Ako Achere Remy

SOLID WASTE MANAGEMENT: WORLD PERSPECTIVES AND THE CAMEROON CASE STUDY

Universidade Fernando Pessoa
Faculty of Science and Technology

Master in Environmental Engineering and Management

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This research is a compilation of data from all those mentioned and cited in the referenced section of this work.

(Ako Achere Remy)

Submitted at the *Universidade Fernando Pessoa* in fulfillment of an MSc in Environmental Engineering and Management, under the Supervision of Professor Maria Alzira Pimenta Dinis and Professor Maria João Simas Guerreiro.

Porto, 2012

ABSTRACT

Nowadays, many nations in the world transform their contemporary waste management practice into a more efficient and sustainable one. This is to render them capable of handling increased refuse generation and the numerous ambiguities of the current municipal solid waste management (MSWM) systems. This has been aggravated by economic activities, urbanization and life quality provided to the city inhabitants. This has influenced the masses to shift from rural to the urban environments. More so, low, middle and high-income countries spend roughly 40% of the annual budget on waste related environmental problems. In spite of the changes in strategy, the quantity of municipal solid waste (MSW) continues to increase, and its diverse characteristics make it a lot more problematic.

This study strives to understand the key drivers of waste handling and present the challenges, threats, and opportunities in transforming the traditional waste streams into optimized practices with acceptable waste administration. In the quest of understanding the challenges, a literature research pattern of facts compilation served as the main model for the study. This work investigates the policies and options that are employed in 29 nations all over the world. It also proposes a direct or indirect framework for a lower middle-income nation-Cameroon.

The study concludes that: firstly, strategies based on, social, economic, political tools, and new technologies, can assist cities/countries in their revolution geared towards a sustainable MSWM system. Furthermore, waste handling difficulties are not only technologically orchestrated, but they are due to political misappropriation. Lastly, the couple force existing between waste volume and income will remain directly proportionate if stakeholders are not educated to hold up with MSW streams in the world.

Keywords: Municipal Solid waste management (MSWM), income group**,** sustainable waste management.

RESUMO

Atualmente, muitos países no mundo têm como objetivo transformar as suas atuais práticas de gestão de resíduos em práticas mais eficientes e sustentáveis. Induzida por numerosas lacunas existentes nos atuais sistemas de gestão de resíduos e agravada pelo aumento da migração das populações das zonas rurais para os ambientes urbanos, a produção de resíduos e os problemas que desta advêm têm aumentado. As atividades económicas atualmente praticadas e o aumento da qualidade de vida das populações são também fatores que contribuíram para o agravamento destes problemas. Em média, e incluindo os países subdesenvolvidos, desenvolvidos e em vias de desenvolvimento, 40% do orçamento despendido na resolução dos problemas ambientais a nível mundial é destinado à resolução destes problemas. Apesar do montante gasto na gestão dos resíduos, a quantidade de resíduos urbanos gerados continua a aumentar e a cada vez maior diversificação dos resíduos gerados dificulta a sua gestão.

Este estudo visa compreender os principais fatores intervenientes na gestão dos resíduos, apresentando os principais desafios, ameaças e oportunidades de transformação dos tradicionais fluxos de resíduos, assim como a otimização de práticas aceitáveis de gestão de resíduos. De forma a melhor entender os desafios do processo de gestão dos resíduos, foi efectuada uma compilação de dados obtida através de uma pesquisa literária, pesquisa esta que serviu de base de estudo deste trabalho. Este trabalho procura ainda investigar as orientações políticas e linhas de conduta adotadas em todo 29 paysage o mundo.

Este estudo permite-nos concluir que: em primeiro lugar, estratégias baseadas em ferramentas e políticas socioeconómicas e tecnologias mais recentes podem conduzir as cidades/países a implementar uma revolução sustentável, sem stresse, acessível, viável e mais eficaz das suas estratégias de SGRS Urbanos; em segundo lugar, verificou-se que os problemas de gestão de resíduos não são resolvidos apenas com o recurso à tecnologia, são essencialmente resolvidos através de políticas de gestão apropriadas; por último, a força mútua existente entre o volume de resíduos gerados e os encargos resultantes continuará a ser diretamente proporcional se os principais intervenientes nos sistemas de Resíduos Sólidos não forem devidamente educados e se estes não se preocuparem com os fluxos de resíduos gerados a nível global.

Palavras-chave: Gestão de resíduos sólidos, Nível de rendimentos, Gestão sustentável de resíduos.

DEDICATION

To my late father Ako Dickson, and Uncle Agbor Mathias Ayukndip.

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Opening, I like to thank the people who supported and helped me immensely with this Study:

To Professor Maria Alzira Pimenta Dinis, my hypothesis advisor, sincere gratitude for Proposing this subject to me, her invaluable assistance and support throughout my involvement in the environmental engineering department, for her reviews, constructive advices, patience and encouragement. To Professor: Maria João Simas Guerreiro, my co-advisor, for her valuable insights, guidance and support. To my family for their endless morally supports throughout this study. To Environmental Engineer: Joel Braga of SULDOURO–Gaia for his timely and angelic support. Many thanks, to Mr. David and all the workers of SULDOURO, for their hospitality and kindness in sharing their valuable experience with me.

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GENERAL INDEX

ABSTRACT……..iii
RESUMO…….....iv
DEDICATION……..…....v
ACKNOWLEDGMENT……...….vi
FIGURES INDEX……..…...ix
TABLES INDEX……..…..x
LIST OF ABBREVIATIONS ……...…...xi

1. INTRODUCTION…….1

2. SOLID WASTE MANAGEMENT: "STATE-OF-THE–ART"……...4

2.1 WASTE GENERATION……..4
2.2 WASTE COMPOSITION……6
2.3 WASTE COLLECTION……...7
2.4 WASTE TREATMENT AND DISPOSAL……..9
2.5 WASTE MANAGEMENT STRATEGIES……11

3. SOLID WASTE MANAGEMENT ASSOCIATED PROBLEMS…….17

3.1 REDUCTION AT SOURCE……..17
3.2 WASTE SORTING AT SOURCE.....20
3.3 WASTE COLLECTION AND CONTAINER……...22
3.4 PARTNERSHIP AND LEGISLATIONS……...23
3.5 TIPPING FEES, RECYCLING AND LANDFILLS……..24

4. MSWM PROBLEMS-OPTIMISATION STRATEGIES……...27

4.1 WASTE PREVENTION……28
4.2 SUSTAINABLE DESIGN……..32
4.3 LEARNING AND COMMUNICATION……...33

5. CAMEROON WASTE FRAMEWORK……..35

5.1 INTRODUCTION……..35
5.2 MINENP (Legislative Tools)……..37
5.3 REGULATORY BODY (Assessment tools)……..38
5.4 MANAGERIAL AND SOCIOTECHNICAL TOOLS……...40

6. CONCLUSIONS…….46

7. REFERENCES……48

7.1 BOOKS, SHORT MAGAZINES ARTICLES, REVIEW ARTICLES, COMMUNICATIONS AND POSTERS ON WEBPAGES……48
7.2 LEGISLATION……..62

8. APPENDIXES…….63

Appendix A - The waste generation rates and total annual waste in thousands of tonnes of the 29 case studies and their respective income group ……...a

Appendix B - Relative composition of household waste in low, middle and high-income Countries in the world…….b

Appendix C - MSW composition of the city of Yaounde in Cameroon……....b

Appendix D - Landfill tipping fee of some countries in high-income countries and the rate of recycling…….……..c

FIGURES INDEX

Figure 1 - Solid waste generation rates in kg/person/day……..…..…….5

Figure 2 - Waste composition in high, middle and low-income countries……...7

Figure 3 - Unassembled waste obstructing rainstorm and street……..9

Figure 4 - A typical disposal and treatment strategy in low-income nations……..11

Figure 5 - Solid Waste Flow stream in low-Income Countries….....14

Figure 6 - The waste flow stream in high-income countries……16

Figure 7 - The rate of change of landfill tipping fee and recycling rates in some high income nations (data source appendix D)……...26

Figure 8 - The solid waste management enhancement strategy pyramid…….……...28

Figure 9 - The proposed operational MSWM Framework and Responsibilities for municipalities in Cameroon……...…..39

Figure 10 - MSW composition of the city of Yaounde with a high concentration of organic matter…….……...…….41

Figure 11 - Illustrates a 16 m^3 waste skip of HYSACAM placed on the sidewalk for waste storage/collection……..….43

TABLES INDEX

Table 1 - Example of some major MSWM strategies and associated problems.……..18

Table 2 - List of some online waste exchange links and the respective countries……32

Table 3 - Roles and responsibilities of key ministerial departments related to solid waste management in Cameroon (Manga et al., 2008; PM, 2011).……...36

LIST OF ABBREVIATIONS

A

ASTC - **A**ssociation of **S**cience-**T**echnology **C**enters

APO - **A**sian **P**roductivity Organisation

ABA - **A**merican **B**ar **A**ssociation

C

CCME - **C**anadian **C**ouncil of **M**inisters of the **E**nvironment

CIA - **C**entral **I**ntelligence **A**gency

CBOs - **C**ommunity-**B**ased **O**rganisations

CSS - **C**enter for **S**ustainable **S**ystems

D

DEF - **D**epartment of **E**nvironment **F**IJI

E

EPA - **E**nvironmental **P**rotection **A**gency

EUROSTAT - **E**uropean **U**nion **S**tatistics **A**gency

EU - **E**uropean **U**nion

EC - **E**uropean **C**ommission

EPR - **E**xtended **P**roducer **R**esponsibility

EGSSAA - **E**nvironmental **G**uidelines for **S**mall-**S**cale **A**ctivities in **A**frica

ERA-CAM - **E**nvironnement **R**echerche **A**ction au **C**ameroun.

