil. In Kampala, organics, for example, peelings of bananas and potatoes are sold at source as animal feeds and in this case, they command a high monetary value. The main reason why organics delivered at the landfill do not attract customers to command a high monetary value is that they are often co-mingled with other wastes, making it difficult to separate them in a clean way for sale to people with animals or to make compost. Glass was left out of recyclable material because most of the glass samples were broken and in Uganda there was no reprocessing firm that was engaged in recycling glass. Glass was considered as end of life and buried. On a limited scale, some individuals, who go to the landfill to collect pieces of wood, occasionally take compost manure for gardening and glasses for putting on perimeter walls of buildings to enhance security, but the amounts are too small to quantify and furthermore, these products are got free of charge.

Recyclable products such as paper, plastics, metal, textile and polyethylene accounted for 14% of material arriving at Kiteezi landfill. This value was not so different from that measured from developing cities elsewhere (Gupta et al., 1998; Talyan et al., 2008; Gómez et al., 2009; Narayana, 2009; Hamidul Bari et al., 2012; Oteng-Ababio et al., 2013). Plastics, paper and metal are the most common materials with great value of recycling and command higher money value (Subramanian, 2000). Plastics were the most common recyclables at Kiteezi that favored the suppliers and the buyers in monetary terms.

The recovery potential of paper was not so profound at the landfill. More focus was directed to the hard cardboards and packing boxes. This was because 'softer' paper in most cases reached the landfill in a sorry state since it was mixed with other waste materials like organics hence needed a lot of processing to add value. The weight of paper was higher than anticipated, and this was attributed to the fact that it got mixed up with other wastes like organics during transportation and got torn and wet thereby making it heavy. However the paper recyclers preferred dry paper that was in good shape, and thus the reason why paper that was received at the landfill was not so attractive in the reverse chain. Kofoworola (2007), found that paper was hardly purchased at the landfill. Instead paper for recycling was obtained from the source, for example, from the point of generation or recycle materials shops, which are equivalent to the small scale merchants in Kiteezi who add value and sell it at a higher price. A large proportion of clean paper was picked out by the waste collectors before it reached the landfill.

