Water and Environmental Studies
Department of Thematic Studies
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Sustainability of Municipal Solid Waste Management in Nigeria:

A Case Study of Lagos

Yetunde O. Agbesola

Master's programme

Science for Sustainable Development

Master's Thesis, 30 ECTS credits

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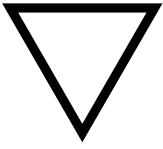# A Case Study of Lagos

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LIST OF ABBREVIATIONS

EU- European Union

FCT- Federal Capital Territory

FEPA- Federal Environmental Protection Agency

GHG- Green House Gas

LAWMA- Lagos State Waste Management Agency

LGA-Local Government Area

MSW-Municipal Solid Waste

MSWM- Municipal Solid Waste Management

PSP- Private Sector Partnership

SWM - Solid Waste Management

SWDS-Solid Waste Disposal Site

TLS- Transfer Loading Station

WtE- Waste to Energy

ABSTRACT

Waste generation is an unavoidable product of man's activities, however, sustainable management of such waste is a challenge faced in many countries today. Nigeria, a developing country in Africa, has been in a quandary of how to efficiently manage the municipal solid waste its population generates. Many states in the country lack adequate plans and infrastructure required for efficient and sustainable management of municipal solid waste. For Lagos, the most populous and popular state in Nigeria, the problem is further compounded by its rather large and still increasing population. In this research, Lagos is taken as a case study; the extant trend for solid waste handling in households, trends in the formal and informal sector as regards solid waste management from household collection to final disposal are focused upon. Many countries, particularly the developed ones, have employed options in the waste management hierarchy for sustainable management of their municipal solid waste and the blend of options employed is usually highly dependent on local factors. Following the waste management hierarchy, possible options for sustainable municipal solid waste management in Lagos are discussed. It is concluded that waste reduction, reuse, recycling and composting are potential management options for the state. Landfilling will remain an important option for final disposal but reliance on this method could be significantly reduced if management options are exploited to the maximum in a sustainable solid waste management structure.

Keywords: Lagos, Sustainable Management, Municipal Solid Waste, Waste Handling, Waste Management Hierarchy, Households, Disposal

1. INTRODUCTION

Most human activities naturally result in the generation of waste. As this is an unavoidable event in day to day living, there is need for waste generated to be managed. How this may be efficiently done poses a problem in many societies today. Another natural process, population growth, makes waste management even more challenging; more people in a specific geographic location would imply higher level of waste generation, hence more waste to contend with in that area. As poorly managed wastes are perceived as environmental hazards of high significance, the inabilities of societies to manage waste generation effectively play no small role in increasing extant environmental pressures (Alam, Chowdhury, Hassan, Karanjit, & Shrestha, 2007).

The challenge that derives from the generation of waste is not just coping with the volume, but also its composition and having the ability to design and accomplish its management in an efficient and sustainable manner; waste should be disposed of in a safe way which takes into cognizance the health of environment and that of the public, while ensuring non detrimental effects on generations to come (Ali, Cotton, & Westlake, 1999). While in developed parts of the world, sustainability encompasses ensuring that future generations are not negatively affected by environmental choices made today; for most developing countries, attention rather lies on what can be currently gained from such choices, especially from the socio- economic standpoint (Khatib, 2011).

Efficiency in solid waste management (SWM) is actively pursued in developed countries, however, the same may not be said of their developing counterparts, where inadequate access to funds, weak institutional framework, lack of access to appropriate technology, little staff encouragement, emergence of less environmental compatible products, unending change in consumption trend, etc., continue to hinder meaningful pursuance and attainment of sustainable efficiency in the sector (Oteng- Ababio, 2011).

A significant portion of municipal expenses (up to 40%) goes into the provision of SWM services in developing countries, making it one of the singly expensive sectors, paradoxically, the expenses are not commensurate with the services rendered as they remain poor and ineffective. Funds mostly available are in insufficient quantity to enable efficient service provision by local governments saddled with this responsibility. In addition to this is the challenge of inadequate and inappropriately located waste disposal points, as well as introduction of foreign technology (especially waste collection machinery), again SWM methods that are often locally incompatible due to different conditions and requirements under which they have been originally developed (UN-HABITAT, 2010). Dumping of solid waste in highly inappropriate places like middle of roads and unauthorized disposal sites are common practices in many developing countries (Igbinomwanhia, 2011). The solid waste management scenario in most developing countries are similar, Nigeria inclusive.

1.1 Description of SWM in Nigeria

Nigeria is a country located in the western part of the African continent, covering an area of approximately 924,000 km^2. The country has a high population of about 170 million, an estimated growth rate of 2.6% and is placed 7th only behind China, India, the United States, Indonesia, Brazil and Pakistan on a global population ranking (CIA, 2012). Nigeria is made up of 36 states and the Federal Capital Territory (FCT) which are collectively constituted of 774 Local Government Areas; SWM has been identified as one of the major environmental challenges being faced in the country (Adeyinka, Bankole, & Olaye, 2005).

In Nigeria, the administrative framework for SWM is three tiered, thus consisting of national and state agencies as well as local government bodies. The Federal Ministry of Environment is the body charged with overseeing the protection of the environment as well as natural resource preservation to the end of achieving sustainable development. As such, they play the role of promulgation of national environmental laws, enforcement and monitoring of the same in addition to ensuring adherence to international environmental guidelines. Operating also on the federal level is the National Environmental Standards and Regulations Agency, in addition to environmental law enforcement roles, the agency is charged with maintenance of effective interaction between national and international actors on issues related to the environment (LSG, 2009). Up until 1999, environmental laws and regulations were put forward and enforced by the Federal Environmental Protection Agency (FEPA); however these subsequently became a role of the Federal Ministry of Environment. In order to ensure protection of the environment is better managed, all states in Nigeria (and their local government) have been given the capacity to create related environmental establishments, the sovereignty of which is limited to the state or local government area it has been established (Ogwueleka, 2009).

Figure 1: Map showing geographical location of Nigeria[1]

Consequently, the management of solid waste has been a primary function of the municipal/ local government in each state; however, attaining efficiency in the sector has been a major challenge especially in the prominent cities within the country such as Owerri, Aba, Enugu, Warri, Port-Harcourt, Kaduna, Lagos and Ibadan where piles of municipal solid waste (MSW) are often observed (Idowu, Omirin, & Osagie, 2011) their sources being households, markets, and places of commercial activity (Momodu, Dimuna, & Dimuna, 2011). The problem of municipal solid waste management (MSWM) has been long standing in the country; households in Enugu (44%), Ibadan (35%), and Kaduna (33%) have been reported to lack access to adequate

[1] Source: https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html

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solid waste management services for over two decades and there appears to be little or no improvement even in recent times (Aderogba & Afelumo, 2012).

The employment of an integrated approach in the SWM sector in each Nigerian state could be an effective way to surmount inherent challenges in the system. Such approach would entail the strategic management of MSW through coordinated development and administration of a blend of new systems as well as significant improvement of current ones, all within a contemporary framework (UNEP, 2005a, p. 30). This would give room for adequate consideration of different actors and aspects in the sector, which may be important if efficiency and sustainability are indeed to be achieved. Sustainability in this study, takes into account the environmental perspective of waste management and potential of waste as a resource that could be utilized in a manner that shall be beneficial now and in the future. The solid waste management hierarchy, which classifies options for waste management in terms of how advantageous they are to the environment, is a fundamental component in the integrated waste management approach that is being employed by a majority of developed countries (ibid). Population size, local geographical features, environmental regulations, social and economic conditions are factors that however, determine how much any of these options are utilized or combined in each country (Babalola, Ishaku, Busu, & Majid, 2010).

1.2 Households
Households are considered major sources of solid waste in comparison to other sources of generation such as educational and commercial institutions or the municipal (from cleaning of public places such as streets). In addition to generating a large part of the organic waste component especially food, households also generate waste such as plastic, glass, metal, paper and rags, and others which are harmful such as batteries, vehicular parts, , etc. (Magutu & Onsongo, 2011). Lagos, Nigeria's smallest and yet most populous state shall be focused upon in this study. Waste management in the state, has been problematic and inefficient due to factors such as inadequate planning and funding issues. About 9000 metric tons of waste is generated per day in the state (LAWMA, 2011), and it has been named the dirtiest state in the country, given the magnitude of its solid waste management problems (Kofoworola, 2007)

In the last few years, changes have occurred which appear to have an impact on MSWM in the state; an example is the establishment of the Lagos State Waste Management Authority (LAWMA) and its subsequent role in the privatization of household waste collection in the state via the Private Sector Partnership program (PSP). However this only addresses a part of the whole MSWM process and remains in an embryonic stage. MSW disposal still requires more attention and strategic planning in the state; while utilization of solid waste disposal sites has been reported as a key means of disposing waste collected from different parts of the state, implementation of this method amidst other management practices, has been questioned (Lawal, 2010). Being a significant source of MSW, this study shall be focusing on households in Lagos and how their wastes are handled right from the source generation to the final disposal point.

1.3 Justification of Study
Lagos state was chosen as a case study given its unique position of being the smallest state, and the most populous in Nigeria. The state also serves as a key center for commercial activities as it is the nation's commercial capital. With its significant population size, and a projected increase over time, is it is important to evaluate the status of MSWM in Lagos and options for sustainable

improvement in the near future. The importance of this study can be tied to challenges of environmental relevance, public health, as well as the resources that may be gained if more efficient management systems are employed in the state. As Lagos may be said to be representative of other major and urban cities in Nigeria, it is envisaged that this study shall engender considerations for other efficient and sustainable waste management options that could be employed in the state.

1.4 Objective

This thesis studies solid waste management in Lagos with special focus on how households handle their waste, how the municipal manages the waste generated from households, and the potentials for sustainable improvements in the sector from an environmental and resource recovery viewpoint following the waste management hierarchy.

1.5 Research Questions

To address the aforementioned objectives, answers to the following research questions are sought in this study:

1) What is the current state of MSWM for household waste in Lagos?
2) How do Lagos households currently handle their waste?
3) What other efficient and sustainable options could the state adopt to improve its management system for household waste?

2. BACKGROUND

This section focuses on the description of waste management and the concept of solid waste management hierarchy. It also gives insight to current global approaches, management options, as well as the description of MSWM in Lagos State, Nigeria based on previous studies.

2.1 Waste and Waste Management

Waste can be generally described as any item or material that is generated and disposed of or intended to be disposed of by a person that has custody of it. However, in addition to considerations of legal nature and geographical location of generation, different definitions of waste exist based on conditions under which they occur (Williams, 2005).

A process whereby strategic combination of methods are employed to efficiently regulate waste from source of generation up to the final disposal point is referred to as waste management, and the aim is to maintain a perpetually safe and healthy environment at minimal cost (Igbinomwanhia, 2011). Waste management has been identified as a challenge in many countries all over the world, much more so in developing countries, and a correlation has been identified between accelerated urbanization, population explosion, industrial development and rate of waste generation in cities found in such countries (Narayana, 2009; UNEP, 2005a).

2.1.1 Municipal Solid Waste

Every unwanted or non-useful solid substance generated in any human population is referred to as solid waste (Kaseva & Mbuligwe, 2003). Over time, consumption practices and activities of economic nature have resulted in generation of MSW (Cointreau, 2006, p. 9) which is basically waste that is generated from different sectors of a society such as households, educational, health and commercial institutions, public places, etc., and which is taken care of either directly or indirectly by the municipal or local authorities (Williams, 2005, p. 74). EEA (2009) defines MSW as:

"…waste from households and other waste which because of its nature or composition is similar to waste from households (cf. the Land Directive). Some of this waste is biodegradable, e.g. paper and cardboard, food waste and garden waste. Biodegradable waste means any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard (cf. Landfill directive)" (EAA, 2009, p. 14).

The components of such waste, often an assorted mix, are seldom the same for different areas due to factors ranging from standard of living and habits of residents to resources and climatic conditions found in each geographical location. MSW is often generated in urban areas and has contents that are organic and inorganic nature; the former being often found more in developing countries than the latter. The reverse is mostly the case in the developed part of the world and this is regarded as a significantly distinctive feature from the waste generated in their developing counterpart (Oteng- Ababio, 2011; United Nations Programme, 2005).

2.1.2 Sustainable Municipal Solid Waste Management

Sustainable development is an intergenerational concept. It has been defined as development that fulfills today's generation needs without blighting the opportunity for successive generations to fulfill their own (Idowu, Omirin, & Osagie, 2011). The whole process of collecting, transferring, treating, recycling, recovering resources and disposing solid waste in metropolitan areas defines

municipal solid waste management MSWM (Ogwueleka, 2009). Sustainable MSWM should entail handling of waste (from collection, treatment to disposal) in a manner that ensures continued safety of public and environment (Adewole, 2009).

2.2 Global MSWM Frameworks and Approaches

Due to its significant role in providing safe environment and addressing public health concerns associated with waste generation, MSW is considered as an essential component of modern infrastructure in any society (Nabegu, 2010). The design of MSWM systems should consider and encourage reduction of waste, recycling and recovery of waste, utilization of appropriate waste treatment methods and more environmentally friendly technology as well as appropriate final disposal (Kofoworola, 2007).

SWM has over time evolved and improved to its current state in most developed countries; with these changes have come also the development of concurrent legislative requirements (Williams, 2005). As such, most have come up with contemporary national strategies for sustainable and efficient waste management; as a premier attempt at ameliorating solid waste disposal in the country, the United States developed the 1965 Solid Waste Disposal Act. This was amended under the Resource Conservation and Recovery Act. The latter represented how the country dealt with issues related to disposal of solid waste; although revised to meet present requirements, it also serves as the avenue through which a framework for environmentally friendly solid waste management (including MSWM) is developed via federal programs in the country (ibid).

In an Asian country such as China, policies and frameworks have also been promulgated as a means of combating the challenge of managing MSW. To improve on a previous management system in Hong Kong for example, there was an adoption of the Waste Disposal Plan developed in 1989, which had utilization of 3 large landfills at the core of its strategies for waste disposal; Waste Reduction Framework Plan was subsequently developed (Ko & Poon, 2009). In 2005, the government in Hong Kong established a MSWM policy framework for the region (A Policy Framework for the Management of MSW in Hong Kong). The goals to be achieved between 2005 and 2014 via the strategies employed within the framework include a reduction of MSW produced in the city by 1% every year, a reduction in the amount of MSW deposited in landfills (below 25%) by 2014, and an increase in the total rate at which MSW is recovered - first to 45% in 2009, then to 50% by 2014 (ibid).