EAYT - **E**arn-**A**s-**Y**ou-**T**hrow

EEA - **E**uropean **E**conomic **A**gency

G

g - **G**ram

GNI - **G**ross **N**ational **I**nvestment

GPP - **G**reen **P**ublic **P**rocurement

GDP - **G**ross **D**omestic **P**roduction

H

HMLI - **H**igh, **M**iddle, and **L**ow-**I**ncomes

HYSACAM - ***H****ygiène et* ***S****alubrité du Cameroon*

I

ISWM - **I**ntegrated **S**olid **W**aste **M**anagement

IMF - **I**nternational **M**onetary **F**und

ISWA - **I**nternational **S**olid **W**aste **A**ssociation

IMCMWM - **I**nter-**M**inisterial **C**ommission for **M**unicipal **W**aste **M**anagement

K

Kg - **K**ilo**g**ram

L

LIPOR - *Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto*

L - Liters

M

MUDI - **M**inistry of **U**rban **D**evelopment of **I**ndian

MSWM - **M**unicipal **S**olid **W**aste **M**anagement

MEP - **M**inistry of **E**nvironmental **P**rotection of **C**hina

MINENP - **M**inistry of **E**nvironment and **N**ature **P**rotection

MSW - **M**unicipal **S**olid **W**aste

MSWG - **M**unicipal **S**olid **W**aste **G**eneration

mm - **m**illi**m**etre

m/s - meters per **s**econd

N

NGO - **N**on-**G**overnmental **O**rganization

NEMP - **N**ational **E**nvironmental **M**anagement **P**lan

O

OECD - **O**rganisation for **E**conomic **C**o-operation and **D**evelopment

OSPI - **O**ffice of **S**uperintendent of **P**ublic **I**nstruction

P

PPP - **P**ublic **P**rivate **P**artnerships

PRC - **P**residency of the **R**epublic of **C**ameroon

PM - **P**rime **M**inister

PAYT - **P**ay-**A**s-**Y**ou-**T**hrow

R

RCRA - **R**esource **C**onservation and **R**ecovery **A**ct

S

SWM - **S**olid **W**aste **M**anagement

SIC- **S**tandard **I**ndustrial **C**lassification

U

UNEP - **U**nited **N**ation **E**nvironmental **P**rogramme

USA - **U**nited **S**tates of **A**merica

UK - **U**nited **K**ingdom

UN - **U**nited **N**ations

UN-HABITAT - **U**nited **N**ations Human settlements programme

USEPA - **U**nited **S**tate **E**nvironmental **P**rotection **A**gency

W

WB - **W**orld **B**ank

WTT - **W**aste **T**reatment **T**echnology

WM - **W**aste **M**anagement

1. INTRODUCTION

According to Section 261.2 of the Resource Conservation and Recovery Act (RCRA) Regulations, solid waste is defined as, *"any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities"* (EPA, 2011).

Municipal solid waste (MSW), also known as trash or garbage is constituted of household waste, such as appliances, furniture, residential garden waste and domestic hazardous waste. Refuse from local council operations like street sweeping, waste bins, commercial, construction and demolition, and some treated industrial waste may also be considered MSW (Weinstein, 2006), that is set aside for street and home collection (Laner et al., 2011). MSW classification has changed since the late 1960's for development of strategies (e.g. waste hierarchy) that enhance handling and planning of all items and materials to be discarded (EPA, 2011a; Eurosat, 2009).

Transition towards consumerism societies based on global markets, new materials and telecommunication development, has disseminated goods and information throughout the world (APO, 2007), with a consequent increase in waste production. Waste production rates are increasing exponentially as the world population grows, powered by changes in lifestyles, development and consumption of more non-biodegradable materials (Asase et al., 2009).

Managing waste with unreliable compositions has progressed from the primary concerns of just collection and dumping, to environmental and human health protection, resource handling, energy generation, sustainable assortment, and other management practices (EPA, 2012a; Eurostat, 2009). Handling of waste in high-income countries is driven by public and environmental health, and natural resources conservation (Desmond, 2007). In the 1970s, high-income countries like USA, UK and some OECD countries included sanitation, environmental protection, commercial and charitable recycling and reuse practices into the modern waste organization plan (EPA, 2011).

In low and some middle-income nations, inadequate service coverage, operational inefficiencies, limited recycling, insufficient management of non-industrial hazardous waste and unsatisfactory landfill disposal mechanisms characterize municipal solid waste management (MSWM) (Parthan et al., 2011). Nonetheless, an increase in the rate of waste generation resembles that of high-income countries. This increase is directly proportional to the number of inhabitants and respective economic status. Hence, failure to provide a suitable discarding system has resulted in immeasurable environmental degradation, with increased health risks to local population and global warming (Al-Salem et al., 2010; MEP, 2010).

Some high and middle-income countries have searched for sustainable MSWM alternatives, like the recent integrated solid waste management plan (ISWM). ISWM is the combination of techniques and programs to efficiently manage municipal waste streams. Considering that waste streams are made up of distinct components that should be dealt with separately in a sustainable manner (EPA, 2012a; Simon, 2008). Sustainability will comprise the usage of a range of different management/treatment options at a local level in each waste stream.

ISWM is broadly evident in the waste management systems in most high-income countries (Pires et al., 2010). Some initiatives towards ISWM in low and some middle-income countries like South Africa, China, and Ghana have been reported, and are often orchestrated by non-governmental organizations (NGOs) (Dong et al., 2010; Lincoln, 2011; Thompson, 2010).

Nonetheless, research statements like; if MSWM strategy problems are technical or political, or/and if high-income citizens generate more waste because of their revenue, were tentatively answered in a number of publications such as research/review papers, articles and thesis. Trends of MSW generation, recycle and composition in some high and low-income countries were assessed by APO (2007), Al-Salem et al. (2010), Hogg et al. (2002), Hoornweg and Giannel (2007), Issam et al. (2010), Laner et al. (2011), Naushad et al. (2008), Parthan et al. (2011), Pires et al. (2010), and Troschinetz and Mihelcic (2008). Additionally, comparisons of MSWM among different cities in the world have also been conducted (Rodic et al., 2010; Tanaka, 2007; UNEP, 2005). The above-mentioned studies have chiefly focused on precise aspects of waste management in most countries, and major cities in the world.

This work aims to identify MSW production, quantity and composition; recognize attitudes and behaviours towards MSW separation and recycling; review different methods for MSW

collection, recycling, treatment and disposal; scrutinize current problems and barriers in MSW management in the world; and analyse strategies for future MSWM in Cameroon, a lower middle-income country in West Africa.

Moreover, the research is conceptually based on five chapters. *Chapter One* introduces background information on solid waste. Notwithstanding, it upholds research background, problems description, research statement, and objectives. *Chapter Two* holds a review of the various MSWM strategies in the world and presents the methods used for data collection, and analysis. *Chapter Three* illustrates some important MSWM problems with facts obtained from overflowing sources, in a comparison format based on the gross national investment (GNI) status of low, middle, and high-income countries in the world. *Chapter Four* paints a picture of the optimization strategies to the identified MSWM problems, with highlights on the socio-technical potentials of all stakeholders involved in MSWM. And, lastly, *Chapter Five* analyses a cautious conception framework of an ideal pattern, for a sustainable MSWM framework in Cameroon.

Furthermore, benchmarking MSWM services is far from being a straightforward exercise, even within a nation with uniform regulations and governance system. Therefore, for comparison to be possible among immensely different socio-cultural and income groups in the world, data was accessed from numerous academic literature, process-based life cycle assessments of MSWM systems, that addresses municipal and/or commercial waste streams published in French, English, and Portuguese, between the years 2007 to 2012 in over 29 countries (See Appendix A). They were accessed in reviewed, scientific journals, the Web, Geo-databases of study countries, online search engines like Google Scholar, science-direct, etc. and the rest is indistinguishable as in the reference section of this work.