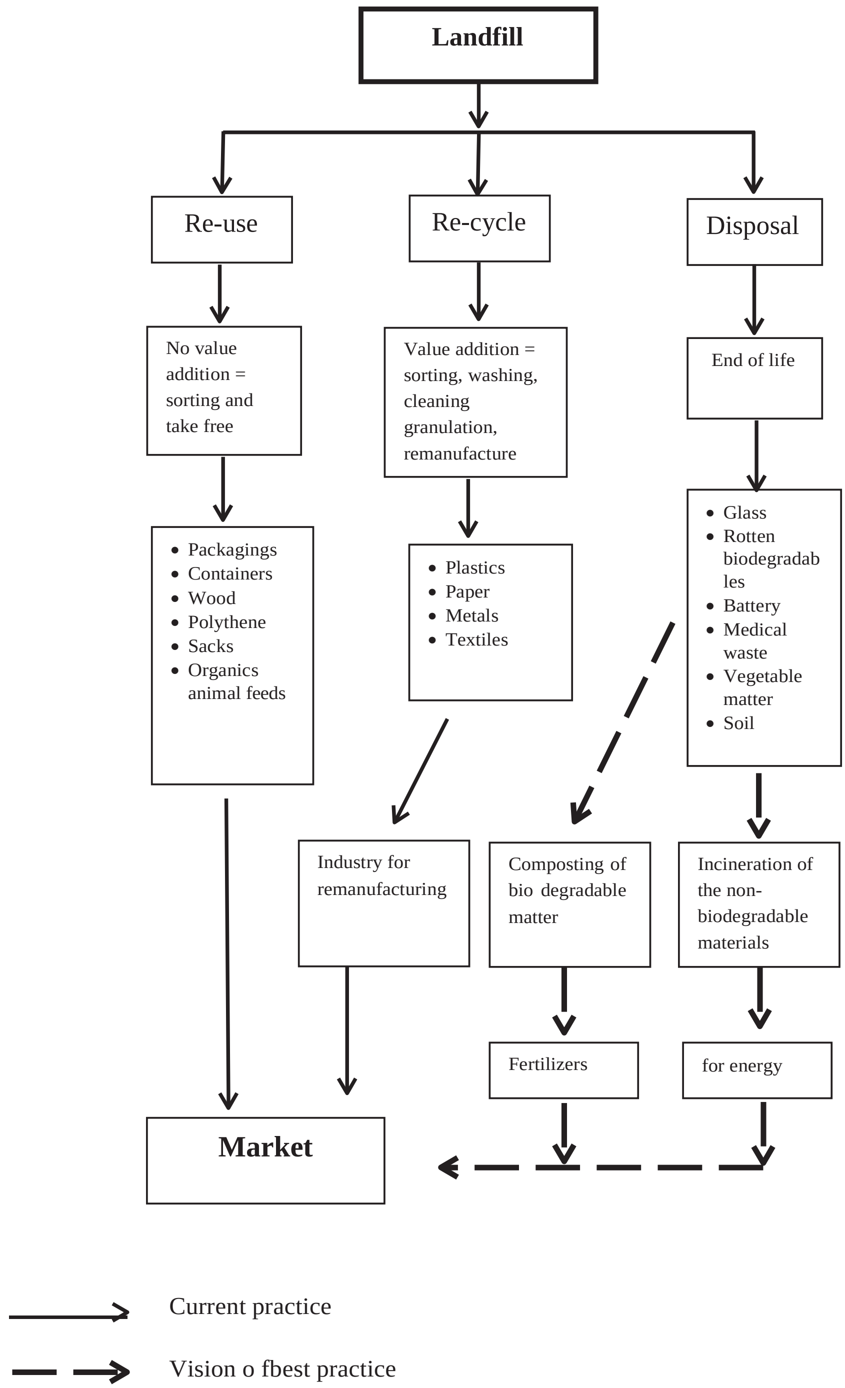

Fig. 3. Structural flow organisation of reverse logistics at Kiteezi and what it should be.

Polyethylene products constituted the largest amount of waste that entered the reverse chain. This could have been due to the trend in packaging of goods from markets and shops in and out of the city (Subramanian, 2000). These products were characterised by a good profitable resale price with a kilogram fetching between UGX 150 and UGX 200 (US$ 0.06 – US$ 0.08). Chung and Poon (2001) reported that such a good price of waste in Guangzhou City is attributed to economic growth, which tends to increase the proportion of manufactured materials, such as plastics, paper and rags, in the waste stream. A similar situation of economic growth could be contributing to the above relatively high value recyclable products of polyethylene and paper from the waste generated in Kampala City.

Al-Salem et al. (2009), asserted that plastics have many uses in our daily lives. It is realistic to find considerable amounts of plastics in the waste stream. However, the fraction of plastics in the waste reaching the landfill was lower than that of polyethylene because plastics have a higher demand, with a kilogram of clean plastics fetching UGX 250–300(US$ 0.10 – US$ 0.12). For this reason, waste loaders sorted out and removed the clean plastics from the waste stream before their trucks reached the landfill. Consequently, only the dirty and broken plastics, whose value was low because of the state, reached the landfill. The price of plastics was not fixed, and it depended on the shape of the products delivered, the appearance and cleanliness. Most of the small scale merchants in Kiteezi specialised in plastic recycling because it