In Europe several acts and treaties have come into existence; all having a common goal of environmental protection and amelioration, although with different concepts and strategies. The 1st, 2nd and 3rd Environmental Act (E.A)- underlined pollution containment from waste, pollution avoidance which underlined avoidance of waste, re-use, recycling and end disposal of MSW through environmental friendly methods respectively. Following this was the development of the 4th E.A in which there was an introduction of a hierarchy as a continuous means of executing management of community waste in the European Union (E.U), there was also emphasis on the use of non- polluting technology during production. More recently is the harmonization of sustainable development, environmental regulations, and decision formulation with EU policies and strategies, as found in the 5th and 6th Environmental Act (Williams, 2005).

2.3 The Solid Waste Management Hierarchy

MSWM practices between countries are distinct; in most however, relevant services are rendered by the (local) government or private service providers and may be carried out by employing the hierarchy of waste management (UNEP, 2005b). The hierarchy is regarded as one of the important foundations of contemporary MSWM systems and has been popularly adopted for the development of policies related to waste management both on regional and national level, especially in developed countries (UNEP, 2005a). The hierarchy of waste management - defined by the 3Rs - reduce, reuse and recycle- stratifies options of waste management and focuses on maximum utilization of resources with minimum generation of resultant waste (UNEP, 2005b). The 3Rs refer to the reduction in the amount of waste being generated, the reuse of items prior to their being commissioned as waste, and the recycling of items once they become waste. An expounded version of this in the waste management hierarchy includes- waste prevention/reduction, reuse, recycling &composting, energy recovery, and finally landfilling.

The hierarchy's function is to aid in the management of waste whilst ensuring little impact on the environment; as such, it is employed in the development of policies for resource management, for handling challenges of landfill scarcity, pollution control (of water and air), and to safeguard public health (UNEP, 2005a). In most nations, prioritization of components in the hierarchy is alike- giving preference first to waste prevention, then reuse, recycling (including composting and material recovery), energy recovery and reduction of waste via methods such as incineration and finally landfilling (ibid).

SW Management Option	Advocated Desirability	Global Trend
Prevention/Reduction	Most Desired	Least Practiced
Reuse		
Recycling & Composting		
Energy Recovery		
Landfilling	Least Desired	Most Practiced

Figure 2: Hierarchical arrangement of waste management options (The SWM Hierarchy)

2.3.1 Waste Prevention and Reduction

Waste Prevention occupies the topmost rung in the waste management hierarchy. It refers to the activities undergone with an item prior to being perceived as waste; these involve: decrease in the amount of waste produced via the prolongment of such item's life span and its re-use; decrease in associated environmental and public health impacts from waste produced; and decrease in quantity of noxious substances contained in products (European Commission, 2010). The concept of waste prevention cuts across the entire process a product undergoes- right from its obtainment in raw form, its manufacture, distribution, to its utilization and end of its useful

life. While prevention or minimization may not be isolated to a certain stage in any product's life time, the more efforts directed at waste prevention in the earlier stages of a product's lifetime, the less impact they have on the latter stages (ibid).

In essence, effective waste prevention at source is based on factors which include adoption of suitable practices, adjustments in the usage of raw materials, as well as in technology and production processes. At the domestic level, such would include making suitable decisions in the management of the household (Williams, 2005). Much focus has been given to food waste which is a major component of household waste. Such waste may be esculent (for example, potato peels, food that may have lost freshness) or non-consumable (for example, fruit peels) in nature. Some waste generated in the former group could also be prevented from occurring (avoidable waste); this however does not extend to those which may only be consumed following strict preparation methods (European Commission, 2011). Generation of non- consumable wastes may not be prevented based on their nature and these include calciferous parts of animal products such as shells or bones (unavoidable waste). Still pertaining more to food waste, prevention translates basically to purchasing only what is required to meet one's needs at any given time and maximizing the usefulness of what is purchased (ibid).

2.3.2 Reuse
Following the hierarchy, the next best option for SWM is re-use and this encompasses the utilization of an item after its initial use, either for a purpose similar to that which it was intended or for an entirely new one. This is exemplified in the reutilization of bottles (of beverages) or plastic bags from stores (Williams, 2005).According to the European Commission (2010, s. 48), reuse refers to

"… any operation by which a product or its components, having reached the end of their first use, are used for the same purpose for which they were conceived, including the continued use of a product which is returned to a collection point, distributor, recycler or manufacturer, <u>as well as reuse of a product following refurbishment</u>;"

As such, the reduction of solid waste extends to reuse as the latter slows down the entrance of an item into the waste stream, as well as prevents the amount of items that eventually become waste (European Commission, 2010). Eventually, such result in the reduction of virgin materials and energy utilized in production of items, however, it also means that items have to be made sturdier in order to be used more than once; hence the utilization of more resources during production phase. These in addition to the energy expended on collecting and transporting such products may have negative effect on environment (Williams, 2005).

2.3.3 Recycling
MSW materials which arise following consumption may be recovered and processed into useful items, bearing in mind the cost effectiveness, marketability and environmental impact it may have (Williams, 2005). The recycling process includes collection, segregation and processing of waste with productive value (Pattnik & Reddy, 2009) as such inorganic fractions of MSW (paper, metal, plastic, glass materials) may be recycled (Williams, 2005). This option's suitability depends on inherent conditions of the environment under consideration. Hence, energy resources utilized during the process of recycling as well as the resultant pollution should be minimal in comparison with the utilization of fresh production material. The effectiveness of cost and marketability of products from such activity should also be ascertained (ibid).

Recovery of inorganic materials from MSW has been identified as a key component in the management of waste (Sharholy, Ahmad, Mahmood, & Trivedi, 2007). In some developed parts of the world, recycling activities have been reported to be quite high. The rates in Germany and Austria for example, go beyond 25%, with Austria being reported to have maintained composting rates of about 40% since the early 90s (EEA, 2007) and Brazil having material recovery rates as high as approximately 41% (Troschinetz & Mihelcic, 2008). For most of such advanced countries, recycling is typified by curbside programs through which collection and segregation of recyclables are carried out (ibid).

Recycling is mostly utilized within the context of the usage of solid waste materials for other purpose than it was originally intended- reuse, such are often segregated from other types of waste either via specified receptacles and vehicles for collection, or straight from unsegregated waste (Magutu & Onsongo, 2011). For most developing countries, recycling rates are low and dominated by the uncontrolled salvaging of inorganic materials by the non-formalized sector made up of scavengers (UNEP, 2005a).

2.3.4 Composting

Organic components in MSW (i.e. waste of food and garden origin) are considered useful composting material (Williams, 2005). Composting is a process which could decrease MSW by an average of almost 68 % of its original volume (Sharholy, Ahmad, Mahmood, & Trivedi, 2007). The process has been defined as the:

"… biological decomposition of biodegradable solid waste under controlled predominantly aerobic conditions to a state that is sufficiently stable for nuisance-free storage and handling and is satisfactorily matured for safe use in agriculture" (UNEP, 2005a, p. 197).

The end product, compost, may be utilized in the conditioning of soils meant for agricultural purposes; its use in this manner gives the soil a stable nutrient source (nitrogen, potassium and phosphorus) that is gradually tapped from, and aids its water retention capacity. The usefulness of compost also extends to coverage material for landfill sites as well as material for land reclamation from mining activities and incidents of erosion (Ali, 2004; UNEP, 2005b).

With regard to reducing the amount of waste that ends up in solid waste disposal sites, composting is considered a more viable and sustainable option for developing countries due to the high organic fraction of waste generated (Troschinetz & Mihelcic, 2008) and resource constraints in such countries (UNEP, 2005a). An advantage of this option when compared with other options in the SWM hierarchy, is its employability in a catalogue of conditions due, inter alia, to its non-rigid requirements, consequently, methods of composting range from the unsophisticated which may be found in developing countries to the highly sophisticated used in developed countries (ibid). However, the success of composting for environmental benefits (i.e. reduction of organics in the MSW stream) and economic benefits (e.g. from sales of recycled organic waste to compost- for agricultural soil improvement) rests mainly on segregation of waste at source, in which case households have important roles to play as they are major producers of organic waste (Ali, 2004)

The organic fraction of MSW may also be useful in the production of carbon dioxide and methane gas in a process called anaerobic digestion. The process is achieved in an enclosed environment under anaerobic conditions (environment lacking in oxygen) with an external

medium for the supply of heat. The methane gas thus generated may be contained and utilized for the production of steam or power; the gas may also serve as fuel upon purification (UNEP, 2005b).

2.3.5 Energy Recovery

MSW contains organic components which are combustible. Thus, energy could be gained from incineration of waste or landfill gas combustion, which may be used to generate electric power (from steam under high thermal conditions) or produce heat for buildings (through boilers) (Williams, 2005). As such, the process of converting solid waste of organic nature into other useful forms such as gas, heat, steam and ash residues via combustion is referred to as incineration and such process is carried out in places often referred to as Waste-to-Energy (WtE) plants (Magutu & Onsongo, 2011).

In the reduction of solid waste volume by 70 to 80% lies also a main advantage of this method of waste disposal, as this minimizes the quantity of waste that is eventually sent to the land fill. Consequently, for nations where land space challenges exist for example, Japan and Singapore, incineration is a popular waste disposal option (Magutu & Onsongo, 2011, p. 6). Further, following the introduction of bans and taxation on landfills with regard to biodegradables, countries such as Sweden and Denmark in the European Union (EU) have been reported to be the most active in the use of incineration for disposal of MSW (EEA, 2007). According to Williams (2005), simultaneous production of heat and power (combined heat and powers) from landfill gas and incineration makes optimum energy recovery from (organic) waste achievable. However, in comparison with their initial forms, new products that arise from incineration of waste (liquid and air discharge inclusive) pose more difficult management and environmental challenges- a development which has increasingly seen many countries banning this option for waste management (Narayana, 2009).

2.3.6 Landfilling

Landfilling is the deposition of waste either in a specific land area with the goal of preventing such waste from impacting negatively on the environment (Narayana, 2009). A landmark in the EU strategy for waste management was the development of the 1999/31/EC directive on waste landfilling. The landfill directive has its roots in the hierarchical prioritization of waste management options- giving maximum preference to prevention of waste, with reuse, recycling, recovery options following and landfilling having the least priority. Realizing how landfilling could be impactful on the environment through greenhouse gas (GHG) emissions and other forms of pollution (through soil, surface and ground water) and how inadequate space could be a challenge, the landfill directive discourages heavy reliance on this option by setting goals which gradually reduce the quantity of municipal waste that is relegated to the landfill until the year 2016 (EEA, 2009), when a reduction in the quantity of biodegradable waste sent to the landfill should be 65% in comparison with the amount that went for landfilling in 1995 (Bogner et al, 2007)

Despite being widely considered as the least desirable option, the most prevalent approach to the disposal of waste globally has been the utilization of landfills. This remains an important aspect of the SWM plan of most countries and varies in structure; ranging from sanitary landfills, to semi-controlled landfills and uncontrolled (or open) dumpsites (Remigios, 2010). Sanitary landfills are designed according to specifications which help to ensure minimal impact of

disposed waste on the environment. As such, they are structured for leachate containment and treatment, as well as management of greenhouse gases (carbon dioxide and methane) which are produced in the event of waste decomposition. Such well-structured landfills exist in nations with developed economies (ibid). Generally in North America and other countries Australia and New Zealand, the most utilized option for waste disposal on a large scale remains landfilling. However, such is highly controlled and goes with adherence to corresponding legislative landfilling and air quality requirements (Bogner et al, 2007). For highly industrialized Asian countries such as Singapore where space for perpetual landfilling is a challenge, this option is only utilized when other means for waste disposal are not feasible (Zhang, Keat, & Gersberg, 2009).

In the global South, partly operated waste disposal sites, referred to as semi-controlled landfills and uncontrolled dumps exist. For the former, compaction of waste and subsequent covering with topsoil is carried out. However, structures for leachate and greenhouse gas containment as well as restriction on the type of waste being deposited are absent. Uncontrolled dumping is the main and favored means of solid waste disposal in a majority of nations on the African continent. This involves disposal of waste on open, non-structured area of land without considerations for environmental impact (Remigios, 2010).

2.4 The Case of Lagos State
The authorities that are mainly concerned with SWM in Lagos state are the Ministry of Environment and Physical Planning, Local Government Councils, Lagos State Environmental Agency and Lagos State Waste Management Authority- LAWMA (Kofoworola, 2007). The creation of Lagos state Refuse Disposal Board in the late 70s marked the beginning of SWM in Lagos state (Igbinomwanhia, 2011). The name of the board evolved to Lagos State Waste Disposal Board in the early 80s with increased scope of services to be rendered in the collection of solid waste. The main body currently in charge of SWM in the city of Lagos is LAWMA a body which operates under the state government and has been in existence since 1991(ibid). It was founded on the realization by the government a need for waste management in a more efficient manner, which not only includes collection and disposal but waste management as well (Lawal, 2010).

Previous studies have revealed inefficiencies in the Lagos MSWM system, which include inadequate number of vehicles for waste collection and transportation, improper disposal methods of waste in dumpsites, administration problems including lack of strong institutional framework, inadequate funding   (Longe, Longe, & Ukpebor, 2009). Adewole (2009) also identified unhealthy waste disposal habits of inhabitants, disposition of employees in waste management to work, continual increase in the state's population, corrupt practices and lack of proper role definition among related agencies as some problems that have been faced in the management of solid waste in Lagos. In addition, Igbinomwanhia (2011) identifies insufficient data on waste, inappropriate tools and low budget allocations to be other challenges being faced in the management of waste by LAWMA.

The cooperation between the LAWMA and private operators is reported to have led to more efficient collection of waste from places of residency; the outsourcing of waste collection to the private sector under the PSP scheme may thus be considered as a significant improvement that has been made (Idowu, Omirin, & Osagie, 2011). Awareness and patronage of private operators

could be a contributing factor to such an improvement; about 90 % of residents in Agege local government area for example, avail themselves of the services offered by the private operators - compared with the more predominant use (almost 94%) of cart pushers and communal waste sites in the past (ibid). Series of monthly records documented by LAWMA (2011) indicate also that when compared with other modes of collection (waste collected directly by LAWMA and Franchising), the private operators have played the most active role in solid waste collection, deposition at landfills and dumpsites provided in the state. On a more general note, Oresanya (n.d) has attributed the improvement in waste collection to good and stable governance at the state level over the past few years.