2. SOLID WASTE MANAGEMENT: "STATE-OF-THE–ART"

Managing municipal waste in the world has been guarded and implemented with respect to a particular pathway, objective, or strategy. These strategies differ from nation to nation and are often in conformity with the urgent needs of the city/country in relation to the actual status of the waste generated.

2.1 WASTE GENERATION

The availability and quality of data has been the major misfortune of the municipal solid waste management (MSWM) sectors, and this work in particular. Waste data are lacking for many income groups particularly those of low-income countries, where data qualities are changeable, and inconsistence or are often approximations (UN-HABITAT, 2010). Nonetheless, to assemble facts for this work, the following criteria served as foundation in selecting case studies and data predominantly, the country should have a socio-economic status of low, middle, or high-income, as designated by the World Bank, standing firm as the main financial institution. It classifies all the 187 member countries into income categories (income groups) based on bank's operational lending categories (World Bank, 2012; 2011).

The World Bank's main criterion for classifying economies is gross national income (GNI) or gross national product (GNP) per capita (World Bank, 2012). Therefore, the World Bank atlas assessment method of 2010, classifies the economies groups liable to the GNI in terms of united state dollars (USD) as: countries who's GNI is $1,005 or less as low-income; lower Middle-income, $1,006 - $3,975; upper middle-income, $3,97 - $12,275; and high-income, $12,276 or more (World Bank, 2012).

Secondly, lower middle and upper middle-income economies of the World Bank, are considered as middle-income economies. Lastly, all case studies originating from member countries/cities within the income group must contain waste characterization data for 10% or more of the county as presented in Appendix A.

Unveiling waste generation, the municipal solid waste (MSW) volume generated depends on the local standard of living, consumption pattern as well as, on the level of institutional and commercial activities. Nevertheless, some factors like rapid economic growth, enormously

contribute to the dramatic increase in waste volume. This instigates the purchase and usage of more materials, and encourages immigration, and high birth rates (Rodic et al., 2010; UN, 2011).

Consequently, in high-income countries such as Germany, USA, Canada, waste generation rates is over 2.3 Kg/person/day, while the residents of low-income countries generate less than 0.5 Kg/person/day (See Figure 1). A similar tendency exists in middle-income nations. Encouraged by the improvements in economic conditions, living standards have changed and the rate of consumption of materials increased as well. Subsequently, it induces production of large amounts of waste. Even so, waste creation is stratified; the rich localities have generation rates of 1.6 Kg/person/day. While, lower-income quarters generate as low as 0.6 Kg/person/day. Likewise, waste generation rates vary within high-income nations like Canada, for example, low-income households generate 2.6 Kg/day; middle-income households produce 2.7 Kg/day, and high-income households, 4 Kg/day (Asase et al., 2009; EPA, 2010b). Furthermore, these variations portrait a clear picture regarding the composition of waste.

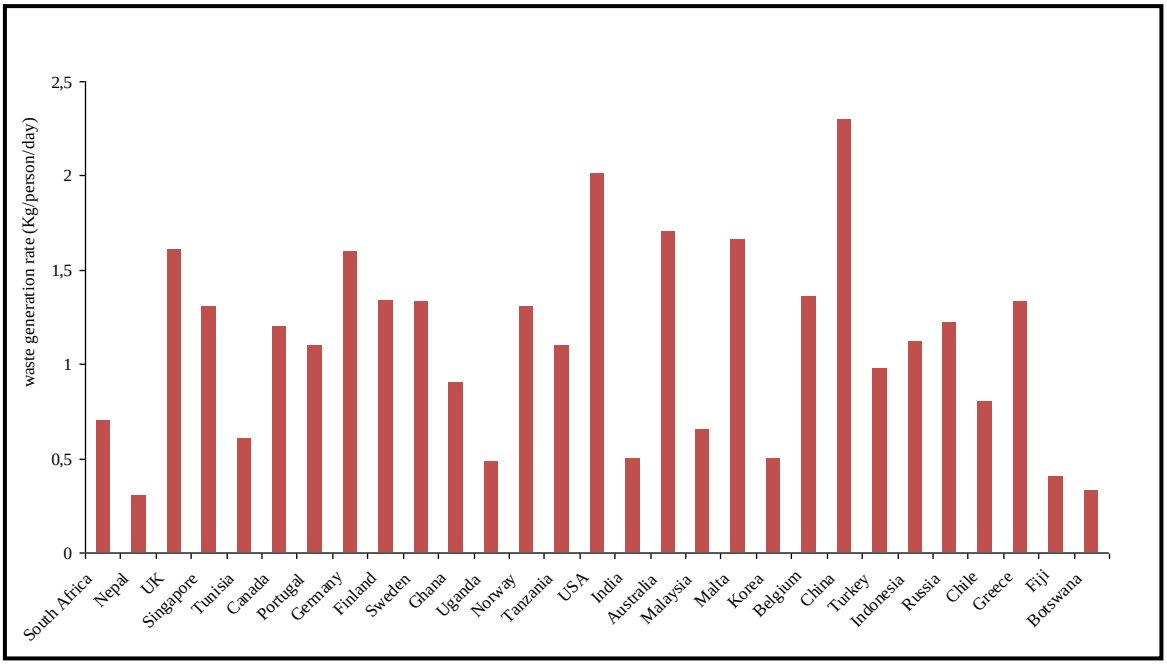

Figure 1 *- Solid waste generation rates within the 29 case studies.*

2.2 WASTE COMPOSITION

Waste is composed mostly of organic matter, paper and cardboard, plastic, glass, metals, textiles, rubber, and leather. Nonetheless, waste composition is based on three fundamental indicators: tradition and culture, lifestyle or eating habits, and the economy of the state.

Waste produced in low-income countries contains a greater percentage of organic materials (82.5%) and moisture content, higher than those of high-income nations as revealed in Figure 1. This is due to the frequent home cooking of freshly harvested tubers, fruits, meat, fish, vegetables, and, to the insignificant rate of consumption of packaged food (Khatib, 2011; Manga et al., 2008). Moreover, waste produced in low-income countries contains paper, but low amounts of plastic, glass and metal (Al-Khatib et al., 2010; Okot-Okumu and Richard, 2011; Thompson, 2010). Furthermore, low-income households generate higher fractions of organic waste than high-income families (Al-Khatib et al., 2010: Lincoln, 2011).

On the other hand, in high and some middle-income countries (parts of South Africa and Russia), lifestyle favours ready-made packaged food instead of home cooking. The prevalent consumption of processed and packaged food products result in a higher percentage of inorganic materials like metals (8%), plastics (8%), and paper/cardboard (45%) (Figure 2).

Plastic packaging like plastic bottles are mostly made of polyethylene terephthalate (PET), yoghurt cups made mostly of polypropylene (PP), wrapping film, bin liners and flexible containers are usually composed of low and high-density polyethylene (LDPE/HDPE) and many others (Khatib, 2011). This diversity partly explains why almost half of the generated municipal solid waste originates from packaging waste (ISWA, 2011; Pires et al., 2010).

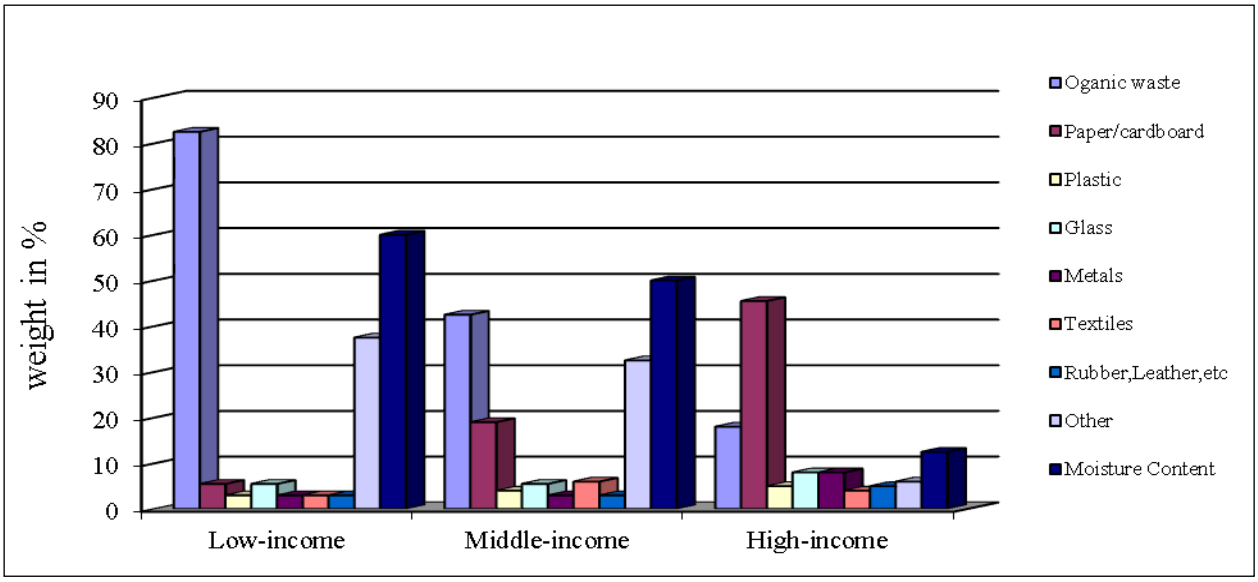

Figure 2 *- The waste composition in low, middle, and high-income countries and in comparison with moisture content.*