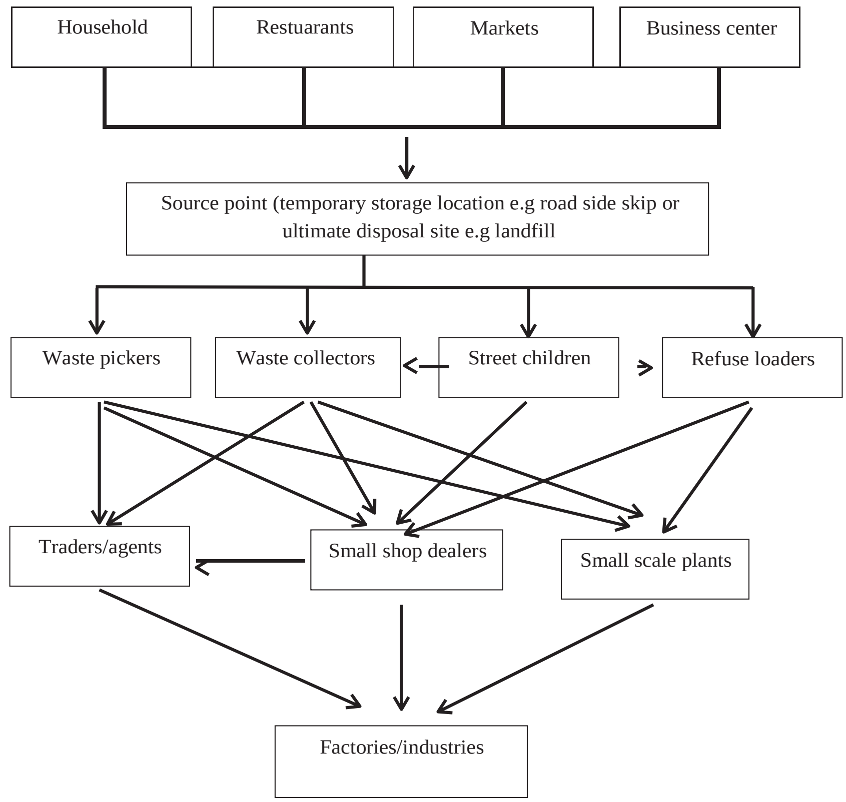

Fig. 4. Reverse logistics distribution network channels.

produced quick income and they easily obtained it from the waste loaders. In other words the products and their market were readily available in and out of Kiteezi landfill.

At Kiteezi landfill, metal was the most valuable waste category in terms of income generation, with each kilogram fetching UGX 500 – 1 000 (US$ 0.20 – US$ 0.40). This range of price was determined by the type, quality and fluctuation in market prices of metal, which was also found by (Kofoworola, 2007). Metal appeared in relatively smaller quantities at the landfill simply because it was sorted out right from the household level, sometimes by street children who sold it to waste loaders. The waste loaders then isolated the metal from the waste stream and sold it before reaching the landfill. Its market is readily available country-wide both on a large scale and small scale. The main large scale customers are iron and steel manufacturing industries while the small scale customers are the black smiths fabricating and selling various metal products.

4.2. Reverse logistics status at the landfill

In Kampala, the reverse logistics chain starts before the landfill with waste collectors, waste loaders and street children. They carry out their operations outside the landfill and their sorted products reach the landfill after which, a subsequent chain was produced (Wilson et al., 2006). The activities were carried out by the people working in the informal sector who were incapable of value addition to the products (Matter et al., 2012). Society takes these people as marginalised and discourages them instead of motivating them. However, they continue to exist because they earn a living from the waste business (Oteng-Ababio et al., 2013). Processing of products with high value addition occurs at established factories due to lack of capacity by the small scale recyclers.

Reverse logistics has been taken as an expensive venture involving activities such as collection, reprocessing, redistribution and sale of products. Frameworks developed by De Brito and Dekker (2004) characterised reverse logistics into a combination of drivers including economics, legislation and environmental concerns. The combination of the above factors will potentially increase the scale of reverse logistics. In a situation where there is no interconnection and enhancement of the above drivers, the actors carry out the chain according to the prevailing market demand and supply aspects of a particular product. For instance, the increase in plastics and polyethylene materials on market has widened the recycling of these products. There is a growing network of firms and other organisations with a common ideology of waste processing and utilisation (Subramanian, 2000). Rogers and Tibben-Lembke (1999) suggested that all business activities must deal with returns of any sort such as end of life, market returns or damaged products to a tune of 3–50% of the total sales of firms. For the case of Kiteezi, results of reversed returns were at 14% of all the products that are delivered to the landfill.