2.4.1 Collection

Improvements in the collection of household waste have been reported in Lagos state. To facilitate easy collection of waste and also to keep the environment clean, about 17,000 wheeler bins have been distributed to places of residence based on payment of land use charges and according to Oresanya (n.d) about 30% of residents in the state now own bins that are used to store household waste. Considering the population size of the state, the number of residents which have been provided with such bins may be regarded as insignificant. While residents in the state are encouraged to bag their wastes before disposal in bins (LAWMA, n.d); Longe, Longe, & Ukpebor (2009) note that activities such as separation of solid waste in residential areas are non-existent in the state.

Again, the use of proper bins by residents has been reported to improve waste quality in terms of reduced moisture content level and specific weight (Oresanya, n.d). An interview conducted by a local newspaper, the Nation (Odukoya, 2010) revealed that residents are expected to purchase the bin bags they use for waste disposal from the local stores or waste collection trucks; however, total compliance with this practice appears not to have been achieved as a result of residents not willing to relinquish their waste bags to the waste collectors.

The wheeler bins introduced are reported to have aided the reduction of household waste collection (to two times within seven days) by collection trucks, hence minimizing the amount of fuel utilized and facilitating less pollution of the environment from greenhouse gases   (Olubori, 2011). In 2009, about 250 trucks were available to LAWMA for waste collection (LAWMA, 2011). However, it is not clear if these to be made available to the private operators for waste collection under some form of agreement or if they are solely for waste collection by LAWMA.

For areas that are inaccessible to waste collection trucks as a result of bad roads, LAWMA has proposed the use of tricycles for waste collection services (LAWMA, n.d). Further, it appears that a definite extent of coverage for waste collection services within the state is yet to be determined, though all local government areas appear to have been allocated private operators. While the introduction of about 9 recycling banks has been advertised by LAWMA, the functionality of these and their use by residents has not been so far documented.

Payment for the services of the private operators is reported to be structured based on the size and type of building from which waste is generated (ranging from 100 paid by people living in one room apartment to 1000 for residents in duplex buildings), Willingness of people to pay has however been identified a major challenge in this regard (Odukoya, 2010).

2.4.2 Recycling, Resource Recovery and Incineration

According to UNEP (2005a) heavier dependence on the use of plastic based packing material in developing countries may result in increased incidences of littering the outcome of which could be more pollution of the environment (including water bodies) and blockage of drainages. Lagos appears to be moving in this direction as the organic proportion in the MSW stream appears to have decreased relative components of inorganic nature, especially plastics. Nevertheless, the organics still make up a large part of the MSW stream in the state. In order that MSW generated may be significantly reduced, UNEP (2005a) suggests that more importance should be paid to the diversion of organic based components and such would be based *inter alia*, on efficient collection methods. In Lagos bin bag production from polythene recycling and paper bailing are currently carried out on a small scale by LAWMA. Composting is also being done in conjunction with a local company where current production capacity is 25bags/day and the installed production capacity is 1000 bags/day. Even with its small operations, the state is considered to be the largest producer of compost in Africa. The waste material used for composting are mainly sourced from certain markets within the state as waste collected from residential areas are not sorted by the residents (Oresanya, n.d). LAWMA estimates that about 12% of the total waste in the state is being recovered from composting, paper baling, and conversion of water sachet bags to bin bags (LAWMA, n.d).

2.4.3 Disposal

Land filling appears to be the main method of disposing the approximately 10,000 metric tons (Olubori, 2011) of waste generated per day in Lagos. The state is reported to have 3 landfills and 2 dumpsites which serve as destinations for all MSW collected. The Olushosun landfill with a total land area of about 42.7 hectares (ha) is the largest landfill in the state. Sited in Lagos' northern axis (Ikeja LGA), it is reported to have been in use since 1992 and shall continue to be for another two decades (LAWMA, 2011). The second landfill at Abule-Egba is sited (within Alimosho LGA) in the western axis of the state. Its covers about 10.2 ha of land but has not been in use for over 3 years, though reported to have a possibility to be used for another 8 years. The landfill located also within Alimosho LGA are split into two with Solous II covering about 7.8 ha and Soluos III about 5 ha and both to be used for about 5 years (ibid).

According to Kofoworola (2007) an integrated approach to the management of solid waste in Lagos state is non-existent. Considering the waste hierarchy; prevention, re-use, recycling, incineration and landfilling (written in a manner of importance in waste management), it appears that the Lagos state government and LAWMA have so far invested more attention and resources on the lowest rung of the hierarchy- especially land filling, dumping and to a lesser extent, recycling and resource recovery (when the recycling activities, are compared with the total amount of waste generated per day and the potential to achieve more).

With a high population of approximately 18 million (Lagos Bureau of Statistics, 2010) and amount of waste generated per day, more may be achieved in the waste management sector if an integrated approach to waste management is employed in the state, with more focus also directed at alternatives of waste management placed higher on the waste hierarchy, especially reduction of waste from generation points, as waste that is non-existent requires no management (Christensen, 2011).

2.5 Solid Waste Management Structure in Lagos

In Nigeria, the legal, policy, and administrative frameworks for environment and indeed solid waste management issues exist, however, inadequacies in the system have rendered these ineffective. For cities such as Aba, Enugu, Owerri, Warri, Port Harcourt, Kaduna, Ibadan and Lagos disposal of MSW has been challenging and indiscriminate of waste is reported to be practiced (Idowu, Omirin, & Osagie, 2011). In Lagos, the administrative framework applies at two levels; agencies charged with administration (regulation, management and enforcement) of environmental issues include the Lagos Metropolitan Development and Governance Project, the Lagos State Ministry of Environment, LAWMA, Lagos State Environmental Protection Agency, Lagos State Ministry of Physical Planning and Urban Development, Lagos State Ministry of Health, Lagos State Ministry of Information, and Lagos State Ministry of Works and Infrastructure. The Local Development Authority and Local Government Authorities take up management roles for waste at the local level (LSG, 2009).

In addition to inadequate staffing, technology, and little funding, overlap of regulatory functions in most of these institutions have been a major setback as it creates a climate for unhealthy competition and little advancement which may otherwise have been achieved if roles of each institution were more specific or complimentary. Also, inadequate waste disposal infrastructure, weak cost recovery plan for SWM services rendered, and non-cooperative attitude of public (not in my backyard-NIMBY) have been identified as challenges in the system (LSG, 2009). Longe *et al.,* (2009), also posit that methods of waste collection and transportation utilized in the state are not efficient.

3. MATERIALS AND METHODS

This section describes the area of study, the means through which data was obtained and the methods employed in the analysis of data.

3.1 Description of Study Area

Lagos, Nigeria's commercial capital boasts almost 20 million of the country's population and hence is regarded as her largest city. Despite this large population, it also happens to be Nigeria's smallest state in terms of geographical size; the state is located in the southwestern part of the country, covering an area of 3577 km^2. With an average growth rate of about 4% per year and about 5032 people/ km^2, the city of Lagos is identified as one of the most rapidly growing metropolitan areas in the world (Lagos Bureau of Statistics, 2010). The population size has an explanation in the state being a major center of the commercial activities (about 70%) in Nigeria as well as it having good geographical location (ibid). The state is expected to be counted among the first 10 cities with the highest population in the world the year 2015 based on a projection that the population shall reach almost 25 million (Igbinomwanhia, 2011). Lagos is made up of 20 Local Government Areas (LGA), with its urban parts covering about 37% of its land area, however, more than 85% of its populace inhabit these areas (ibid).

Figure 3: Map of Lagos showing major Local Government Areas[2]

In this study, households interviewed fall under Alimosho LGA, Kosofe LGA and Ifako Ijaye LGA. As at two years ago, Alimosho LGA was the largest and the most populated LGA in the state with a population of 2,321,893, while Kosofe LGA and Ifako-Ijaye had a population of 1, 060,110 and 844, 268 respectively (Lagos Bureau of Statistics, 2010). Observation of waste disposal sites and scavengers covered in this study fall under Alimosho LGA and Ikeja LGA while that of the private operators fell under Alimosho LGA and Kosofe LGA. [2]

3.2 Methodological Framework

Case study methodology describes the general framework within which this research was carried out. The method is typified by its use in the study of phenomena at differing levels of complexity and also serves an avenue through which theory may be applied; it is the organized collection of

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[2] (http://mapsof.net/map/lga-lagos, May, 2012).

data about an individual or individuals, a social situation or issues- through different means and in a way which furnishes better understanding of the study topic (Berg, 2009). Case study method is suitable to this study as it focuses on municipal solid waste management in a specific geographical region (Lagos State) within a country (Nigeria) and data was obtained for the study through a combination of data collection techniques.

Lagos was chosen as a case study in this research because from a socio-economic viewpoint, it is an important city in Nigeria. Again, the state appears to be a pace setter for development activities carried out in other states, as such, a study towards improving the management of waste collected from households in the city may serve as a driver for improvement of the same in other cities in the country. A third reason lies in Lagos being the city where the researcher was born and has lived for years. Finally, while many studies have hitherto focused on the challenges of solid waste disposal in the state and little attention has been given to all the key actors in the sector. This thesis takes a holistic approach in its study of solid waste management in Lagos. The type of solid waste generated by households, the disposition of this group and other stakeholders towards waste handling, management and disposal options are studied to the end of identifying inherent challenges at each level of the MSWM system. Improvements are suggested using the solid waste management hierarchy as a reference point.

3.3 Data Collection and Approach

In order to achieve its associated aims, the approach utilized in this research is essentially a qualitative one- as it focuses more on the quality of data obtained and analyzed and less on quantity of the same within the topic of study (Bryman, 2004) to the end of finding answers to research questions via studying a society and its inhabitants (Berg, 2009). Data utilized was obtained through primary and secondary sources; for primary data collection, field observation and interviews of some stakeholders in Lagos' MSWM sector namely households, private operators, LAWMA personnel and scavengers. Secondary data was retrieved through an extensive desk research of relevant literature.

3.3.1 Choice of Stakeholders

Four stakeholder groups: households, private operators, LAWMA and scavengers were chosen in this study as they may be considered key actors in the SWM cycle of the state, right from generation to final disposal.

Households are one of the main sources of MSW in the state; consequently, the attitude and disposition of this group to waste generation may be regarded as critical and thus, should be given more attention in order that programs put in place by the waste management authorities produce desired results. Private operators are important in the SWM cycle given their role in the collection of waste generated from households, and the conveyance of such to solid waste disposal sites. In this study, it is presumed that efficiency of this group affects the whole cycle as they serve as a vital link in the MSW collection-disposal process. Waste management programs are created and effectuated by LAWMA, decisions of MSW treatment and disposal options also lie with the agency. Being a major institution in charge of MSWM in Lagos, LAWMA is chosen as one of the stakeholders in this study. Finally, albeit playing a largely informal role, scavengers are perceived to be major stakeholders in the state's solid waste management as what they segregate appears to drive most recycling activities while also serving as an income generation avenue.

All four stakeholders though important in themselves, are considered in this study as important links in the SWM chain in Lagos. In addition, it is presumed that the successful employment of an integrated approach in the management of waste would involve a sustainable synchronization of the activities of these main groups.

3.3.2 Size Selection

Management personnel in LAWMA, ten households, two private operators, and three scavengers were interviewed. The sample size was not meant to be representative of all actors in the state, neither was there an intent to utilize random sampling methods across the state; the choice was informed by the need to obtain detailed information about the MSWM situation from related and important actors in the state- which may not be the case if a larger population were utilized. In addition to the scope of this study, a larger sample would have been a challenge given financial and time constraints of the researcher. As such the sampling method could be described as non-probabilistic, and purposive as described by Bryman (2004) since all actors were chosen bearing in mind their pertinence to the research questions. A snowball approach was employed in household, private operator and scavenger interviews. In the case of the latter, itinerant scavengers were initially targeted, however, restrictions placed on their activities in neighborhoods especially in terms of what they collect, make scavengers on the landfill more relevant actors to this study. Interviews were granted by the scavengers based on recommendations made by onsite solid waste disposal staff and the first scavenger interviewed onsite.

3.3.3 Stakeholder Interviews

The interviews carried out on members of all four stakeholder groups i.e. households, private operators, LAWMA personnel and scavengers were semi- structured in nature as described by Berg (2009); as such, pre- formulated questions were asked following a determined pattern (Appendix A1-A4); however, follow up questions were posed for further elucidation of questions and responses during the course of the interview. In addition, the vocabulary usage was adjusted to suit the level of understanding in these groups. The aim of using semi-structured questions is to draw out and gather data by posing pre-formulated questions which will give an interviewer insight into interviewees' perceptions, view-points and behaviors as regards the study topic. The non-rigid nature of this method of qualitative interviewing provides the chance to gather robust information from responses of subjects being studied, while also making room for adjustments in the focus of research if need be (Berg, 2009; Bryman, 2004).

3.3.4 Field Observation

Observation (Appendix A5) could serve the purpose of helping to validate information provided by subjects during a study; hence the ability of a researcher to experience firsthand, social happenings and actions of related actors in the same environment, furnishes a means through which validation of data and further understanding of the topic may be achieved. This may be achieved via seeking correlations or disparities between what actors in the study say and what they practice in reality (Bryman, 2004).

Observation activity on solid waste disposal sites and collection of waste by private operators in this study was based on participant observation. Pictures were taken as part of the process; and in the case of households, notes also made. The private operators were observed during waste collection from households in 3 different neighborhoods, while waste disposal sites were visited for observation. Although observation protocols were developed prior to the field study, these

only served as a guide and were not restrictive as regards what could be observed. As such, some unplanned points of observation were included during the study; this was especially the case during the observation of the private operators and solid waste disposal site.

3.3.5 Household Interviews and Observation

In total, ten households (Household A, B, C, D, E, F, G, H, I and J) were interviewed and the interview questions were posed to the head of the household or their spouse; focus was on dynamics of household waste in terms of content and volume, practices, attitudes associated with household waste disposal, as well as knowledge of SWM practices by households in Lagos.

Prior to the interviews, households were asked to keep their waste for a day and components were subsequently observed. Bags were not distributed to the households for this purpose. This was not done to avoid restrictions in the amount of waste that may be generated based on the size of bag given out for the exercise.