2.3 WASTE COLLECTION

Waste collection implies gathering of waste, and transport to either the processing facility (WTS), transfer facility or disposal site (EPA, 2010a; b). This process has taken several designs at various collection sites in the world. Firstly, In high-income nations like America, Portugal, Germany, and Canada and some middle-income states like Russia, and part of South Africa, colour code bins are placed in convenient locations, permitting waste holders and producers of a given area to dump it in the respective bins (Pires et al., 2010; UN-HABITAT, 2010).

Separate, aesthetic, covered roadside collection bins, handling mixed recyclables, paper/cardboards and biodegradable wastes, are positioned along the streets and in homes by the homeowners/municipality to be emptied by improved rear loaders, side loaders or forehead loader compactor waste trucks on the collection day and returns the empty containers to their storage location until the next gathering day. Moreover, street waste calls for road cleansing often executed automatically by sweeping trucks (CCME, 2009). The overall collection trend has an efficiency rate of above 90%, enriched by the presence of a constant and reliable road network and a global tracking system.

In contrast, a fairly different assembly approach is used in middle-income countries like South Africa, China, and India, even though they practice a mixed waste collection stream. Household waste is commonly placed in plastic and woven bags or in other sorts of improvised containers and stored at home before taken to the gathering points. Collection containers and skips of sizes 6-16 m^3 are placed on roadsides to be collected by waste vehicles or hand-operated carts once a day or twice a week in some nations like South Africa. Notwithstanding, the frequency and area covered is lower in some fatherlands, because of budget and infrastructural constraints. However, the assortment area coverage within a country or city is lower than 50% (APO, 2007; Lincoln, 2011; Tay, 2012).

Additionally, disparity is the order of the day among indigenous groups, often the frequency of collection ranges from twice a week for the high-income residential areas to once a week in the low and middle-income localities. The high-income societies are endowed with adequate collection systems, while low-income regions do not benefit from the same treatment. Therefore, open roadside dumping within a given municipality and country becomes rampant (Manga et al., 2008; Tay, 2012). Despite this disparity, a variety of strategies are employed. Door-to-door collection, where household waste is placed at the doorstep for waste collectors to carry to the primary gathering vessels, it is the collector of the waste who has the responsibility to collect the waste separately (APO, 2007).

The second strategy is Block collection; the assemblage vehicles arrive at a particular place and time to collect waste from households. Families bring waste in assorted vessels and empty them directly into the waste truck. However, this vast social inequality and pitiable MSWM systems instigate citizens to exploit open dumps. Furthermore, municipalities employ sweepers to sweep the streets and public areas using simple utensils and at times automatic sweeping mechanical trucks are employed particularly at the city centers (Lincoln, 2011; Manga et al., 2008).

Notwithstanding, waste assemblage in low-income countries such as Ghana, Nepal, Botswana, and Uganda takes a drastic tactic; collection systems used have a significant effect on the quality of recovered materials. Handicapped, by the lack of economic means and technical know-how only a small fraction of the generated waste is discarded. In Nepal, for example, only 2% of the total waste generated is collected. In Uganda, waste collection coverage is around 15 and 40%.

Most cities in low-income countries collect only part of the overall waste and merely a tiny fraction of the wastes is treated or fairly disposed of (Okot-Okumu and Richard, 2011). The absence of a reliable refuse assortment system, compel family circles to use open dump (15.5%), or simply burn it in their backyards (10%). Accordingly, the unassembled wastes (58.7%) may also accumulate on the streets thus, obstructing rainstorm and water drainage systems (Figure 3) (APO, 2007; Okot-Okumu and Richard, 2011; Tay, 2012).

Figure 3 *- Unassembled waste obstructing rainstorm and street.*

Moreover, the urban low-income vicinities receive very low or no waste gathering services due to inaccessible roads (Manga et al., 2008). Furthermore, these areas are totally neglected due to their illegal status. In Fiji and Mumbai-Uganda for example, illegal shanty town of over a thousand inhabitants are formed every year (UN-HABITAT, 2010). Besides, waste pickers roam the streets in search of recyclable goods. Being predominantly biodegradable (82.5%) lower-income families dispose waste daily, because of poor and improvised storage utensils, while high and middle income homes dispose twice a week and commercial premises dispose daily as well (Okot-Okumu and Richard, 2011; UN-HABITAT, 2010). The gigantic nature of engendered waste seeks for immediate treatment and clearance options to limit instantaneous effects to the holder.

2.4 WASTE TREATMENT AND DISPOSAL

MSW collected in most high-income nations are disposed of in a sanitary landfill, yet, some recyclables collected through the coloured code bins are transported in a resource recovery

facility. In UK-London for example, the recyclables are sorted, baled, and 98% are shipped to their respective recyclers whom then transforms it into new products and only 2% of it ends up in the landfill (Asase et al., 2009). Furthermore, in Portugal for instance, with a global recycling rate of 20%, the recycling rates for the different materials are: 12.5% for paper/cardboard, 4.5% of plastics, 30.2% for glass, 24.8% for steel, 6.9% for aluminium and 80% is landfilled, where landfill methane gas is recovered for electricity production (LIPOR, 2008). Notwithstanding, the above treatment strategies, and several others are used either to get rid of the waste (incineration), or to transform it to fertilizers (composting, aerobic digestion), and many more (Thompson, 2010).

Indistinguishable, in middle-income countries MSWM is oriented by the rapid urbanization and globalization, therefore, some of the above treatment and techniques such as, landfill gas recovery, waste incineration, composting are being employed. However, 70% or more of it ends up in controlled and semi-sanitary landfills, with less recovery and shipment of recyclables (APO, 2007; Okot-Okumu and Richard, 2011; UN-HABITAT, 2010).

Meanwhile, in low-income countries the use of appropriate treatment technologies is a rare factor. Open dumping and burning are widespread methods used to reduce the volume, and odour of the MSW (UN-HABITAT, 2010). Lastly, recycling activities is principally handled by the informal sector, where scavengers collect and sell recyclable materials for livelihood. Driven by poverty, high unemployment rates, low education level, and the demand for secondary materials, scavengers recover recyclables like papers, cardboards, plastics, glasses, and a few metals from the streets skip/bins, open dumps and at the disposal sites. Anywhere, they later sell them to waste merchants or directly to recycling companies (Figure 4) (Al-Khatib et al., 2010; Sam, 2009; Thompson, 2010). The above MSWM strategies might seem ideal in high-income countries and flawed in low-income countries. Yet, all the above income group's MSWM strategies are far from being perfect or ideal, but hypnotized by the following MSWM problems.

Figure 4 - A typical disposal and treatment strategy in low-income nations (world environmental day).

2.5 WASTE MANAGEMENT STRATEGIES

The international plan of action to sustainable development manifested in the United Nations (UN), *Rio de Janeiro* Summit of 1992, and the goals of Agenda 21 achieving sustainable development that meets the needs of the poor and recognizing the limits in development to meet global needs (Cutler et al, 2007). More so, the European Council in 2001 adopted the first European Union (EU) sustainable development plan with overall aim, to sustain and endorse actions enabling high-income countries of EU to realize continuous improvement of life for both actual and upcoming generations (Naushad, 2008; Pires et al., 2010). Last but not the least, in 2002, the EPA launched the 2020 vision whose need is to shift focus away from waste to resource materials management. All these ushered a new phase in the regulatory framework of MSWM in the world (EPA, 2012b).

In spite of this enhancement in policy, low-income countries like Tanzania, Nepal, and Botswana and some middle-income countries (India, and Ghana.) municipalities spend 20-50% of their available recurrent budget on MSWM. Nonetheless, it is common to observe that

30-60% of all urban waste is not collected and less than 50% of the population is served (APO, 2007; Khatib, 2011; Kyessi and Mwakalinga, 2009; UN-HABITAT, 2010: World Bank, 2012). In some cases, as much as 80% of the collection and transportation equipment is out of service, in need of repair or maintenance. Consequently, open dumping and burning becomes legal (World Bank, 2012).