Contrary to the developed countries, where consumers or end users pay recycling fees for the products (Hayami et al., 2006), in Kampala, it was the receivers of these products that paid for the obsolete products from households. The waste collectors transmitted and in turn sold the products to small scale merchants or small scale recycling plants that sorted, cleaned and graded the products later to be sold to the agents or established factories. This entire activity was embedded in a reverse logistics network that included collectors, dealers, traders and recyclers whereby at each stage there was value addition in order to increase on the profits. Further to this, jobs were being created at each stage of the chain in a similar manner as Wilson et al. (2006). With an increase in the volumes of recyclables especially the plastics and the command of returns in form of revenues, there has been some form

Table 2
Arrangement of reverse logistics actors at Kiteezi landfill.

Stages	Reverse logistic actors	Description
Prior to the landfill	*Waste collectors/ street children*	This group moves within households and temporary storage dumpsites looking for recyclable materials such as plastics, metals, glass bottles and old shoes. The slight difference between the waste collectors and street children is that the waste collectors sometimes pay for the materials from the households. The street children just search for the products and they are normally sited near temporary dumpsites waiting for waste which they collect and sell to the refuse loaders. The products are then purchased by small scale merchants who then transport them to the landfill and increase their inventory
	Refuse loaders	They move on waste trucks loading waste within the city and are contracted by KCCA and receive a salary for their work. In addition to their formal employment, they also collect and trade recovery materials in order to earn extra income. Their access to the waste sources makes it possible for them to collect and separate waste materials
At the landfill	*Waste pickers*	These collect different products from the landfill. The quality of products collected by the waste pickers is of a much lower quality compared to those collected by loaders and waste collectors. The main reason for this is that the sorting has already taken place earlier in the system, for instance at the household level and at storage dumpsites. Therefore, quality materials that reach the landfill site are of a much lower value
	Small shop dealers	They buy the products at the source mainly from waste pickers, waste collectors, street children and refuse loaders. They aim for a variety of products available. They are normally situated near the landfill. They go an extra mile of adding value to the products by cleaning, washing and sorting them in categories
	Traders/agents[a]	These normally targeted a particular product. They buy products from the small scale merchant dealers and prefer cleaner products. Payment mode was made per kilogram of the products bought and also depending on the quality of the product
	Small scale plastic processing plants [a]	These are small firms that have sprung up in and around Kiteezi landfill to target plastic recycling from the landfill. They aim at adding value to the products which are later sold to the bigger factories. They carry out limited processing like cutting plastics into smaller pellets
Post landfill	*Factories and industries*	They add great value through processing and remanufacture of the products purchased. They usually require a minimum quantity of sorted and clean materials, which encourages the existence of intermediaries and waste dealers who purchase the recyclables recovered by the waste pickers

[a] These groups more or less do the same activities and it is difficult to distinguish between them. The difference is in size and location where the small scale processing plants are bigger and have a permanent location.

of specialisation in a particular product for higher profits. This was also supported by Baud et al. (2001) who described private sector involvement in the recycling sector and the impact of specialisation in a particular product.

Waste loaders separated some recyclables materials from the mixed waste at temporary collection dumpsites during loading onto the trucks and sold them to small scale recyclers, agent brokers or small scale merchants. The products that reached the landfill were usually broken, very dirty, mixed with other waste and of low quality because the valuable products had been removed by the waste collectors and the waste loaders. Wilson et al. (2006) noted that when waste loaders are doing their work, there is a lot of time wasted and their efficiency reduces because they are also busy sorting out products for their beneficiation. Likewise, at the landfill waste pickers also craved for the products when the vehicle arrived, which again was dangerous to them in terms of potential accidents. In Uganda, reverse logistics is still a new subject and hence there are no regulations or standards set in regard to the safety and operations and quality of the products from waste recycling.