Observation was carried out in all the households and this included a survey of disposal points, method(s) of waste storage and composition of waste. The observation was done by separating the waste components into different segments using a makeshift separation mat and a pair of disposable gloves. Ocular guestimates were then made to determine the volume of one waste component relative to the other. Upon completion of the process, the waste was gathered into a waste bag and disposed of immediately.

3.3.6 Private Service Participation Operator Interviews and Observation

Two private operators working under different local government areas (LGAs) within the state, Shomolu and Alimosho, were interviewed and the information thus obtained was combined with information gathered from field observation. In total, observation was done at 3 different locations within the state and in each case, operational activities of the private operators during collection of waste from different households were observed, including the type of vehicles, protective gear used by the waste collection crew, and waste scavenging. Two of the observed operations fell within Alimosho LGA and a third within Kosofe LGA. One of the observation rounds within Alimosho LGA included the researcher going on a day's collection trip with a private operator truck. The observation ended with the truck's trip to the solid waste disposal site.

3.3.7 LAWMA Interview

LAWMA personnel were interviewed and information on their activities as regards MSWM in the state - from collection of household waste to final disposal- were points of discussion in the structured interview. Observation of this group was not done, as their role in addition to the coordination of private operators, involves development, management and execution of solid waste management projects. The agency also plays regulatory roles in the state's SWM..

3.3.8 Scavenger Interview and Observation

In order to gather information on scavenger activity, a total of three scavengers were interviewed on the solid waste disposal sites using semi-structured questions. All three interviewees lacked formal education; consequently, English language was not utilized as the primary means of communication. This was also done in order to ensure that all questions being posed were fully understood and responses effectively communicated to the interviewer. Thus, as two of the interviewees were of Yoruba origin, the interview was conducted in Yoruba language. The third interviewee was Hausa; hence the questions were posed and answered in pidgin English which is

a general means of communication in the country between people from different ethnic groups, as well as for those which are not formally educated. Observation of scavengers was non-structured and it consisted basically of the photographic capture of how waste was picked on the landfill, the tools utilized in the process of picking and what was done with some of the waste materials after picking and sorting.

3.3.9 Solid Waste Disposal Site Observation

Field observation also included a concurrent survey and gathering of landfill information with site manager. Pre-structured points for observation were developed and modified accordingly during the planning stage of the observation protocol. These were used as a guide to ask questions and obtain information about the land fill; such include data on landfill operations, physical conditions, available equipment and scavenger activity. Pictures were also taken at different points on the landfill. The same process was repeated at the Solous dumpsite that was visited.

3.4 Materials

Materials utilized for data collection from the field include a tape recorder for the interviews; this is a particularly useful tool in qualitative interviews as it furnishes the researcher with an opportunity to give full attention to the subject's response, asking further questions on points of interest in the response, while also identifying inconsistencies if any (Bryman, 2004). The same was used during observation on the waste disposal site in addition to the use of a camera.

For household observation, a pair of gloves, a makeshift cardboard mat for observing the contents of a day's waste generated in each household interviewed and a camera were utilized. The utilization of a camera was basically for the purpose of obtaining photographs that would improve the description, presentation and understanding of the topic of study and results. Consequently, pictures were taken of different objects of focus in the field right from households' solid waste storage to collection, disposal and landfill activities. Upon the completion of the field work, all recorded interviews were transcribed and pictures grouped in preparation for analysis.

3.4.1 Analysis of Data

There are several methods that can be applied in the analysis of qualitative data. Content analysis is the thorough and in-depth evaluation of data for the purpose of bias or trend identification and interpretation. More specifically, it has been described as "any technique for making inferences by systematically and *objectively* identifying special characteristics of messages'' (Holsti, 1968 in Berg, 2009 pg. 341). Data gathered during this study was analyzed by employing of an interpretative technique; as such, categories, trends and themes were identified and drawn out from the interviewees' responses and field observation. These were compared both within groups and across groups. For easy reference in the presentation of results for this study, stakeholders are cited collectively when a similar opinion or trends are identified within each group (for example, 'Households, 2012' or 'Household A, 2012; Household B, 2012'). The converse is done when responses are not the same or when an interviewee is being quoted.

3.4.2 Limitations in the Field

Given the nature of qualitative studies, strict schedules were not followed; the interviews were carried out when granted by the subjects. It was a challenge to get households that would be willing to grant interviews during the day time- many were either out at work or were about

other daily activities. As such interviews appointments were either carried out during the evenings or postponed more than once before finally holding. This was a challenge considering the heavy traffic situation in the city during working days of the week, especially in the evenings Households were asked to keep their waste for a day prior to the interviews in order to determine the components of waste generated without introducing bias from the interview questions to be asked during the study. In instances where interviews with households had to be postponed, the researcher had to request that another collection of a day's waste be repeated. Some of the households concerned found such requests inconvenient.

With LAWMA, the researcher experienced (about 6) days of delay before being granted an interview. This was due to several protocols observed within the organization and perhaps some bureaucratic barriers unclear to the researcher. This also delayed the researcher's access to the waste disposal sites; according to the site manager, a letter of introduction which stated the purpose of the researcher's visit did not suffice. The researcher obtained and presented a letter of authorization from LAWMA before access was granted to the sites. Access also included having the freedom to speak with scavengers, waste disposal site manager and other members of staff, as well as taking photos at the site without being apprehended.

Interview of scavengers was limited to those at the landfill; itinerant scavengers have become fewer due to restrictions placed on their waste collection activities in the city since many also were cart pushers. Consequently, scavenging is more concentrated at solid waste disposal sites in Lagos. Secondly, language barrier was a challenge as the scavenger population is dominated with people from the northern part of Nigeria, in which case none could comprehend English and only few, pidgin. Many spoke only Hausa, a language the researcher neither speaks nor understands. Other scavengers that understood pidgin either pretended otherwise or avoided the researcher altogether, especially once they sighted the camera being used for observation. This was also noticed in the case of the few from other tribes in the country such as the Yoruba and Ibo tribes. In addition to this was the scavengers' perception that they had more to loose from spending time on an interview- interviews would not earn them money, scavenging would. As such, it took combination of putting the camera out of sight, repeated assurances on the part of the waste disposal site staff and the interviewer's offer of incentive in exchange for interview time with the scavengers.

4. RESULTS

Data obtained from the field are presented in this section using tables and descriptive methods. Solid waste management practices and opinion of different actor groups interviewed are presented.

4.1 Classification of Households

The LGAs which fall under this study, Alimosho, Ifako Ijaye, and Kosofe, have been classified as low income, middle income and high income based on the perceived economic status of households interviewed.

LGA	No of Households	Socio-Economic Feature
Alimosho	2	Low Income
Alimosho	2	Middle Income
Ifako Ijaye	3	Middle income
Ifako Ijaye	1	High Income
Kosofe	2	High Income

Table 1: Showing classification of households based on perceived economic status (Author's Field work, 2012)

4.2 Components of Household Waste in Lagos

From ocular guestimates carried out during observation of a day's waste generated in each household, approximately 55% of the waste was organic (food waste), about 25% was plastic, paper made up about 12%, while the proportion of metals in the waste was estimated at 8%. Glass, textiles, ashes and dust were not observed in the waste generated in any of the households.
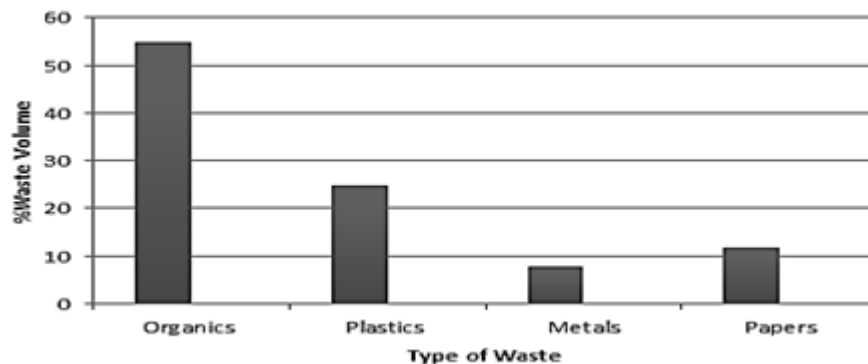
Figure 4: Distribution and components of household solid waste by volume
(Author's Field work, 2012)

Organic waste components were similar across all ten households interviewed. In all the low income and middle income households, paper, empty sachet water bags and plastic shopping bags were observed. From some of the middle income households (Household C, D and E), empty beverage cans and empty plastic water bottles were also observed (Field Observation, 2012). In addition to plastic shopping bags and paper, empty PET bottles, and metal bottle corks were observed from the households perceived to be of high income status .i.e. household H, I, and J (Field Observation, 2012).

In the year 2001, a large part of MSW was reported to be made up of vegetal components followed by ashes & dust, miscellaneous inert, paper, plastics, metals, glass, textiles, and bones making up the remaining fraction. In terms of relative proportion, organic waste (vegetable, putrescible & bones) made up about 32% of MSW in the state, while also in approximate values, paper made up 10%, plastics 8%, textiles 4%, metals 4%, glass 3%. Others such as miscellaneous inert, ashes & dust (fines) were 19% and 22% respectively (Kofoworola, 2007). In addition to the previously mentioned, other components such as soil, ceramics and rubber have been identified as components of the waste stream (Ogwueleka, 2009). MSW generated in the state as at 2011 reflect some variation in proportion, with vegetables accounting for about 45% of the waste, plastics 15%, paper 10%, putrescible and fines 8% each, glass and metals approximately 5% each, and textiles about 4% (Olubori, 2011). About 0.5kg of waste has been reported to be generated by each person daily in the state (ibid). Comparing these data from 2001 and 2011, proportion of organic waste and plastics increased more significantly than metals and glass. Ashes and dust represent the most significant change in volume and this could be due to less burning activity in the state.
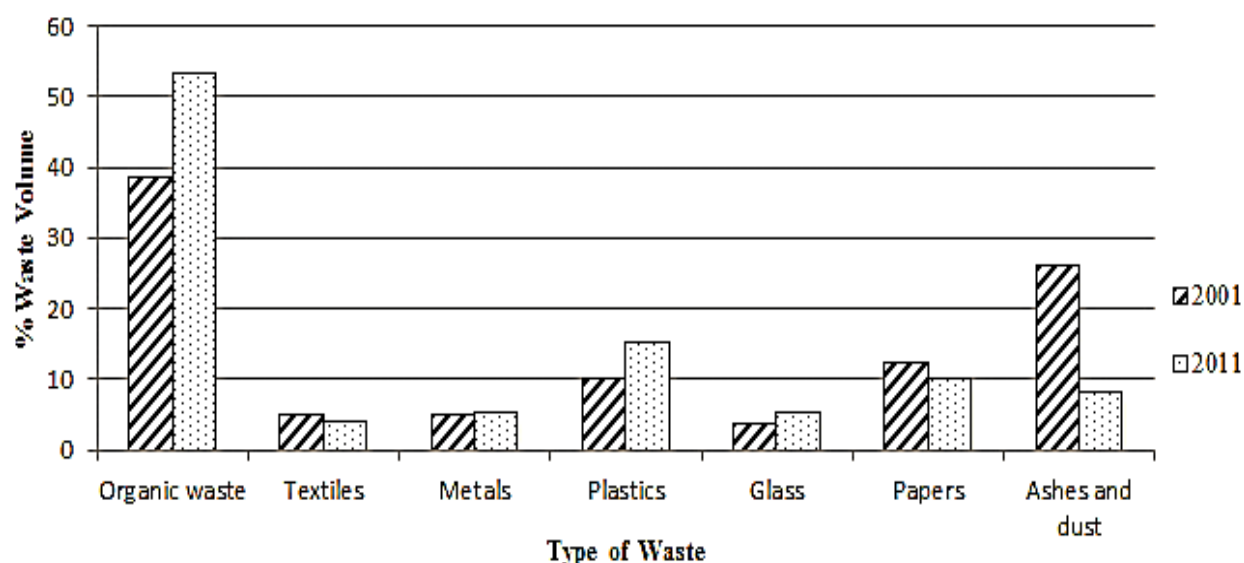
Figure 5: Relative proportion of MSW components in Lagos state.
(Source: Olubori, 2011; Kofoworola, 2007)

4.3 Changes in Household Solid Waste

The interviews reveal that all ten households have experienced continuous increase in the volume of waste generated in their homes in the last 20 years. Factors attributed to this include increase in family size, age of household members, change in eating habits, influx and increasing trend in the use of items made from disposable materials such as plastic bags, plates, cutlery, PET bottles, commercial sachet water nylons and canned beverages. Few (about 2) households however indicated fluctuations in volume of waste generated due to change in marital status and family size over the last two decades (Household D, 2012; Household F, 2012). The same upward trend in volume, and change in content of solid waste generated in the state was affirmed by the private operators, LAWMA and scavengers interviewed.

According to all the households, private operators and field observations, organic waste generated from homes are mostly from food preparation; these include bean chaff, plantain peels, yam peels, egg shells, vegetable stalks, tree leaves for local food packaging & preservation, fish intestines, meat bones and inedible parts of fruits such as banana peels, mango and orange skins, maize cobs. Uncooked food which end up as waste is mostly a result of improper storage of food items starting from the place of purchase, as seen in the case of yam tubers. For such food items, it may be difficult to ascertain spoilage prior to purchase. All ten households reveal that the proportion of organic waste in comparison to other components of solid waste generated in their household has reduced over the last 20 years; this has been identified as a consequence of improved technology in the production and preparation of food items. While the use of tree leaves is still in practice, such use has reduced tremendously; plastic plates, polythene and foil paper are being used more as substitutes for wrapping and packaging food (Households, 2012).

Figure 6: Comingled household waste

The increase of inorganic waste proportion over the years has also been attributed to the increasing adoption of western culture and lifestyle which in turn informs change in eating habits, consequently, packaging material, bags, plates and cutlery made from plastic is being generated more from patronage of the numerous fast food outlets that have cropped up across the state (Households, 2012). Changes in the waste proportion are also acknowledged by the private operators, LAWMA and scavengers interviewed. According to these groups, component of household waste are also affected by the socio-economic status of residents; more organic waste from food preparation may be observed and commercial sachet water nylon in the case of low income households, while the same including PET bottles and other disposable items may be found in middle income or high income households (Operators, 2012; LAWMA, 2012a; Scavengers, 2012). Factors such as seasonal availability of certain food types (e.g. maize in the rainy season), and festive periods (e.g. Christmas) also contribute to seasonal increase in volume of solid waste generated from households (Operator B, 2012).