Additionally, acknowledging that humanity is chiefly resource constrained thus end-of-life products and materials have a positive value. Therefore, in low-income societies, wastage is minimised, products are repaired and reused, some organic matter returns to the farms and some food remains are utilised as animal feed (See Figure 5). However, as cities mature, waste mount up in the streets and watercourses, posing acute health risks (Okot-Okumu and Richard, 2011).

More so, streamlined by the economy, refuse stream management is further stratified at the local strata, dependent on the local income standing, road infrastructures and degree of urbanization (APO, 2007; Manga et al., 2008). In addition, there are no clear roles/functions of the various national partners in relation to this sector and no single agency or committee is designated to coordinate the projects and activities of all allies (UN, 2011).

The absence of organization among the relevant intervening actors has resulted in different agencies becoming the national complement to different external support agencies for different MSWM collaborative projects without being aware of what other national agencies are doing (Manga et al., 2008). Hence, the waste stream obeys a haphazard trend, where partially disposed portion of the organic refuse is reused in agriculture, composting, and for agriculture. The rest gets to the collection vessels, where fragments are being collected by waste pickers for sales. This collection also occurs at the landfill site, and there is no accountability (Regassa et al., 2011). Lastly, a huge fraction ends up in/by the roadside and riverbeds as open dumps. Nevertheless, recyclables from the open dumps, primary/secondary collection streams, and landfills, do return to the waste market (waste merchants and intermediaries). The purchased materials are either traded locally to on-site recycling firm, if any or exported as presented in Figure 5 (Asase et al., 2009; Ranjith, 2012).

Furthermore, in any up-to-date MSWM system, fees represent an important component. Traditionally, residents pay for waste collection through property taxes, goods, or through

other indirect means, regardless of how much or how little waste they generate. Part of the funds is later distributed to the municipalities depending on the sizes and importance. For that reason, homes and public areas are mainly interested in receiving effective waste collection and disposal service (World Bank, 2012).

In addition, about 70% of the city's population live in low-income, high-density populated areas; the middle class is occupied by 17% of the population, and only 3% lives in high-income, low-density residential areas with organized infrastructures (Asase et al., 2009). Tantamount to this, waste service providers who are often from the 3%, provide service in a selfish manner, so long as the quality of their own living environment is not affected by dumpsites, then, the system is effective. Furthermore, inadequate gathering, information, quantification, and classification of waste have often resulted in health, social, economic, and environmental impact within this group (Agyepong, 2011).

Conversely, middle-income countries exhibit a similar approach as above. Waste assembly is the most prolific of all local services that incite a great deal of discontent (Asase et al., 2009). For many municipal taxpayers, they can identify this only municipal service. Therefore, local authorities are striving to manage public expectations (Manga et al., 2008). At this juncture, MSWM is experiencing a gradual migration from the collection and disposal of waste, to resource management in countries like South Africa, India, Ghana, and Cameroon come 2011 (Asase et al., 2009; Blogadmin, 2011; Minghua et al, 2009). Each nation is fostering a refuse executive plan founded on green environmental principles. For example, the white paper plan on integrated pollution and MSWM of South Africa as drawn from the waste act of 2008 (Lincoln, 2011), also the Sanitation Policy of 1999 guides refuse management practices in Ghana (Agyepong, 2011), just to name these two.

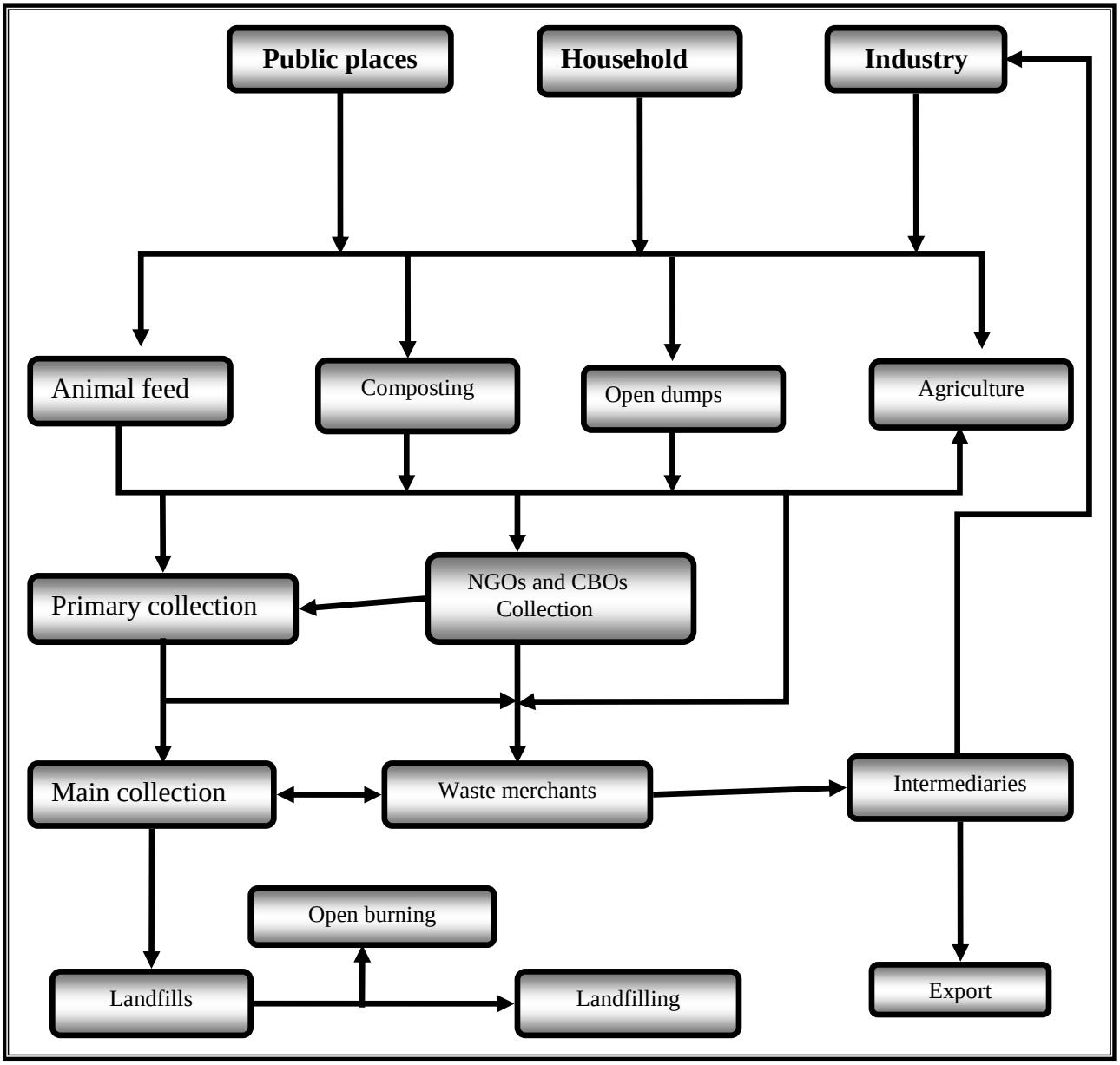

Figure 5 *- Waste flow stream in low-income countries, from producers to collectors, treatment and finally to disposal and recycling.*

On the other hand, handling waste in high-income countries, has taken a completely altered trend with fundamental strategies confined to public and environmental health and safety, waste collection, treatment/landfills directives implementation and waste minimisation (EPA, 2012a; Eurostat, 2009; OECD, 2011). Waste assembly is a necessity rather than a luxury as in low and some middle-income countries, with collection rates often above 90%. Approaches implemented in this economic group is composed of a variety of methods; vacuum waste collection system (VWCS), payable collection bins (PAYT), sophisticated compacting waste storage means, and adapted collection trucks (Naushad et al., 2008). Besides, collectors practice door-to-door collection using low capacity waste compactor trucks, to carry both

mixed and segregated waste from households in districts with narrow streets. Furthermore, the assembled waste is transferred to a waste transfer station (WTS) as shown in Figure 6. Anyhow, the amount and composition of municipal waste disposed depends on national and regional waste supervision practices and rules (EPA, 2012a; d).

Besides, regardless of these improvements in MSWM approaches, and polices such as the Waste Directive of EU-27 and EPA Act 490 (EPA, 2012a; Europa, 2011). Only a few countries have succeeded in dropping or stabilising the quantity of wastes disposed of. Anyhow, the kilogram of municipal waste *per capita* created each year is gradually stabilizing, in some countries like Portugal, Germany, Finland, and Sweden (OECD, 2011).