The sorting at the landfill was done manually by the waste pickers who used their hands to pick the products. The waste pickers used bare hands without gloves even though, amongst them, they are advised to take precaution. The materials sorted were then subjected to the initial processing, involving cleaning, washing and drying before being packed to be sold to the dealers. Al-Salem et al. (2009) pointed out that sorting was by far the most important step in the recycling loop. The lower level reverse logistics practitioners (i.e. the waste pickers and waste collectors) are exposed to health risks during their work. Most of them undertook the work without precautionary measures such as use of gloves, making them exposed to hazardous substances in the waste stream. For example, electronic waste contains hazardous substances which can be harmful and risky to human health and the environment (Widmer et al., 2005; Wang et al., 2012).

Transportation of returned products at the landfill is one of the main activities in reverse logistics. Products that are recovered need to be physically moved from the collection place to the destination where they are sold. Transportation costs on many occasions greatly influence economic viability in the reverse distribution channel (Tibben-Lembke and Rogers, 2002). Product movement out of the landfill was still labour intensive with low quality transportation system including manually by head/hand, bicycles, and motorcycles (Fig. 9) and occasionally by the trucks. The trucks were normally provided by the factories to their market channel of small scale merchants and small scale processing plants to move products. This means that a well-developed transport design is crucial in the success of a reverse distribution channel.

Like in the developed world, third party logistics (3PLs) was also indirectly involved in the reverse chain distribution of products at the landfill. This was through retrieval (collection), transportation and disposition. The small scale merchants and agents acted as a

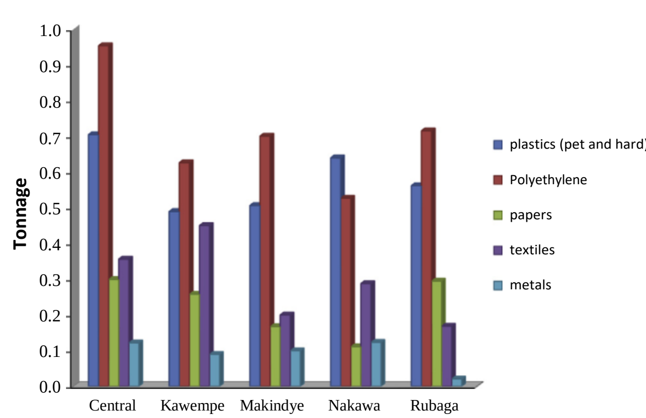

Fig. 5. Reversed products per division.

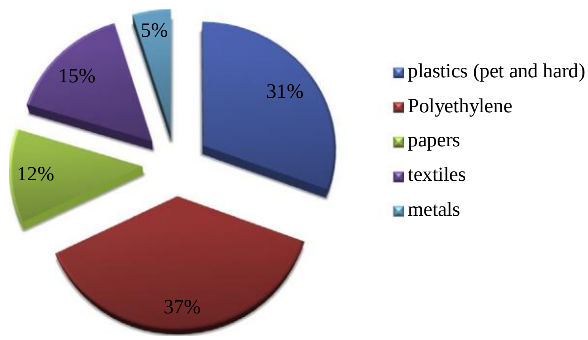

Fig. 6. Percentage of reversed products at the landfill.

link between waste collectors, waste pickers and the established factories in building marketing channels. This was because the former has no contact with the latter. Some of the small scale merchants also had contracts with the factories to supply constant products even though there was no clear documentation. The employment of third party logistics into the outsourcing approach was to help the firms focus more on their core activities and flexibility in reverse logistics operations and also to transfer the risk to the third parties. Unfortunately 3PLs were not willing to enter into the system. They were either not capable or unsure of the process of entering the reverse logistics market due to uncertainty and lack of knowledge (Dowlatshahi, 2000).