4.4 Results Following the Waste Hierarchy
In the following section more results are presented following waste management hierarchy

4.4.1 Reduction of Waste from Households
All the households interviewed do not believe that waste reduction could be an effective management option, above what they already practise. This group considers the waste they

generate as unavoidable ones (Households, 2012). From the private operators' point of view, organic waste reduction may be impossible; according to one of the operators:

"…we cannot say people should not eat, reduction of waste if is to be accomplished at all, it would be from the inorganic component of waste; it would involve the introduction of recycling programs to households by the government in which case awareness is created that certain waste when separated from the others, may be exchanged for financial gain" (Operator B, 2012).

4.4.2 Reuse of Items

Reuse of items is common amongst all the households interviewed. The degree to which this is practised however vary from one to another, as such, at least one item made out of plastics such as beverage bottles or commercial water bottles, plates from fast food outlets and shopping bags are reused in most of the households (Household A, 2012, Household B, 2012; Household D, 2012; Household E, 2012; Household F, 2012; Household G, 2012; Household H, 2012; Household J, 2012). Other items that are reused include textiles in the form of old clothing; these are used as dusters or foot mats, or given out to the less privileged (Household E, 2012; Household I). Newspapers serve as glass door & mirror wipes as well as creative art material for school pupils, however its use for these purposes is infrequent (Household B, 2012; Household C, 2012). In addition to reuse for water storage purpose, sales and barter of plastic bottles is actively practised in one of the households. Plastic bottles and glass bottles from beverages are taken to the market and exchanged for cooking oil, groundnuts and at other times sold or used as storage containers for cooking fuel i.e. kerosene (Household H, 2012). Sales of newspapers, journals and magazines to itinerant buyers used to be a practice in some of the households; items such as newspapers, textiles, glass bottles were not sighted in any household during observation.

Figure 7: Itinerant metal scrap buyer negotiating with household seller

All the households are of the opinion that there is a limit to the amount of items that may be reused and the length of time such remain useful; according to members of this stakeholder group, such items ultimately constitute a nuisance in the household if retained perpetually for reuse, hence, they are mostly discarded once perceived as useless (Households, 2012). It was observed that all reuse activities within are tied mostly with economic benefits that may be derived, and sometimes convenience.

4.4.3 Recycling of Items

Recycling activities were not carried out by any of the households interviewed and no segregation is done for final disposal of waste generated. In one household perceived to be of low income (Household A), metal scraps are an exception because they can be sold to itinerant scavengers at relatively fair price. In addition to selling metal items, the household revealed that the metal waste is sometimes piled up and taken to local fabricators once every few years and converted into new items such as metal pots and kettles (Household A, 2012). Before now efforts towards formal recycling were not existent in the state because the initial focus of LAWMA was to provide better waste collection services and reduce indiscriminate dumping in the state. Co-mingling of waste and inadequate infrastructure for recycling have also been identified as reasons for the low level of formal waste recycling achieved so far in the state (LAWMA, 2012a). Recycling programs for glass, plastics, metals and paper appear to be in the planning phase by LAWMA; the first would include placement of recycling banks in a few locations in the state and the second involves the establishment of a polythene recycling plant at the Olushosun landfill. The recycling plant offers monetary reward of 30 Naira (an equivalent of approximately 1.30 SEK) in exchange for 1kilogram of commercial sachet water polythene (LAWMA, 2012a); very few households mentioned hearsays about a plastic recycling program embarked upon by the government, uncertainty as to the validity or existence of such program is evident across this stakeholder group. The figure below explains the fate of waste generated from households.
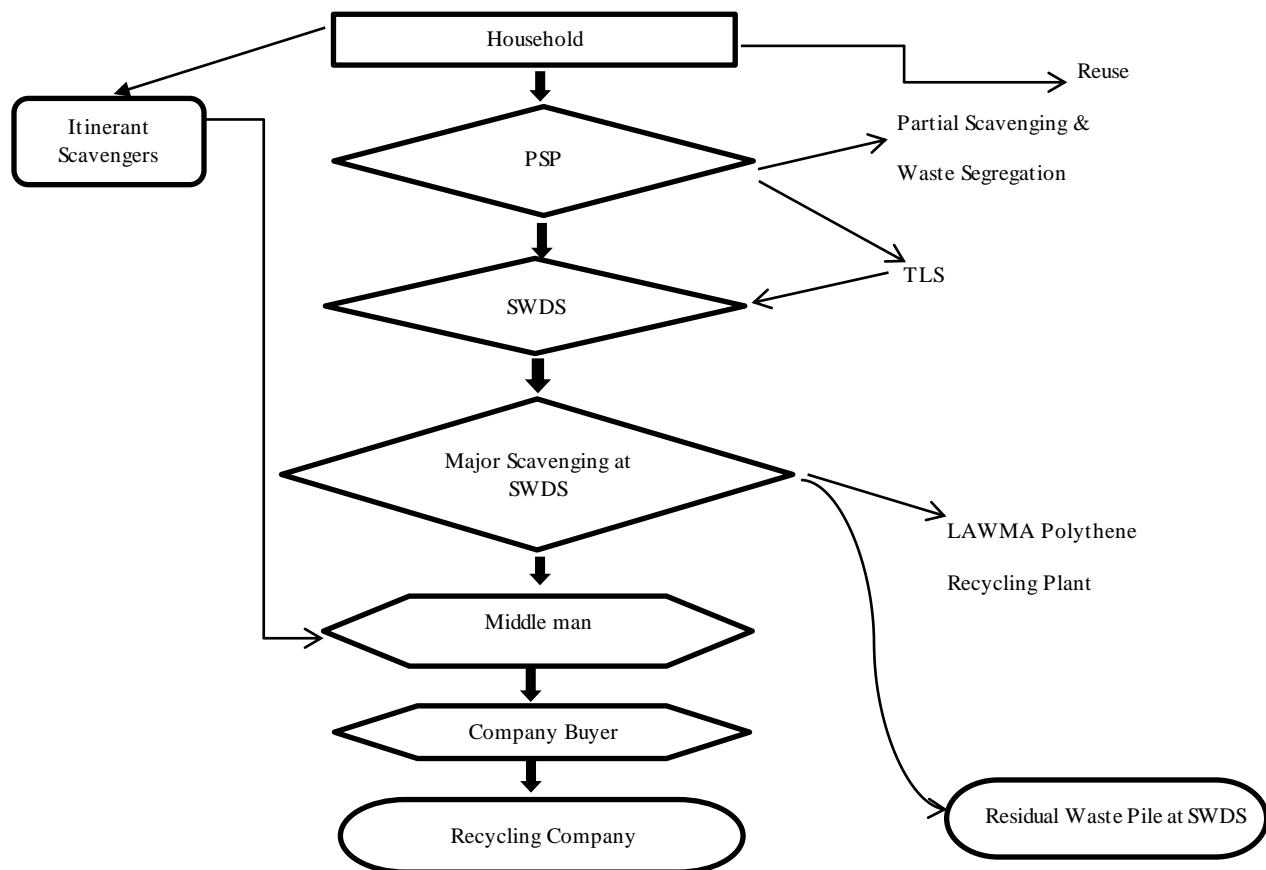

Figure 8: Flow of household waste from generation to final disposal in Lagos

Consequently, frequency of people at the recycling plant for this purpose also appears to be negligible. Participation of households in recycling is very limited because well-established recycling programs or infrastructure that encourage recycling are not in existence (Households, 2012). Despite its rather reduced practice at household level, households and private operators believe recycling will be a major way of tackling the MSWM challenge in Lagos. There is also a general belief among all ten households that recycling would only be successful with proper public education and introduction of incentives. According to an interviewed resident:

"An average Nigerian would be ready to recycle waste if monetary reward is attached. If this is added to better awareness creation, there would be more recycling activity which would lead to a cleaner environment" (Household B, 2012).

The private operators added that the financial incentives had to be introduced in a well-planned waste segregation and collection program (Operators, 2012).

4.4.4 Composting
Composting is not practiced in any of the households interviewed and majority did not see it as practical at household level. While some middle income and most high income households had flower gardens at their frontage or within their compound, this was not the case in the low income homes. Although potential gardening space was observed in some cases; only two middle income households had both a flower garden and a small vegetable garden. Lack of ownership of place of residence, little gardening space or little knowledge of composting may be plausible reasons for non-popularity of this option (Observation, 2012). Both private operators interviewed suggested composting as a potentially effective means of managing municipal waste in Lagos. According to one private operator:

"The compost project at Ikorodu could be better if the government is very serious about it (the project). The federal government could assist the state and there can be more compost plants. Instead of wasting billions of dollars on the importation of fertilizer, compost can be made from most of the waste that goes to the landfill" (Operator B, 2012).

Willingness to segregate household waste for (municipal) compost production was indicated by all of the households - generally on the condition that adequate provision would be made by the government. Again, incentives were mentioned, by both operators, as a way to encourage their meaningful participation.

4.4.5 Incineration of Household Waste
Incineration (open burning) has been banned by LAWMA in Lagos state, however, it is still practiced at a reduced level in some of the households and is restricted often times to the burning of paper waste. *En masse* burning of household waste was only found to be practised in one household and even this was circumstantial, as it was only done when the private operators failed to show up for collection of waste for a long period of time. In addition to nuisance created from smoke during burning of waste, awareness that open household waste incineration had become illegal and could lead to pollution of the environment was indicated by all the members in this group.

LAWMA and the private operators do not consider incineration of waste an option for efficient SWM in the state. For LAWMA, high moisture content of the organic waste component, the

potentially hazardous by-products of incineration, aggravation of the global warming challenge and high cost were mentioned as factors that make incineration impractical for the state (LAWMA, 2012b). For the private operators, the high moisture content of household organic waste is believed to be a major barrier to incineration in the state (Operators, 2012). Previous state government administrations had in the past embarked upon the construction of incineration plants, which however "turned out to be a white elephant project" because of the unsuitability of the technology for the nature of waste generated in the state which most times, are high in moisture content (Operator A, 2012). The private operators also suggest that the technological expertise, economic and management resources needed to make such an option for waste management successful in the state is lacking (Operators, 2012).

4.5 Household Storage of Solid Waste

The households vary in the ways by which they store their waste prior to disposal. With the exception of Household A and Household B which had 2 storage points, others have an average of 3 storage points in their household; the bedroom, kitchen and an outer storage bin which is the final destination for all waste generated in the household. The latter two were however observed to be the major storage points. Before waste generated reaches the final storage point, households sometimes store certain waste (such as cardboard) separately from kitchen waste. This was done for easier disposal and prevention of disturbance from houseflies and rodents. Such waste is eventually mingled with other types at the final disposal point in the household. Final waste disposal point for households is usually located at the frontage of their premises. The manner with which waste is stored for collection at this point varies, ranging from bagging and storage in a waste receptacle (containerization using waste bins) to only bagging or containerization without bagging. Households sometimes do not bag due to reasons such as uncertain access to bin bags and the nature of waste being disposed (dry waste such as cardboards are not bagged). The latter reason is common even among those who bag their waste prior to containerization.

9 (a)   9 (b)   9(c)

Figure 9: Final waste storage receptacles used by households in Lagos

Households are expected to buy bin bags from private operators waste collectors operating in their neighborhood or to purchase them from other sources such as local stores. Some households claim to be given these bags once in a while by the private operators at no cost, in the absence of which they use other available substitutes such as cement bags (see figure 9a) or

simply dispose without bagging (see figure 9c). Very few households buy bags at local stores. Some suggest bagging to be a time consuming activity irrespective of whether bin bags are available or otherwise.

Observed Storage Methods	Number of Households	Assigned ID	Perceived Income Status	Final Waste Receptacle
No bagging prior to Containerization	Two	Household E and Household F	Middle Income	Household 1: Improvised plastic bin Household 2: Improvised plastic bin
	One	Household J	High Income	Improvised plastic bin
Bagging prior to Containerization	Two	Household C and Household D	Middle Income	Household 1: (LAWMA) wheelie bin and improvised plastic bin Household 2: improvised plastic bin
	Two	Household H and Household I	High Income	Household 1: 1 private wheelie bin and 1 improvised plastic bin Household 2: Improvised plastic bin
Bagging without containerization	Two (all interviewed)	Household A and Household B	Low Income	Household1: Cement bag and rice sac Household2: Plastic bin bags
	One		Middle Income	Plastic bin bags

Table 2: Showing households interviewed and their waste storage methods

Many of the households claim to patronize the private operators for major disposal of their solid waste. However, one family (Household D) located within Alimosho LGA depends on LAWMA trucks which collect other types of municipal waste (market waste and street sweepings). According to this household, a private operator does not operate in the neighborhood where it is located; as such solid waste is bagged at the households' discretion and dropped at an undesignated point along the road where they may be found and picked by LAWMA en route to a solid waste disposal site. They noted that this was common practice in the neighborhood (Household D, 2012). The other households claim that they simply pile their waste and wait when the private operators missed collection and the waiting period could vary from 2 weeks to

3 weeks. One household (Household H) admitted to the patronage of cart pushers, though infrequently (as low as once or twice in a year). Solid waste meant for collection at the final disposal point in households is stored in improvised bags (i.e. cement bags or rice sacs), regular bin bags, improvised bins called drums (see figures 9b and 9c) or wheelie bins. The improvised bags are retrieved for reuse by households, especially those of low income (Field Observation, 2012).

Contrary to what was said by all the households in this study, waste found in street corners and drainages during the field observation indicate that some households or few itinerant scavengers (cart pushers) still practice disposal of waste in undesignated spots. Households in low income areas give instances uncouth means of disposal such as dumping of waste at undesignated points within the neighborhood (figure 10a) or in drainages during heavy rainfall (figure 10b),

| 10 (a) | 10 (b) |

Figure 10: Waste dumped at street corners and drainages

Four of the households revealed that they incinerated paper waste mainly due to security reasons and sometimes to reduce the amount of space taken up by this waste. Security reasons stem from awareness that other people sort through their waste before or after collection, hence by incinerating, an event where old, discarded documents may be picked up and used for fraudulent activity would be averted (Households, 2012). Only two households (Household C and D) bury fast decomposing waste such as fish intestine, and once in a while dead small rodents or reptiles (e.g. rats and lizards) to prevent foul odor that may emanate from such waste (ibid).