Nevertheless, there are some states USA, and Canada, with apparently the same MSWM strategies and boundaries whose waste volume is yet to stabilise. Likewise, most countries in this context have in place quality, assurance systems that either stand freely, or are supportive of the existing legislative standards. These systems have a variety of objectives aimed at ensuring the production of quality collection, transportation, and treatment services, often highly dependent on the local and regional policies, such as those of the EU-27 countries (Pires et al., 2010).

Moreover, the MSW collected is quantified by legally authorised waste entities at the various WTS, and the waste is taken directly to its treatment point, where partially treatment is done, or it goes to the landfills (EPA, 2012a). Equally, at the WTS each waste type is then channelled to the various handling unit, from where valorised fractions are segregated and recycled or used as raw material for energy and other recycling processes as exposed in Figure 6.

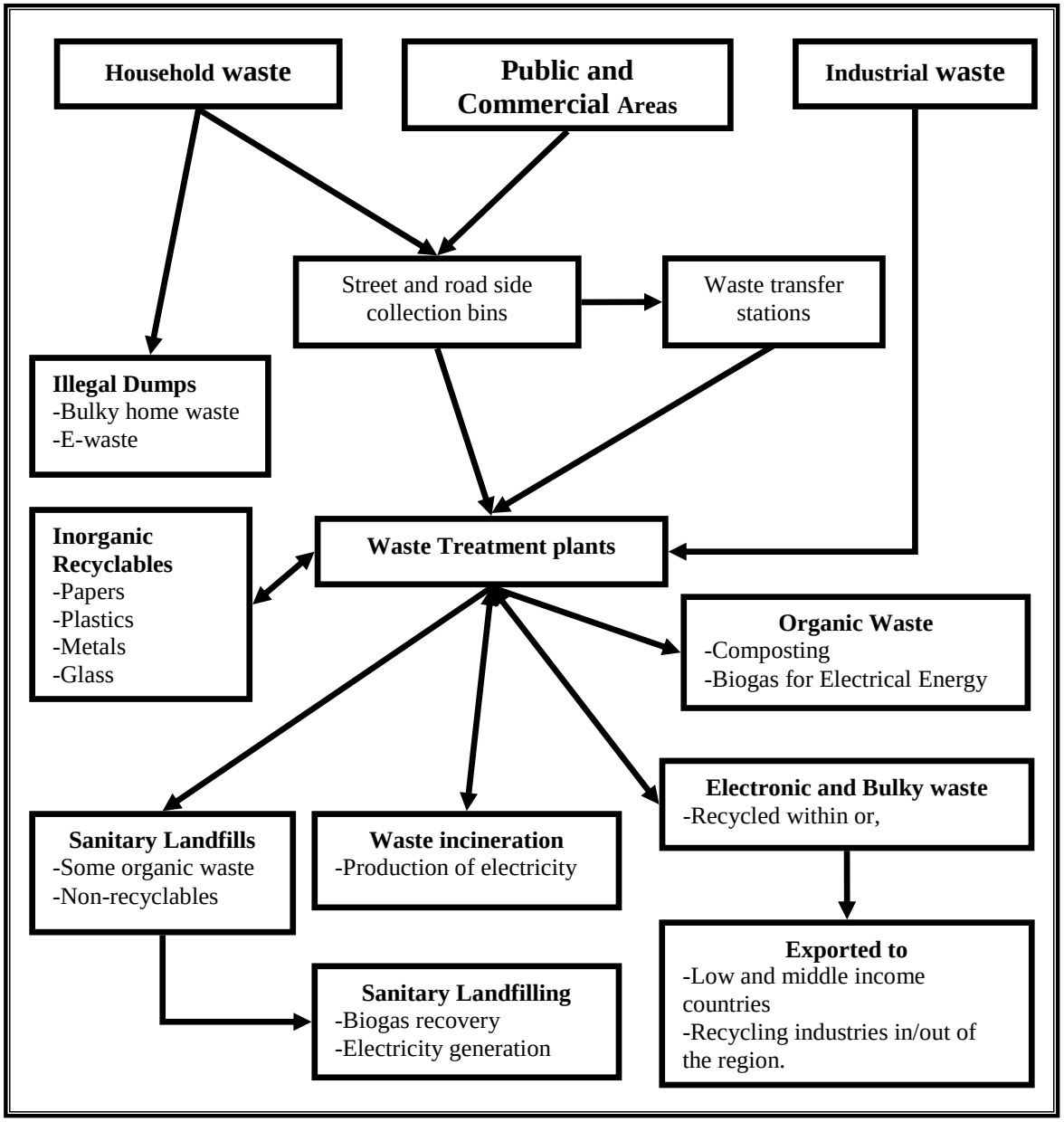

Figure 6 *- The waste flow stream from point of generation, collection, transportation and to respective disposal sites.*

Furthermore, sales and shipments are highly regulated, for example the EC Regulation No 1013/2006 regarding waste shipments in EU countries, governs all transactions and types of waste that goes within and without the zone (Europa, 2011). In spite all these strategies, huge volumes of waste gets to the landfills without being treated. Nevertheless, some illegal river side, back yard, bridges or open bush dumps can be spotted in this economic group (EC, 2008; EPA, 2010c; OECD, 2011).

3. SOLID WASTE MANAGEMENT ASSOCIATED PROBLEMS

The socioeconomic status of high, middle, or low-income countries, as designated by the World Bank, is based on the country's gross national investment (GNI), as previously elucidated. Therefore, for representation of facts in this comparative analysis, countries without a national illustrative statistic were not considered (Appendix A). In addition, statistics from non-governmental organisations such as UNEP, WB, UN, OECD, EU, do not consistently provide actual national data, but rather provide data for particular large population centres in the nation, and all of these were encompassed in this study.

Waste management systems have social drivers (consumption habits, lifestyle and communication); economic (waste cost and benefit), political (waste regulation and laws), technological (various waste treatment technologies), and environmental drivers capable of shaping the operating system (Pires et al., 2010; Zaman et al., 2011) and that should be given equal attention. Contrarily, the utmost ideal waste design will be unsuccessful. Neglecting the dynamics of the drivers involved has resulted in problems such as source reduction, source sorting, recycling, waste collection (Table 1), for the various income groups in the world (UN-HABITAT, 2010).

3.1 REDUCTION AT SOURCE

Proper handling of generated waste is not limited to the acquisition of improved technology, technical expertise, and legislation. Ambiguously, MSWM strategies addresses waste issues with models consisting of a combination of source reduction, combustion, recycling, and landfills plans (EPA, 2012e). Nevertheless, source reduction is a front-end approach in addressing MSWM problems by changing the way products are made. It also means an attempt to move away from the traditional "end-of-the-pipe," waste management approach (Zaman et al., 2011).

Table 1 – Example of some major MSWM strategies and associated problems.

MSWM problems	Countries according to their GNI			Reference
	Low-income	**Middle-income**	**High-income**	
Reduction at Source	No reduction programs, nonetheless, reuse and low per capita waste generation rates are common	Some discussions of sources reduction, but rarely incorporated into any organised plan	Organised reduction programs to emphasize on source reduction and reuse of materials.	Al-Khatib et al., 2010; APO, 2007; Dong et al., 2011; Khatib, 2011; Lincoln, 2011; Okot-Okumu and Richard, 2011; Ranjith, 2012; Rodic et al., 2010; Thompson, 2010; Troschinetz and Mihelcic, 2008; UN, 2011; UN-HABITAT, 2010
Sorting at Source	No segregation at all, as homes usually have single, assorted waste container, often without a lid.	Little waste separation, practiced by a few advocacy citizens	Average waste separation at source, in some areas with public bins while, in others very little is done.	APO, 2007; Dong et al., 2011; Khatib, 2011; Kyessi and Mwakalinga, 2009; Rodic et al., 2010; Tiawo, 2010; UN, 2011
Waste collecton and containers	Sporadic and inefficient service, limited to high visibility vicinities, the wealthy, and those who can afford. Collections represent 80-90% of the municipal budget. Containers (skips) are very limited and poorly used and maintained	Improved services, increasing containers, and collection effectiveness, often mechanised but limited to accessible areas. The collection requires 50-80% of municipal funds	The assembly rate is higher than 90%, spiced up with sophisticated/practicable collection trucks, usage of Hi-tech systems like vacuum waste collection network. Collection cost often requires 10 - 20% of council budgets	Al-Khatib et al., 2010; APO, 2007; Dong et al., 2011; EPA, 2010c; Khatib, 2011; Kyessi and Mwakalinga, 2009; Okot-Okumu and Richard, 2011; Pires et al., 2010; Rodic et al., 2010; Ranjith, 2012; Thompson, 2010; Troschinetz and Mihelcic, 2008; UN, 2011
Institutions and Partnerships	Large scale of isolated operations of NGOs, CBOs, usually operating in a particular neighbourhood within a municipality at their own funds.	Semi partnership with any private company mostly on collection and recycling	Harmonised system of private and public partnership founded on the laws and rules of the art.	Al-Khatib et al., 2010; Agyepong, 2011; Lincoln, 2011; Manga et al., 2008; Thompson, 2010; UN-HABITAT, 2010