The increased participation of factories and industries in the reverse logistics was because of the increased competition in the market that was available within the manufacturing sector. Industries spent a lot of money purchasing imported raw materials so they entered in the reverse logistics chain in order to stay in competition. In the competitive environment, firms make strategic and operational decisions to optimise and manage their logistic processes efficiently. A virtual important operation for this is finding a way of managing reverse logistics to offer great service and quality sustainably (Dowlatshahi, 2000; Dekker, 2004). At Kiteezi landfill, many small scale recycling shops had sprung up nearby the source of materials. This proximity allows the flow of information about the products available for the market. Dowlatshahi (2000), noted that firms locate near the source of raw materials for economic gains that are enhanced by reducing on transport expenditures.

One major problem that affected reverse logistics at Kiteezi was uncertainty in terms of the availability of the product and its price, which are influenced by demand and supply. There was limited value addition because, high quality products may command high transportation costs (Fleischmann et al., 1997). Additionally, there was limited or no specialisation in the products due to the difficulty in predicting the demand and supply. Consequently, many of the small scale recycling dealers engaged in the purchase of a variety of products so as to stay in business and remain competitive.

In a nutshell, the potential reversed products at Kiteezi were 77% (14% reversed products and 63% potential products left out) which included plastics both soft and hard, paper, textiles and metals. The remaining 23% was not considered a resource hence just buried and compacted in the landfill. Of the material buried, the organic component could be used as a source of energy but the means of converting end of life products is still lacking in Uganda. Organics would have been resourceful but mostly what reached the landfill was rotten or co-mingled with other non-organics state and did not attract for instance animal keepers to take it as animal feeds. The unmixed organics were sorted out at the source before reaching the landfill. Another setback of the low reversed products at the landfill was that most of the recyclable products never reached the landfill. They were separated and sorted out by waste collectors, waste loaders who directly sell the products to the recycling shops. There was no factory processing and adding value to waste glass.

4.3. Ways forward to improve the reverse logistics chain

The common causes of poor waste management in developing countries are inadequate technical expertise, limited financial resources, inappropriate government policy and legislation (Vidanaarachchi et al., 2006). As such, there is need of an integrated solid waste management strategy that must include aspects such as waste reduction, reuse, recycling, resource recovery and proper landfilling. This coupled with activities such as sorting of the garbage right from the household till the landfill will ease grading of the products thereby facilitating value addition (Matter et al., 2012). Reverse logistics integration should be seen as a strategy to optimise all the available options of waste management and reduce on the pressure asserted to the landfill (Kinobe et al., 2012).

There is a need to introduce technologies that can facilitate the reduction of the quantity of waste reaching the landfill both in terms of bio- and non-degradable waste. The available technologies for treating biodegradable waste components are composting, anaerobic digestion, landfilling with methane capture for power generation, and incineration. Anaerobic digestion and

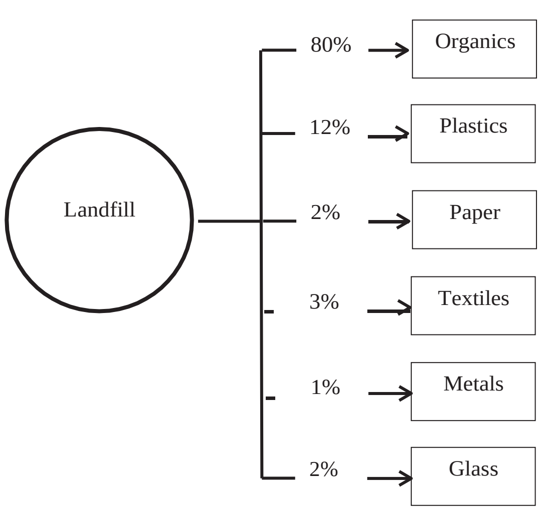

Fig. 7. Reversed flow material analysis. Average percentages of the different products that can be recovered from the landfill.

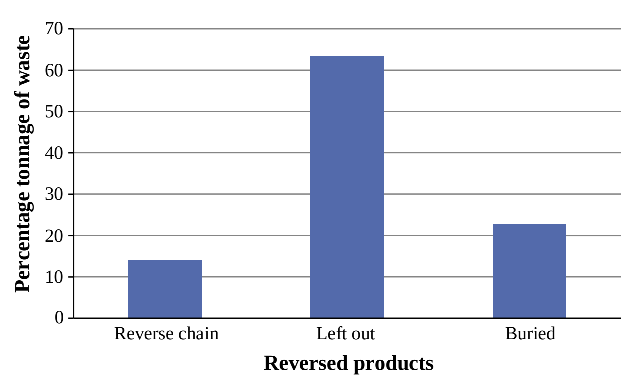

Fig. 8. Products reversed, those with potential to be reversed and products to be discarded.