4.6 Collection and Disposal of Household Waste

The private operators do house to house collection of waste, an average of 5 people was observed on the compactor trucks during collection trips- 2-3 evacuators, one supervisor and the driver. The driver stops intermittently on the street of the residential area and the evacuators get off the truck to collect waste brought out by the households or stored at the frontage of each residential building. Some households carry their waste all the way to the truck in order to retrieve and reuse their waste storage sacs; this was common in a low income area observed at Alimosho LGA (see figure 11a). The supervisor's job is to ensure that each household serviced during the collection round confirms that their waste has been collected by signing on a collection card provided by the private operator (Field Observation, 2012).

During collection, some waste segregation/scavenging activity occur –transfer of waste to the compactor truck is done manually and items deemed to be valuable are immediately removed once sighted by the evacuators. Such items are dropped into designated sacs hanging from the truck (see figure 11b, 11c) and are sold to buyers at the end of the collection trip en route to the waste disposal sites or at the waste disposal sites (see figure 11d) (Field Observation, 2012). The materials thus bought by the buyers are separated into categories like: plastics, shoe soles, aluminum, copper etc. after which they are bagged, loaded in trucks and transported to be sold to companies that recycle (Scavengers, 2012).

11(a)

11(b)

11(c)

11(d)

Figure 11: Collection, scavenging and sales of recyclables by private operator collection crew

Waste collected by the private operator is transported directly to one of the designated solid waste disposal sites within the state- which is more often the case. The role of the private operator end at the waste disposal site as soon as the waste collected is tipped (Operators, 2012). The waste is sometimes taken to one of the two existing transfer loading stations (TLS), where it is compacted into blocks and conveyed to the solid waste disposal sites.

4.6.1 Level of Satisfaction on Collection Services

All households interviewed found collection services of the private operators to be somewhat satisfactory. No household expressed full satisfaction, however, it was acknowledged by all that waste collection services have improved when compared with what was obtainable in the past. Non-satisfaction persists in irregularity of waste collection; households that live in middle-income areas especially in well planned housing estates, report collection frequency to be once a week for the most part, though this is not the case all the time. Also, a reason attributed to infrequency of collection in the case of one high income household, is the issue of bad access roads in the neighborhood which is even worse in the rainy season (Household I, 2012). Others believe it is sometimes due to the breakdown of collection trucks (Household E, 2012, Household F, 2012). Another point of dissatisfaction is the current payment regime; some households (one low income, two middle income, and one high income) believe that there is no justification for the current monthly fees they are being charged for collection services (Household B, 2012; Household C, 2012; Household F, 2012; Household I, 2012). These households believe pricing to be based on the type of the building and residential area being serviced and not on the amount of waste generated by each household. It is considered unfair that a household that lives in a room is charged less even when waste generated from within may be higher than that which is generated in a household that lives in a flat or duplex (Households, 2012). According to one household:

"I don't think they [the private operators] have any justification for the amount of money they are collecting. This is because they do not come for collection all the time and their rates are based on assumption; they assume that a flat for example should contain certain number of people, so they end up overcharging some people and undercharging others" (Household C, 2012).

In the opinion of these households, the amount of waste generated is less a function of the size of accommodation and more a function of the amount of waste being generated by the members of the household. Also, for some (one low income, two middle income and two high income households) service rendered is value for money; however, dissatisfaction concerning issuance of bills for collection periods missed by the private operators is expressed (Household A, 2012; Household E, 2012; Household G, 2012; Household H, 2012; Household J, 2012). In the words of one household:

"When they [the private operators] show up, they take away all our waste. However, I am not satisfied because when their vehicles go bad, they do not contact us and their inconsistent service does not reflect on the bill. For example, in January 2012, they didn't show up for three weeks but we were still issued the full bill for the month." (Household H, 2012).

Few households (Household C and H) also complain about littering of the streets by the private operators during collection and the manner with which bins are handled after collection.

4.7 The Private Operators and their Challenges

Introduction and recognition of the private operators are considered significant improvements made by Lagos state government and later LAWMA to combat the problem of MSW collection in the state (Operators, 2012). Vehicles used for MSW collected from households are purchased by the private operators; recently, all the service providers are mandated to have compactor trucks for collection operations; a minimum being two per political ward before the private

operators can be allowed to register for collection services. The imposition of such advanced collection vehicles is regarded by the interviewed private operators as a step in the wrong direction; required compactor vehicles are very expensive, further, technological knowledge and maintenance skills of local mechanics are not at par with that employed in building of such vehicles. Hence, repairs are mostly based on trial and error which cost the operators money and render their waste collection services poor (Operator A, 2012). As at 2011, LAWMA bought 100 new compactor trucks which they made available to some private operators on a lease to own arrangement. The arrangements between LAWMA and the private operators depend on the area (or political ward) they have been allocated to operate within a LGA. Some parts of Lagos could be termed as rural, and for such, total collection of revenue is unrealistic given the low economic status of the residents. Hence, contractual agreement exists between the private operators in such areas and this is defined by LAWMA paying a fixed sum for waste collection services rendered by the private operator. In the other type of agreement (franchising), the franchisee (i.e. private operator) does not receive subsidy from LAWMA, and is expected to recover all their cost (Operator B, 2012). The greatest challenge faced by the private sector under this type of arrangement however, remains revenue collection. Payment for waste collection services which should be on a monthly basis, is avoided or delayed indefinitely by some residents. In order to ease the burden of revenue loss experienced by the private operators to some extent, LAWMA has taken it upon itself to reimburse them   a certain percentage (60%) of unrecovered cost (Operators, 2012).

4.8 Disposal Activity at Soluos Waste Disposal Site

The Solous II waste disposal site in Lagos is located within a residential area at Igando; with the nearest residential building less than approximately 50 meters from the site. The waste disposal site is more of an area of land designated that has been for dumping of municipal waste. The site is partially fenced and has inadequate structure to control human and vehicle traffic, also, given the narrowness of the road that leads to the site, the turn-around time of waste collection trucks could be up to 1.5 hours or more (Operator A, 2012). Another reason for the long turn-around time appears to be inadequate dumping space- the site is small and previously dumped waste

12(a)   12(b)

Figure 12: Soluos solid waste disposal site

have not been properly managed (Field Observation, 2012). There were no signs of the equipment needed in a fully operational and well-structured waste disposal site; as such there

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was no compaction and covering of waste being dumped and dumping was done quite close to the opening that served as entrance to the site. In addition, leachate control facility was not found on the premises. Foul odor was observed to emanate from the dumpsite even at a distance of several kilometers from the site. Scented liquid is used to suppress the odor, but this has very temporary effect (ibid).

4.9 Olushosun Waste Disposal Site

The site is the most sophisticated waste disposal site in Lagos state and is basically land that is being reclaimed via the filling of gorges with disposal of waste. Excavation of laterite is still ongoing on the land fill. The front entrance on one end of the site leads to major road- Ojota (which leads to the Lagos Ibadan express way- an interstate road) while the hind entrance leads to a residential area and a mechanic village. The nearest residential building is less than about 100 meters from the hind entrance. The site is equipped with two computerized weigh bridges- the inlet and outlet weigh bridges at the front entrance. However, weighing is only done for all incoming trucks, according to LAWMA (2012b), the tar weights of the trucks are already known and only the weight of waste being brought has to be noted.

A methodical approach is used for dumping of waste on this site; disposal of waste is rotated between (four) different locations referred to as tipping cells. Access roads called platforms have been created from waste being dumped to ensure continuous access to the tipping cells even during the rainy season. Observed turn -around time for trucks was approximately 20 minutes.

Site management activity observed include pushing and leveling of waste emptied from collection trucks by the use of a bulldozer, followed by the use of a compactor to press the waste further. Covering of compacted waste on a daily basis is not done at the site and scavenging activity goes on both before compaction and after compaction of waste at the disposal site. The site has deodorizers which are used to disperse scented liquid close to the cells and around areas where traffic is high within the site. However not all of these are functional. Also, occurrence of fires at the dump is common and efforts are made by the scavengers to put such out, the LAWMA staff are however, notified in instances which the fire cannot be easily contained (Scavengers, 2012).

Equipment	Number	Purpose	State of Operation
Bulldozer	2	Pushing of waste heap	Both Functional
Deodorizer	8	Suppression of Stench on the site	4 Defunct
Compactor	1	Leveling& Compaction of Waste	Functional

Table 3: Showing Equipment used at the Olushosun Waste Disposal Site

4.9.1 Leachate Control and Gas Capture

Rough channels have been created to allow the flow of leachate from some of the tipping cells into ditches that serve as collection ponds. It was reported, that plans are being made to improve the channeling of the leachate via pipes (LAWMA, 2012b). Treatment structures for leachates

were not observed on the site. While underground pipes have been laid thus far for landfill gas collection from one old tipping site that has been covered, the current facility put in place is still very much in the experimental phase (ibid). Thus, landfill gas capture activity is currently at its barest minimum and its utilization non-existent.

Figure 13: (a) Stagnant leachate pond   (b) Rough leachate flow chanel at Olushosun

4.9.2 Scavenging Activity at Solid Waste Disposal Sites

Scavenger activity is very high at the Olushosun waste disposal site and Solous II, some activity was also observed at older and abandoned Soluos sites. Scavengers found mostly on the solid waste disposal site utilize simple tools for their activity, such as a small iron rod with curved tip (called 'Koro') and rice sacs. The locally made 'Koro' is used for rummaging through waste dumped at the site, and the rice sac is used to gather items found. Some scavengers utilize cotton hand gloves on one hand, few on both hands, while many do not utilize gloves at all. Almost all wear flip flops as feet covering.

14 (a)   14(b)

Figure 14: Waste picking activities during and after waste deposition at Olushosun

Recyclable material found and sorted during scavenging are bagged into similar categories and sold on site to company buyers by the scavengers (Field Observation, 2012). Occasionally, such plastic bottles and polythene are sold to the plastic recycling plant at the Olushosun site, but this is seldom the case (Scavengers, 2012).

Scavenging is a major source of livelihood for many people found on the waste disposal sites; some have scavenged consistently for close to two decades or more (Scavenger C, 2012) and poverty appears to be the main reason for taking up the activity as a source of livelihood. Unlike in the past, when there was uncontrolled access to the Olushosun site, scavengers now have specific time frame (about 12 hours from dawn till dusk) per day to look search valuable waste (ibid). From sales of sorted waste items to middlemen, average monthly income for a fulltime scavenger on the site could range between 30,000 Naira and 40,000 Naira (roughly equivalent to 1250-1666 SEK) (Scavengers, 2012)

Both private operators and most households view the activity of scavengers as beneficial to the environment; however disadvantages of itinerant scavenger activities exist (Operators, 2012; Household A, 2012; Household B, 2012; Household C, 2012; Household D; Household E, 2012, Household F; 2012; Household G, 2012, Household I). For, example, in neighborhoods where scavengers' activities are not restricted by security in residential areas, issues of theft occur-- including theft of plastic bins lids at the frontage of people's homes which has consequently seen many households leaving their bins uncovered (Household A, 2012; Household D, 2012). Some itinerant scavengers also work as cart pushers, collection of waste with carts have however been banned in the state by LAWMA due to illicit dumping of waste at undesignated places like drainages and roadsides by the cart pushers. Though their activities have negative sides, a majority of the households believe scavengers/cart pushers would remain relevant as long as the MSW collection system remains inefficient. This is because as they sometimes help cart away waste when the private operators does not show up for collection (Households, 2012).

15 (a-b) Truckload of plastic waste sold to middlemen

Figure 15: Sales of sorted waste by scavengers at the Olushosun solid waste disposal site

According to LAWMA (2012a), plans are underway to turn the activities of the informal sector to a formal one. A major strategy being considered is to integrate them into MSWM sector by manning of proposed recycling banks in certain locations in the state. All the scavengers interviewed however believe the creation of an enabling environment for their activities via reconstruction of the waste disposal sites and their continued access to the solid waste disposal site to be preferable. This preference was mostly based on financial reasons as all believe such changes would lead to them earning less than they currently do (Scavengers, 2012).

5. ANALYSIS AND RECOMMENDATION

5.1 Volume, Content and Source Segregation

From the results presented in the previous chapter (section 4.3), it may be said that a direct relationship exists between population size and volume of waste generated in Lagos. Previous studies (Adewole, 2009; Ogwueleka 2009) suggest the same. Increase in population could cause major space constraints for solid waste disposal at landfills in the near future as higher volume of waste generated from population increase would reduce the life span of existing disposal sites. This, in addition to the increasing use of disposable items emphasize the need for full adoption and integration of more sustainable waste management options, especially those that significantly reduce the amount of household waste that end up in waste disposal sites.

The high proportion of organic waste observed in all households in this study (see section 4.2) is mainly attributed to the types of food consumed as well as the cooking culture in Lagos. Residents seem to be very reliant on home cooking and there appears to be a high proportion of waste generated from non-edible components during food preparation; these include plantain peels, yam peels, beans chaff, and fish bones. Most of the food and fruits consumed are of high moisture content or have non-edible parts. That the same composition was observed across the low income, middle income and high income households could be an indication that social status has lesser impact on the content of food waste generated from households in the state. The same cannot be said for the volume and content of inorganic waste generated across these socio-economic groups in Lagos; volume and inorganic content were observed to be higher for middle and high income households. Having knowledge of waste composition in a community is important in helping to efficiently determine the type of sorting, storage, and transportation needed as well as options available for resource recovery, disposal and possible environmental impact from mismanagement of the waste (UNEP, 2005a).