MSWM problems	**Countries according to their GNI**			**Reference**
	Low-income	**Middle-income**	**High-income**	
Legislation and policies	General laws, handling all environmental drivers	Very good waste policies, but the implementation is problematic, coupled with the absence of assessment tools.	Too many laws but local and regional, often with specific objectives and targets, enhanced by abundant assessment tools.	Al-Khatib et al., 2010; Agyepong, 2011; Lincoln, 2011; Manga et al., 2008; Nigatu et al., 2011; UN-HABITAT, 2010
Waste charges (Tipping fees and PYAT)	Waste fees are regulated by local government taxation system. no PAYT strategy	Waste fees are regulated by some local and national governments, and there are more innovation in fee collection.	PAYT and landfills tipping fees large employed in waste treatment facilities. Upfront community participation reduces costs and increases options available to waste planers (recycling and composting)	Al-Khatib et al., 2010; Agyepong, 2011; EPA, 2010c; EPA, 2012d; Lincoln, 2011; Manga et al., 2008; Nigatu et al., 2011; Okot-Okumu and Richard, 2011; Thompson, 2010; UN-HABITAT, 2010
Waste Treatment (Recycling)	No direct governmental recycling plans except some isolated practice from the private sector and individual scale	Informal and partial municipal participation, involving some high technology. sorting and processing facilities (composting, recycling, and incineration. some materials are exported for recycling	Formal municipal, private and government participations in treatment facilities with hi-tech technology on site.	Al-Khatib et al., 2010; APO, 2007; EC, 2012; EPA, 2010; Dong et al., 2011; Kyessi and Mwakalinga, 2009; Nigatu et al., 2011Rodic et al., 2010; Ranjith, 2012; Sam, 2009; Thompson, 2010; UN-HABITAT, 2011
Landfills acquisition	The presence of cheap, abundant land makes it very easy	Availability of cheap land facing rapid and disoriented urbanisation soon encroach landfill.	Controlled Sanitary landfills, with leak detection, leachate collection and treatment systems, gas collection, and treatment units. Is facing a huge dismay in locating a new site within the vicinities of the host city.	Al-Khatib et al., 2010; Agyepong, 2011; EC, 2012; EPA, 2010; EPA, 2010c; Lincoln, 2011; Manga et al., 2008; OECD, 2009; UN-HABITAT, 2010

Reduction at source comprises designing, manufacturing, and usage of post consumer and pre-consumer materials in a way that reduces the quantity and toxicity of waste, when products reach the end of their valuable lives (EPA, 2012c). Additionally, source reduction activities include product reuse, elimination of unnecessary product packaging, reduction of products toxicity, increase in product lifespan, and decrease consumption, by changing consumer-buying practices. Consequently, source reduction varies according to the income group.

In high-income countries (e.g. USA) and some middle-income countries (e.g. Russia, Malta), the amount of waste each person generates has been on the rise since the 1960s, ranging from 1 to 2.5 Kg/person/day. This results in about 250 million tonnes of waste generated in 2010 in the USA alone (EPA, 2010a). EPA introduced an integrated waste hierarchy program in the early 1990s, the "Pay-As-You-Throw (PAYT)" program, in which citizens pay for each can or bag of waste they set out for disposal, rather than through a flat fee.

Therefore, by reducing waste at the source, people dispose of less waste and pay lower waste bills (EPA, 2012d). Nevertheless, the waste volume continues to rise, based on the above-mentioned drivers. Bulky wastes like furniture, mattresses and white goods like home appliances made chiefly of metal, textile and other recyclables, are being disposed of alongside regular house waste (UN-HABITAT, 2011).

Contrariwise, source reduction in low and some middle-income nations is achieved to its extremes. Held down by low economic potential, tradition and lifestyle, white goods, bulky wastes and some waste such as plastics and glass bottles are being used and reused for over a long period before they are disposed of (Troschinetz and Mihelcic, 2008). Huge volumes of waste are therefore, diverted from the waste stream.

3.2 WASTE SORTING AT SOURCE

Waste sorting involves activities associated with the waste management until they are placement in storage containers for collection. Sorting, handling and storage of waste at the source, is predominate in MSWM. Thus, waste sorting at source makes it the best practice to separate waste materials for reuse and recycling (Dong et al., 2011; Khatib, 2011). Every waste management strategy depends on how well the mixed MSW is separated into dissimilar

components (Tiawo, 2010). Sorting out the different elements in refuse is indispensable for recovery of useful materials, minimizing landfilled resources and allowing recyclable materials to a new embodiment (Dong et al., 2011; UN, 2O11).

In low-income countries, in-home waste separation is considered a horrible exercise, and everybody wants to get rid of it as quickly as possible. Useful objects are not dumped in waste bags. Nevertheless, storing mixed wastes makes recycling operations very time consuming, reduces productivity and increases production costs. It also reduces the quality of recycled products. (Dong et al., 2010; Tiawo, 2010). Notwithstanding, the development of a recyclable market in Tanzania, Fiji, Nepal has boots the aptitude of some individuals to practice source separation and gain some money from the sales of the recyclables (APO, 2007; Dong et al., 2010; Okot-Okumu and Richard, 2011).

In some middle-income countries like South Africa, India, Russia, China, and Tanzania, communities that are sorting waste at the source are continuously increasing, especially, within the low-income regions. However, the inadequate number of classified containers for recycling in residential areas induces users to dispose waste in a mixed state. Besides, lack of public education and incentives weakens residents sorting intentions. In these countries, materials recovery takes place in the informal sector since government shows little interest (UNEP, 2011).

Waste sorting at home in high-income countries resembles that of middle-income nations, with a colour code for each type of waste. For instance, in Portugal, from the total quantity of generated waste of 4,746,021 tonnes, only 192,069 tonnes (4%) are separated at the source within the three-colour code bin system (Magrinho et al., 2007). In UK-London, for example, six out of thirty-four municipalities have more than 95% of homes with a separation service, while thirteen do not provide any form of separation process (Desmond, 2007; Ehling and Körner, 2007). Germany provides containers to separate waste, and at times fights erupt among neighbours over improper sorting in some apartment complexes (Geyer, 2008). Nevertheless, in other nations like Greece, although it has legal support sorting represents less than 20% (Pires et al., 2010).

3.3 WASTE COLLECTION AND CONTAINERS

In low-income countries like Tanzania and Ghana, failure to consider local parameters (containers placing, type and size) at each locality has led to many situations where, gathering vehicles and containers have been purchased in large numbers but have not been effective and have been operational for a short duration (UN-HABITAT, 2011).

More so, the characteristics of waste from this region 82.5% organic matter according to Figure 2, very moist and heavy, often fill the trucks faster and overload it. Hence, lesser amounts are collected. Worthwhile, more time is needed for further collection as the truck has to undergo several trips per day. In addition, hand loading the trucks require more time and usually need more men per truck. Lastly, trucks breakdown for long duration caused by poor maintenance and lack of spare parts, which at times have to be imported (Kyessi and Mwakalinga, 2009; Thompson, 2010). Finally, the nonexistence of adapting trucks, limited equipment, street lighting and adequate road networks completely prohibit night collection periods, and consequently, less than half of the day's production is collected (UN-HABITAT, 2011).

Furthermore, collection circumstances are not so different in middle-income countries. With a developing economy, some basic infrastructures like roads, streetlights, etc., have been constructed to permit the usage of any modern waste equipment such as compactor trucks, and roll off skips trucks. The local municipality then collects mixed waste disposed in the skip (dumpsters) or compact trucks during collection days and disposes them in a control landfill. Notwithstanding, as similar problems often result in approximately the same effects, huge volumes of waste wallow in the streets and river beds due to non sustainable designing. Nonetheless, local authorities have the responsibility to provide or arrange for the collection of household waste while employing different strategies like point to point, door to door and skip collections, unless an alternative collection service is available or/and cost of providing assortment service is unreasonably expensive (Geyer, 2008; Thompson, 2010).

Lastly, waste gathering services in high-come countries like Ireland, USA, and Germany, mixed waste collection is under the responsibility of municipalities, whereas the responsibility for separate collection changes from nation to nation and region to region, and can be assumed by the metropolises or/and private companies. In addition, the presence of adapting waste equipment such as compactor collection trucks, wheeled waste handling Container and

plastic waste bins of 20L, 50L, 100L, 240L, and 1100L, all season roads and applicable laws, actually favours a 99% collection of generated waste in all vicinity throughout the year (Desmond, 2007; Pires et al, 2010).