Fig. 9. Common transportation means at the landfill.

incineration are expensive operations and require a high level of technical skill and competency for design, construction as well as operation and maintenance and these skills are not yet available in Uganda. Composting of the biodegradable matter that constitutes the largest percentage of waste generated is an option that could be considered. Composting is the biological decomposition of organic matter under controlled conditions to a nuisance free state. This compost can later be sold to gain revenue to be used as an organic fertilizer or soil amendment (Matter et al., 2012). To succeed with composting, there is need to pay attention to the biological process involved (Hoornweg et al., 1999). Energy recovery can yet be another aspect to recover energy value from the products especially the non-degradable materials. This can involve combustion of these materials at high temperatures in incinerators to produce energy (Cointreau, 2006). Subramanian (2000) pointed out that plastics, when burnt generate high energy values greater than any other category in the waste stream. The author further noted that in order to receive the best results from recycling waste, there should be a designed mechanism where all the recyclable materials are sorted and each stream put to their best use.

Another technological advance in reverse logistics could be developing product identification and labeling system from small scale merchants and small scale recycling plants to factories. There was no form of tagging of products at the landfill, for example, plastics inform of PET, LDPE, HDPE, paper etc, after sorting and grading. One example of such a system would be the use of Radio Frequency Identification (RFID) for a particular product. The tagging would make tracking and retrieval of products easier and faster.

Furthermore, there should be a form of Government intervention to integrate reverse logistics chain into the waste manage- ment aspect, where policies regarding recycling are developed and passed. These policies could be in form of coming up with organisations dealing with reverse logistics or recycling related activities. Such interventions will lead to better services like improved processing thereby increasing product value. Patel et al. (2000), in his work noted that government involvement in the waste management via recycling reduces on the pressure exerted on the landfill and also increases environmental awareness. Another way is to come up with programs that can support the reverse chain distribution network of waste collectors, street children and waste pickers. These people work in extremely bad conditions so, if they can be supported, they could be registered and their activities formalised to work jointly and increase efficiency as was done in Chennai India (Baud et al., 2001).

5. Conclusions

Generation of solid waste is a consequence of increasing population in many urban cities in Sub- Saharan Africa. End of life through disposal of products that is happening at the landfill for Kampala City has greatly distorted the idea of reverse logistics. Landfill space in cities in developing countries is increasingly becoming limited. In order to combat this growing problem, the municipalities and/or cities need to come up with a system that aims at reducing the tonnage of wastes produced.

The various reverse logistics activities presented in this paper contribute to an understanding of the distribution channel of waste management system in Kampala City. Re-use and re-cycling of products at the landfill will lead to proper reverse logistic operation. The existing system pertaining reverse logistics at the only landfill that serves Kampala City suffers from unfavorable economics, legislative, technical and operational constraints.

Of the products delivered at the landfill, food waste constituted the greatest amount delivered at 39% followed by vegetation 23% and 21% soil. The potential reversed products from the landfill include plastics (soft and hard), polyethylene soft, textiles, paper and metal with percentages that leave the landfill at 31%, 37%, 15%, 12%, and 5% respectively.

The most suitable way to improve reverse logistics in Kampala is to develop an integrated solid waste management strategy at the landfill aimed at coming up with techniques, technologies and management programs to achieve prescribed goals of waste management. Incorporating reverse logistics into the waste management sector will cut down the disposal capacity of the landfill, lower emissions from landfill, reduce litter, reduce expenditure on energy, and also provide income to the groups involved in the practice. The system will further increase the service level of firms and reduce the costs of production hence increase profitability.

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