The interviews and observation in this study show that waste is not segregated by households in Lagos (section 4.5, fig. 6 and 9c); yet, the ability to introduce and sustain waste segregation would be fundamental to successful exploitation of other waste management options besides landfilling in the state. Given the financial constraints that may be involved in initializing and implementing source segregation of household waste, a practical starting point in Lagos would be a basic separation of organic waste from inorganics, in which case households could be required to have at least two proper waste receptacles such as wheelie bins. In the way of encouragement, LAWMA could make efforts to provide green and red wheelie bins to all households for storage of organics and other waste respectively. The current criterion for provision of wheelie bins is payment of land use taxes in each residential building. This, however, is not practical because households, especially some middle income and many low income ones, are tenants in the buildings they reside in. They should not be punished for non-payment of land use tax by their landlords. Instead, bins may be made available to residential building at a subsidized rate. The cost could be factored into the waste collection bills over a time spread that could make payment possible and convenient for households irrespective of socio-economic status. Since wheelie bins have non-detachable lids, provision of such to households could also solve the challenge of lid theft and unhealthy exposure of waste placed outside by residents. An even less expensive approach could be the constant provision of different color bags (again, green and red) to residents at affordable cost; this could afford some flexibility while the minimum requirement remains segregation and bagging of waste. If bagging

would be properly enforced, reasons for this requirement and clarity on whether the bags are free or not should be made to the public, otherwise, households would be less inclined to buy if they know they could sometimes get the bags from the private operator at no cost. Aggressive and constant public education would be pertinent in creating the awareness required for the success of proper household storage and segregation prior to collection by the private operator. Based on information gathered in the field (section 4.4), financial incentives would play a major role in encouraging and sustaining waste segregation in households over time. Following successful introduction of waste segregation at household level, LAWMA could also introduce heavy fines as a way to make non- segregation or improper segregation of waste become unattractive to the households. Igbinomwanhia (2011) suggests a similar approach to the commencement of source separation of waste and incentive provision. According to the author, waste segregation is an important component of sustainable MSWM especially since it also reduces the amount of tasks in the total management process by up to 30% or more. A gradual improvement may be made in the system by increasing the number of waste receptacles to accommodate more categories – organic, plastic and other types of waste. Further, a common advantage should also exist for both the persons that generate waste as well as those in charge of its management if the process is to be sustainable; the advantage for households could be source segregation in exchange for discounted collection fees (ibid). Separation of organics from inorganics would mean easier separation of paper and consequently an expansion of formal paper bailing in the state for sales to recycling companies. The same can be achievable for metal waste recycling which appears to be currently driven by low income households and scavengers because of the higher financial gain when compared to other components of waste.

5.2 Dynamics in Solid Waste Collection

From the results of this study, it was found that not all areas enjoy effective waste collection services due to truck breakdowns, non-accessible roads and financial constraints from cost recovery challenges. Some LGAs or wards within the LGAs in this study appear to be better served by the private operators than others, indicating that waste collection services rendered are not uniform throughout the state. For example, while no resident indicated absolute satisfaction with private operators' services in this study, Idowu, Omirin, & Osagie (2011) found that a majority (about 80%) of residents in their study area were satisfied. An implication of the observed non-uniformity in services rendered by the private sector could be the continuous use of unconventional waste disposal methods, such as patronage of cart pushers and indiscriminate dumping in street corners or drainages by households.

Strict requirement of compactor trucks for waste collection may be unsustainable and inappropriate for solid waste collection in the state. Compaction trucks are designed to compress low density waste (such waste in developed countries) in a way that would enhance efficient waste collection and maximize each collection trip (UN-HABITAT, 2010). Due to this, there is high tendency for compactor trucks to breakdown prematurely when they are used to compact high density waste; the breakdown could occur because the hydraulic system become strained from doing more work than they are designed to do (Ogwueleka, 2009). Further, the cost of new compactor trucks appear to be beyond the financial means of most private operators in Lagos, this may result in a tendency to purchase second hand vehicles that are highly prone to mechanical problems and consequently lead to high maintenance costs. For these service providers, the primary purpose of servicing households for waste collection would be for financial gain (Cointreau-Levine, 1994) however, when this becomes difficult to achieve, poor

collection services- including epileptic collection of household waste may persist in the system. Most households interviewed about collection of waste indicated epileptic collection of waste and the others were only somewhat satisfied. LAWMA's efforts to alleviate cost challenges associated with the private operators' acquisition of compactor trucks through a lease to own arrangement may not be wrong in itself, however, the non- suitability of the trucks for Lagos' household waste, as well as lack of technical expertise required for their maintenance, reflects non- efficient use of the already constrained financial resources available in the MSWM sector. Rather than depend heavily on foreign technology and methods, creation of the right ambience for local manufacture of collection vehicles, developing labor intensive systems and modification of municipal finance methods could help ameliorate collection of MSW (UNEP, 2005a). Local conditions and characteristics of waste should be used as criteria for selecting appropriate collection trucks. For example, side loading on- compaction (tipping) trucks with bin lift systems could be efficiently used for collection of high density waste; their relatively bigger load space, reduced cost of purchase, operation and maintenance make them more suitable (UN-HABITAT, 2010). Such trucks could be potentially appropriate for MSW collection in Lagos.

5.2.1 Willingness to Pay for Improved Waste Collection

While households interviewed in this study indicate willingness to pay for improved waste collection services, it appears that many do not currently pay for such services since the private operators report cost recovery to be the major problem they encounter in waste collection (see section 4.7). This challenge could be tied to some households' opinion that there is no justification for the current waste collection fee regime. In the end, low cost recovery could persist because non-payers cannot be excluded from the services rendered by private operators. Cointreau-Levine (1994), identifies services in SWM as a collective good which cannot be rendered exclusively to people that pay for their waste to be collected because healthy waste disposal is vital for the continued well-being of the general public and environment; any form of differentiation would result in uncouth methods of disposal. By compensating the companies up to 40% of the arrears, LAWMA tries to help overcome this challenge; it appears however that such intervention has had little impact since epileptic collection services were indicated by the households. Cost recovery could be improved at lesser cost to LAWMA if regulations which hold households more accountable for non-payment for services rendered to them by the private operators are to be developed and enforced. Ugwuh (2009) suggests that authorities should make provision for effective monitoring of non-compliant households, collection activities of private operators, as well as policies which would suit local conditions and would rarely require adjustments.

5.3 Dynamics in Reduction, Reuse and Recycling

In Lagos, practices attached to solid waste reduction and reuse were found to be predominantly informal and influenced by factors other than those related to environmental awareness. From the results (see section 4.5) it can be inferred that while waste storage and containerization methods in the state vary; the use and reuse of rice and cement bags for waste storage prior to collection is practised more in low-income areas and to a lesser extent in middle-income areas. Containerization is also not common in low income neighborhoods. Further, reuse of materials appear not be indicative of conscious efforts to reduce amount of waste that could end up at solid waste disposal sites, rather, such activities may mainly be attributable to financial status, frugal habits of the interviewees or a combination of both. Even with this, reuse and recycling in Lagos households could still be described as limited since items that are not optimally used or reused

prior to disposal appear to drive the informal recycling chain and reuse in locations other than households. The waste handling habits of interviewed households, and observed activities of waste collection crew and scavengers (see section 4.6 and figure 11), indicate that (informal) recycling hardly begins at household level. While waste scavenging is actively done by the private operators' collection crew, it is apparent that this activity occurs less extensively at neighborhood level. Major recycling of waste in the state appears to begin at solid waste disposal sites because it is where scavenging activity was observed to be highest. This further indicates that the volume of inorganic waste which ends up in the landfill is still very high.

Private operators indicate waste segregation during collection rounds to be strictly initiated by their collection staff; that such scavenging activity is not curbed in any way by the waste company could be an indirect acknowledgement that the workers are underpaid; scavenging and sales of recovered materials could be a way to keep them on the job. However, optimum efficiency of waste collection crews may not be wholly achieved if sorting and keeping recyclable material during collection trips pose a distraction.

5.4 Potentials Following the Solid Waste Hierarchy

5.4.1 Potentials for Reduction and Reuse

Reduction and reuse are important in Lagos SWM and could be quite complementary to recycling and composting if properly exploited. In Lagos, the economic situation and essentially frugal habits of residents appear to take care of organic waste reduction, while this could be capitalized upon as a way to improve waste reduction and reuse at household level, the author of this research believes that only little more could be achieved in this regard. Waste reduction at source of generation could be effective if suitable practices (including household management decisions); adjustments in raw material use, technological and processes can be focused upon (Williams, 2005). There is greater potential for the reduction of inorganic waste generated from households and this could be more focused upon. Local manufacturing companies could use less packaging material, they could be encouraged to use environmentally friendly materials for production as well as develop attractive incentivized programs. Such programs would encourage consumers to save and return non-biodegradable waste such as empty beverage containers. This could create a win-win situation as waste segregation at source would be encouraged, companies could experience lower cost of production from the use of recycled materials and the amount of waste that ends up in the landfill could be reduced. Since reuse is already being practised in most households in Lagos; advise on simple, cheaper, better and environmentally friendly choices such as purchase of ceramic plates for use in homes instead of disposable plastics, reuse of plastic bags could lead to further improvements for this option.

5.4.2 Potentials for Recycling

Again, from the data presented in the previous chapter, it can be inferred that plastics make up about one quarter of the waste generated by households in Lagos; this in itself is an indication of the potential for recycling in the state. Households, the private operators, LAWMA, scavengers all have significant roles to play in waste recycling; the major role for households in this regard shall be proper waste segregation and storage, the private operators' role shall include efficient collection of waste, scavengers shall remain crucial in oiling the wheels of the recycling market. LAWMA's roles would be to create an integrated plan and the right environment for recycling to

grow in Lagos. Kofoworola (2007) suggests that policies which encourage recycling and ensure compliance should be created by the state.

LAWMA's plan to integrate scavengers into the formal solid waste management sector is a step in the right direction because it indicates recognition of this group's importance to the SWM sector. According to Medina (2000), SWM programs that integrate and make scavenger activity formal turn out to be more successful and the opposite can be said for those which discourage or endeavor to limit such activity. LAWMA's integration plans may not be successful if scavengers do not identify advantages that are more compelling than what they currently enjoy from informal waste recycling. Manning of proposed recycling centers could be unattractive to this group if the financial gain and work flexibility is not significantly better. Further the large number of people in this group makes such a solution less practical because all the scavengers cannot be given recycling centers to manage. Even if this happened, it would merely create room for more poor people to engage in scavenging. Source segregation would also have to be effectively introduced and sustained in the system before recycling centers could even be effectively operational. About 30% of waste that urban cities generate is removed from the waste stream by scavengers making them significant to the MSW sector (Ogwueleka, 2009). Given the right conditions, this group could become even more relevant and productive in Lagos. As part of an integration plan, LAWMA could create an enabling environment for scavengers to form small scale enterprises that would afford better planned waste picking, sorting and sales of sorted materials. This could create a win-win situation in which improved efficiency in recycling would be achieved and profitability would increase for the scavengers. To boost onsite recycling, certain conditions could be developed and attached to scavengers' access to the waste disposal sites. To this end, LAWMA could guarantee continued access if scavengers could sell certain kilograms of recyclable waste to the onsite recycling plant per month. The plant could be upgraded to be more efficient and also accommodate metal and paper recycling; more plants may also be sited on or at reasonable distance to other current waste disposal sites. Rates at which the scavengers would sell materials to the plants could be made competitive with those offered by company buyers. Such arrangement would drive higher rate of waste picking and more recycling activities. It could also create competition for middle men and company buyers, hence, ensuring that scavengers get fairer prices when they sell sorted waste. Effective waste management and socio-economic benefits stand to be gained from identifying and using the strengths of scavengers during an integration process (Wilson, Araba, Kaine, & Cheeseman, 2009).

5.4.3 Potentials for Composting
The proportion of organic waste, opinion of private operators about composting, households' indicated willingness to segregate waste and the author's observation in this study (see section 4.2 and 4.4.4) are all indicative of the potentials that exist for compost production from MSW in Lagos. Compost production should be fully exploited as a means of reducing the organic waste that could up at solid waste disposal sites. More attention should be given to the management of organic household waste through composting because it makes up of over half the proportion of waste generated in Lagos. In addition, the persistent and mephitic odor observed and reported to emanate from solid waste disposal sites in the Lagos is largely due to decomposition of organic component of waste. According to UNEP (2005a), decomposition of freshly disposed or old organic content in MSW results in the generation of unpleasant odor. Through segregation of organic solid waste and its subsequent conversion to compost, the reduction of landfill waste, landfill gas (GHG), leachates as well as amelioration of environmental conditions and public

well-being could be achieved (Taiwo, 2011). Detailed market surveys could be done to identify how a large share of the agricultural sector could be encouraged to use compost both at the state, national level and international level. UNEP (2005a) suggests that possible use of compost abounds mostly in the agricultural sector of developing countries, other areas where compost may be useful include landfilling and reclamation activities, landscaping of public and private properties including home gardening. A combination of centralized and decentralized approach may be adopted for compost production in Lagos. The former could be achieved by setting up production plants in the state, and the latter could be used to encourage and integrate compost making at household level. Again, public education would play a big role in enlightening households about the practicability of this practice at household level; this would in turn encourage source segregation and create efficient organic waste collection for further processing. Households, especially low income ones and the private operators could become important actors in collection of organic waste for compost production if there is a thriving market for it in the state. EEA (2009) suggests that compost markets could be sustained if the product is of good quality and standards are developed and maintained for production.

5.4.4 Incineration

Due to associated high investment, operational, and environmental costs, the author of this research does not consider incineration to be sustainable SWM option for Lagos. Others (Kofoworola, 2007; Ogwueleka, 2009) also suggest non-suitability of this option, according to Ogwueleka (2009), the high moisture content and low calorie value of the solid waste makes its combustion difficult and only achievable with the use of fuel- an option which is not cost effective.

5.4.5 Potential for Improved Solid Waste Disposal Site

Based on the features observed in this study (see section 4.8 and 4.9), solid waste disposal sites in Lagos cannot be described as sanitary landfills; at best they could be regarded as semi-controlled landfills (Olushosun) or dumpsites (Solous II). Even when viable management options such as reuse, recycling and compost production have been successfully introduced and fully integrated into Lagos' SWM systems, solid waste disposal sites would continue to play a significant role in the disposal of household waste that are irrecoverable for further use. Management of the disposal sites in Lagos should be improved to ensure that waste deposited in the past or future would not constitute environmental or public health challenges for people working on the sites as well residents dwelling close to such sites. For example, the Solous site appears to be ready for closure; it is recommended that this be done soon and in a proper manner, not only because it is full but also because of its proximity to residential buildings.

Considering the significantly high organic waste proportion that ends up in the disposal sites, there should be adequate provision of leachate collection and treatment systems on waste current disposal facilities in the state. The potential for landfill gas extraction and production appears to be huge and should be fully exploited on recently abandoned disposal sites and current ones. At least one new well engineered sanitary landfill site with capacity similar to or greater than the Olushosun SWDS should be sited and built in a non-residential area in Lagos. Kofoworola (2007) suggests that improper siting and poor design of landfills could impact negatively on SWM efficiency due to the possible challenge of leachate and landfill gas pollution. Sites with adequate gas capture facilities could generate energy that could be sold or utilized on the landfill (ibid). Apart from the environmental benefits, such energy generation activities if properly planned and implemented, could also be a potential solution to the power shortage challenge that

has plagued the state for many years. The current practice of short term odor suppression via the use of deodorizers is neither effective nor sustainable. An alternate method of covering compacted waste with thin layers of soil on a daily basis could be more suitable and the application of compost in this regard could be very useful. According to UNEP (2005a), daily and intermediate coverage of waste are usually carried out during the operating lifetime of a waste disposal site; coverage of waste on a daily basis would help to reduce stench from disposal sites, curb vector activity, control fires, moisture and littering.

6. CONCLUSION

Like in most other developing countries and major cities, sustainable solid waste management in Lagos, Nigeria remains a herculean task, especially with its ever increasing population. While it may be said that LAWMA have been making efforts to improve waste management in the state, there are still a lot of untapped opportunities for sustainable waste management.

From this study, it is believed that no single waste management option can be employed in isolation for SWM in Lagos. Disposal on waste sites is the dominant means of managing waste in the state but this is clearly not sustainable. Considering the nature and components of waste generated by Lagos households, a blend of certain management options in the waste management hierarchy (reduction, reuse, recycling and composting) would be more suitable in tacking the challenge of SWM and the state should look to landfilling only after other management options higher in the hierarchy have been fully explored. These management options should be integrated in a sustainable framework with adequate consideration be given to their hierarchical importance. In order that the desired result is accomplished, these options should also be considered and employed based on local conditions rather than foreign methods.

The backbone of most options in the waste management hierarchy is waste segregation at source. Other key aspects are proper storage, more efficient waste collection systems, sustainable recovery and disposal. Public education and properly planned waste management programs need to be introduced into the current waste management system. These are relevant because households should know and understand the importance of waste segregation and proper storage, as well as those of recycling and compost production. Integration of scavengers into the SWM sector is also necessary for recycling to become more efficient in the state. Friendly climes for waste reduction, recycling, compost production have to be created by the authorities through introduction of complimentary programs and policy development. The idea of incentivized waste segregation is popular among all the households -whether low income, middle income or high income. Therefore, to encourage and enhance cooperation of households; inclusion of incentives should not be overlooked when designing programs for waste management.

Better efficiency on the part of the private operators could be achieved if the use of less expensive collection trucks that are more suited to the type of waste and conditions in Lagos are introduced by LAWMA. Further, the private operators can be relieved of the burden of cost recovery if LAWMA could develop strict payment regulations for households, and these should be enforced following improvement of collection services. Also, properly designed and well operated solid waste disposal sites are needed in the state. Key considerations should include proper siting and design. Operations should target odor elimination, leachate and landfill gas control and energy generation.

Finally, this study gives significant insight to MSWM in Lagos and how improvements can be made. Nevertheless, there is need for further studies of similar nature with significantly higher number of interviewees in each actor group across all the LGAs in Lagos. Data from such studies would give more in-depth knowledge of MSWM challenges faced in the state and would provide invaluable details needed for the development and implementation of sustainable SWM programs and policies that are most suitable for the state.

7. ACKNOWLEDGEMENTS

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APPENDIX

A1: Question Guide for Household Interview

1. Could you please describe what changes have occurred in the content of waste generated in your household in the last 20 years? Follow up: Has the volume changed during this time? Could you estimate how many bags of waste you currently generate per day?

2. What are the typical components of your household waste? Follow up: Food waste? Paper? Beverage cans? PET bottles? Shopping bags? Glass? Leather? Rubber? Textile? Food tins? Others? (Physical observation of components).

3. Do you sort and sell any kind of the waste materials you generate to scavengers? Follow up: If yes, what kinds of waste materials do you sell? Textiles, plastics, bottles, shoes, newspapers?

4. Do you reuse any kind of waste material in your household? Follow up: Plastic, bags, bottles..? If yes, what kinds of materials do you reuse? Follow up: Could please explain how you reuse these materials i.e. the new purpose they serve in your household after that which they were originally intended for? Are there special reasons why you reuse these materials?

5. Could you please describe how and where you store your waste? Follow up: Do you prefer to use bin bags, sacs, or direct disposal without bags? If yes, have you in any way practiced this when disposing your waste? If no, could you please tell me why?

6. Who collects the waste from your household? Follow up: Do you patronize private waste collection operators or utilize other means of waste disposal?

7. How often does the collector come around for waste collection in your neighborhood? Follow up: Is the frequency of waste collection satisfactory with you? If no, how often would you like your waste to be collected?

8. Are you satisfied with the fee currently being charged for the services rendered by the waste collector? If no, could you please explain why?

9. In the event of the collector not coming around to collect waste, how do people in the neighborhood dispose of it?

10. Are you satisfied with the services of the waste collector? Follow up: If yes/no, what aspects are you/ not satisfied with? If no to previous question, will you be willing to pay more in order to receive improved services?

11. Are there other ways through which you manage the waste you produce? Follow up: burning, burying, or composting? Follow up: could you please explain why you use this option?

12. What do you think happens to your waste after it has been collected? Follow up: Do you think the waste collected from peoples' households is properly managed by the municipal (LAWMA)?

13. Do you think households should be encouraged by the municipal to sort the waste they generate? If yes, could you explain why you think so?

14. Will you be willing to sort your waste in fractions such as glass, cans, plastic bottles, paper, tins, etc. if provision for this is made by government or LAWMA?

15. What is your opinion of waste scavengers you may have observed in your neighborhood? Follow up: Do you find their activities beneficial to the environment? Could you explain why you think so?

16. Could you please describe how you think re-use and recycling of waste should be ideally carried out? Do you think this could significantly reduce the amount of waste you generate?

A2: Question Guide for Private Operator Interview
<u>Equipment and Staffing</u>

1. How long have you been in the waste collection business?
2. Could you please describe what changes have occurred in the content of waste generated in the last 20 years in the city of Lagos? Follow up: Do you think the volume has changed during this time?
3. How did the private operator business start in your case? Follow up: In which part of Lagos do you operate?
4. What type of arrangement exists between LAWMA and private operators? E.g. contractual agreement, franchise, etc.? Follow up: What is the time span of your contract?
5. What type of trucks do you use for solid waste collection? Follow up: Does LAWMA have a minimum requirement for the number of trucks you should have in order to collect waste in your area of operation? How do you obtain your trucks for solid waste collection services? Follow up: Do you buy them on your own? If no, are they provided by LAWMA under some type of agreement?
6. How are your trucks maintained? Follow up: Is it solely the responsibility of the company? If no, is there a special arrangement with LAWMA concerning maintenance? What happens when your truck breaks down?
7. What kind of occupational safety policy does the company have? Follow up: Do these include rubber gloves, uniforms, boots, nose masks, etc.?

<u>Household Waste Collection: Operations</u>

8. Could you please describe how wastes are collected from households? Follow up: door to door collection, collection from a central disposal point by households, house to house, etc.?
9. How often do you collect household waste in your designated area? Once a week, twice a week or on a fortnight basis?
10. How do the households mostly store their waste for collection? Follow up: Does the private operator sell bin bags to households? Follow up If yes, how much and what is the mode of payment?
11. What typical components of household waste do you observe during collection?
12. Is there any sorting of waste by households or by the company?
13. Do you think the proper storage and volume of waste from households depends on factors such as different seasons in the year, socio-economic status of residents and festive seasons?
14. Could you please describe what happens to the waste you are collecting? Follow up: Are they taken to the transfer loading stations or directly to dumpsites and landfills close to your area of operation? What determines if the waste collected would go to either a dumpsite or landfill?
15. What happens with the waste at the dump site or landfill? Follow up: Could you estimate the average time it takes you to get to the landfill, dumpsite or TLS? Could you estimate the number of trips do you make to the land fill, waste dump or TLS on a waste collection day?
16. What challenges do you face in collecting and transporting waste from households to dumpsites, landfills or transfer loading stations?

17. How are households charged for waste collection services? Follow up (Monthly? quarterly?) Are there challenges experienced with fee collection?
18. Do you think the waste you collect from households are efficiently managed by LAWMA? Follow up: If yes or no, why do you think so?
19. What is your opinion about waste reduction from households as a method of solid waste management in Lagos?
20. Do you think incineration of waste could be an effective way to manage solid waste in Lagos? If no, why do you think this may not be effective in the state?
21. What is your opinion about activities of waste scavengers found in neighborhoods and dumpsites? Follow up: Do you think they constitute a nuisance? If no, do you find their activities beneficial to the environment? Could you explain why you think so?
22. Could you please describe how you think re-use and recycling of waste should be ideally carried out? Do you think this could significantly reduce the amount of waste that is generated from households?
23. Do you think informal recycling by scavengers could be integrated into the formal sector? How do you think this can be achieved?
    Follow up: Do you know if there are current or future programs for this option in the state?

A3: Question Guide for LAWMA Interview

1. Could you please tell me how the challenges of the sanitation sector have changed over the last few decades here in Lagos? Follow up: In what ways have content and the volume changed during this time?
2. Could you please tell me why LAWMA was established? Follow up: Is LAWMA autonomous in its operation? What role does LAWMA play in municipal solid waste collection?
3. Could you give an overview of the solid waste management strategy that is currently being adopted by LAWMA? Follow up: could you tell me why this management strategy has been chosen? Example: Low cost? Environmental concerns? Better social acceptance, etc.?
4. What kind of arrangement exists between LAWMA and the private waste collectors (type of arrangement, including duration, payment of fees payment, etc.).
5. What is the number of trucks currently available to LAWMA for waste collection in the state? Follow up: Are the collection trucks solely for LAWMA operations? If no, are they loaned out to the private collectors under some form of agreement?
6. How are fees charged households for the services rendered by private operators? Are the fees paid to the private operators through LAWMA or directly to private operators? Could you please tell me the challenges faced in the collection of service fees from households, if any?
7. What kind of waste goes to the landfill? Follow up: What determines whether the solid waste collected should go to a land fill or dumpsite?
8. What happens with solid waste when it reaches the dump site or landfill?
9. Are there any programs planned or currently in place to encourage waste reuse and recycling?
10. What is your opinion about activities of waste scavengers found in neighborhoods and dumpsites? Follow up: Do you think they constitute a nuisance? If no, do you find their activities beneficial to the environment? Could you explain why you think so?
11. What bodies under the state government work with LAWMA for the selection of new location for dumpsites and landfills? Follow up: What factors are mostly considered by LAWMA in siting landfills and dumpsites in Lagos?
12. Could you tell me what has changed since the reconstruction of the Olushosun land fill? Follow up: Are there current or future plans to reconstruct the other two landfills in the near future?
13. What challenges have LAWMA been facing in the management of the state's solid waste? Follow up: Are there any challenges with the landfills and dumpsites in Lagos (in terms of containment of leachates, location, access to appropriate technology, etc.)?
14. Do you think encouraging households to reduce their waste could be a good method for solid waste management in Lagos? Follow up: Are there any current or future programs for this option in the state? If yes, could you mention what the implementation constraints may be?
15. What is your opinion about incineration of waste as a way to manage solid waste in Lagos? Follow up: If no, why do you think this may not be a potential option for waste management in the state?
16. Do you think informal recycling by scavengers could be integrated into the formal sector? How do you think this can be achieved?
17. What do you think a sustainable waste management system should ideally include?

A4: Question Guide for Scavenger Interview
1. How long have you been working here at the disposal site?
2. Could you please tell me how the waste volume and content has changed over the last 10- 20 years? What else has changed?
3. What kinds of material do you find in household waste brought to this disposal site? Follow up: Plastic, iron, cardboard, glass, cans, bottles, copper, aluminum, textiles, others?
4. Could you please describe what you do with different kind of materials you collect? Follow up: Do you take what you want to saleable items to somebody or do they come to you to buy? How much of each waste material do you collect per day?
5. Is it possible to feed a family on the income you earn from collection of waste material?
6. Do you have certain households or others places you go to when you want to pick useful materials from other people's waste?
7. Could you describe the relationship between you and the municipal waste collectors?
8. Is there competition between you and the waste collectors for salvaging saleable waste?
9. Do you think it would be good if the government could employ you to pick and sort materials from waste?
10. Do you notice any kind of fires or odors from the land fill or dumpsites when you go there to collect valuable waste items?

A5: Observation Protocol

Households: The residents are asked to keep their waste for a day in a plastic bag. The idea behind this is to observe and record what constitutes the waste they generate.

How (direct disposal in bin or use of bags, separation if any) residents store their waste shall be observed. Materials used for storage (sacs, plastic bags, bins) shall be taken note of. In order to ensure little interference with peoples' attitude as may be the case when there is a consciousness of being watched, the observation shall take place when the private operators are about to collect waste from households. Hence, a preliminary check on certain areas will be done to know when waste often collected. What is observed shall be matched with what the residents say in their interview in order to determine a correlation or otherwise. Direct Disposal or indirect .i.e. use of bags, sacs, others:

1. Number of disposal points within and outside the premises.
2. Items disposal points are intended for.
3. Components of waste observed and their classification into different categories.
4. Covered waste bins or otherwise.
5. Bins provided by LAWMA, bought privately or improvised.
6. Conditions of disposal points: e.g. Foul odor, attraction of cockroaches, flies, other vermin if any.
7. Direct disposal or indirect .i.e. non usage or usage of bags, sacs, etc.
8. Place for burning waste outside the house if any.

Private Operators: Observation of private operators' activities shall be done to see how waste is collected from each household. More specifically, the following shall be noted.

1. The type of collection vehicles used
2. Other equipment used
3a.If waste collected based on how it is sorted by residents
3b.Any kind of informal sorting done by the private operator crew
4. Average number of staff on the waste collection trips observed.

Landfill: The landfill at Solous II shall be visited to observe its conditions and operation activities that go on in the landfill. The operation activities may be important in shedding light on how the waste that goes to land fill is managed efficiently or otherwise. Olushosun waste disposal site shall also be visited. Pictures shall be taken as needed during the entire observation period and scavengers sighted shall be interviewed. Observation on whether the scavengers protect their hands and feet while working shall be done, how and what they use for sorting & handling waste would be observed.

Things to observe include:

1. Where the landfill is sited.
2. Physical condition of the landfill and its surroundings
3. How the waste is handled (observed from activities of on-site landfill operators)
4. Types of equipment/ plant used in landfill operations.
5. Kinds of waste taken to the disposal sites by private operators
6. How the issue of leachates is handled

7. Existing supporting infrastructure for landfill gas capture or leachate control.
8. Scavenging activities shall be noted
9. If activities such as burning of waste occur on the dumps or landfills.
10. Presence or absence of odor, and any kind of odor minimization activity being carried out.