3.4 PARTNERSHIP AND LEGISLATIONS

Cooperation and policies are considered as perfect cement in the waste stream, exists in countries all over the world (UN-HABITAT, 2011). The application of precise rules varies from one nation to the other. For example, in China, there exist four laws on waste management: environmental protection law of the People 's Republic of China (PRC), the law of the PRC on prevention of environmental pollution caused by solid waste, cleaner production promotion law of the PRC, and the Circular Economy Promotion Law of the PRC (MEP, 2010). India, on the other hand, fosters Article 48-A, and 52-A of Indian's Constitution (Chakrabarti, 2006; MUDI, 2012). Germany, Portugal, and the USA also, have laws and directives pointed earlier, that are prepared to battle; waste minimization, promote reuse, reduce philosophy, recycling, regulate waste transportation and shipment, and EPR for all stakeholders and search to impose stricter monitoring procedure for waste disposal (EPA, 2012c; Pires et al., 2010).

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In addition, there exist public and private sectors in all the income groups handling MSW activities, ether formality or informally for the betterment of the sector as a whole and the

community in general. (Sam, 2011: UN-HABITAT, 2010). Moreover, public-private partnerships (PPPs) exist in the form of municipalities, Waste pickers, Itinerant/stationary waste buyers, Small-scale recycling industry, micro-enterprises, large-scale recycling industry, community-based Organisations (CBOs), and NGOs. PPPs is an alliance by which government and private companies assume co-responsibility and co-ownership for the delivery of services (Dong et al., 2010; Okot-Okumu and Richard, 2011; Sam, 2009; Ranjith, 2012; Thompson, 2010). The degree of applicability of these laws and partnership results in enormous challenges and varies within the world.

Foremost, in low and some middle-income countries like Ghana, Nepal, South Africa, India, and Uganda, the private sectors- dynamism, access to finance, knowledge of technologies, managerial efficiency, and entrepreneurial spirit, combined with the social responsibility, and environmental awareness, is involved in the day-to-day gathering of homes waste in this area, with the creation of jobs for the local population, and enhancement of livelihood of the poor. Nonetheless, these partners work under shadow laws and conditions, with no clear directives and pattern to enhance their status (Scribner, 2011).

Contrarily, under mutually favourable circumstances, it is advantageous for both the public and the private sectors to play active roles, despite the disadvantages. Thus, capitalizing on the strengths of each sector, yet, this is far-fetched in this area. Furthermore, the public sector whose main rule is to regulate policies often assumes a blind eye or acts sporadically (Maria, 2008; Okot-Okumu and Richard, 2011). In contrast, in high and some middle-income countries, like, Germany, USA, Portugal, Sweden Finland and Russia, PPPs and legislation are under scrutinized local and zonal waste policies. These rigorous checks and control keeps the waste stream in a dynamic status, with each partner having a watchful eye on the activities of the other. Notwithstanding, in some regions such as the EU, local waste policies at times conflict with EU Directives. This at times, generates strains in some countries (Lincoln, 2011; OECD, 2011; Pires et al., 2010; Simões et al., 2012).

3.5 TIPPING FEES, RECYCLING AND LANDFILLS

Lastly, discarding MSW on land is by far the most common means in many countries and perhaps remains the sole accepted disposal means (Sharma, 2009). Sanitary landfill continues to be the cheapest satisfactory means of disposal that is if suitable land is within economic

range and not far from the source of waste. Typically, collection and transportation account for 75% of the total cost of solid waste management, and recycling has been relying on landfill tipping fees (WB, 2011). MSWM and partnerships have been greatly dependent on the refuse charges, where each tonnage of waste disposed at the site is taxed, and the amount paid influences the search for recycling and other disposal methods from one country to the other. (Achyut, 2008; Eco Governance, 2004).

Primarily, in most low and some medium-income countries, almost 99% of the generated waste goes to the landfill. Persuaded by the prepared tax (flat tax) system for waste collection, which is acquired through, land tax, electricity and water bills, goods, or other means as mentioned earlier. Supplementary budgets come from the state financial budget on the basis of projected fiscal revenue flows, and finally, as cooperation aids from foreign bodies. Hence, regardless of how huge or how little the waste volume, the municipality has to get rid of it. Moreover, abundant land within and around the towns/cities makes landfill disposal easy and cost effective. Nevertheless, as the cities grow bigger the vital space gets smaller as in high-income countries, thus disposal becomes problematic (Marques et al., 2011; Okot-Okumu and Richard, 2011; World Bank, 2012).

On the other hand, high-income nations and Russia, restricted by urbanisation and landfill Directive like that of the EU countries. Ideal landfill sites can be located only in the hinterlands and which are often far away from the waste sources. The scarcity of landfill space, endlessly contributes in the escalation of landfill tipping fees per tonne of refuse and the enrichment of recycling. Even so, the building and operating landfills, transfer stations, material recovery facilities, and waste-to-energy plants require money. The funds often come from hauliers, who pay per-load upon arriving at a facility and the amount could vary from $15-$87 or more as confirm in Figure 7. Waste transporters in return charge customers (waste producers) through PAYT bills for waste collection services to cover the cost (EPA, 2012d; Helou et al., 2011; Simões, 2012).

Nonetheless, so long as landfills tipping fees (LTF) are relatively low, less than $15-$45 Landfilling waste remains cost effective. However, it will intend to hinder recycling and vice versa, as illustrate in Figure 7. Furthermore, the waste reduction strategy, projected as the best MSWM enhancement philosophy, shall promote recycling at the level of haulers, since they shall pre-treat the waste, by collecting all recyclable and dump only a small portion of non-

recyclables. The recyclables can be sole for extra profit, and the biodegradable organic matter can be sold as well to mechanical biological treatment plants (MBT) plants, to be used as raw material in the production of biogas, fertilizer and electricity (CSS, 2009; Helou et al., 2011; Sterecycle, 2012).

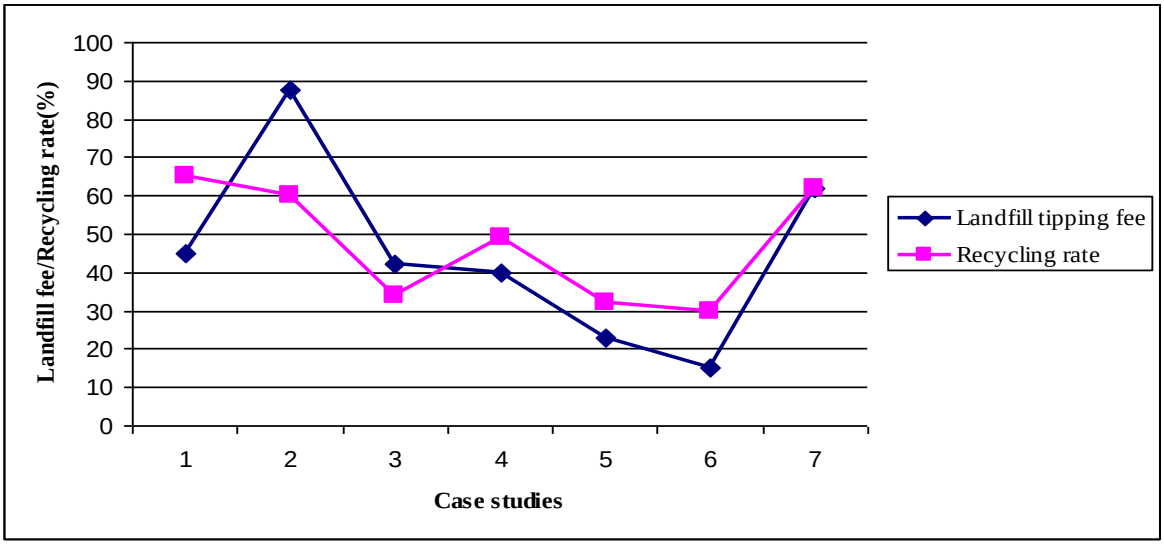

Figure 7 *- the rate of change of landfill tipping fee and recycling rates in some high-income nations*

4. MSWM PROBLEMS-OPTIMISATION STRATEGIES

Despite the achievements obtained in waste recycling, the amounts of waste discarded or pending disposal are on the rise. This raises important questions on the aptitude of the existing treatment facilities (ISWA, 2012). Nevertheless, the era where MSWM systems were designed in isolation of its main components (people and waste content) is now a matter of the past. People, environment, technology and finances, are vital components in the fight for resource conservation (EGSSAA, 2009), which begins with awareness of the natural limits of resources, both materials and energy (EC, 2012). This awareness present in ancient times has gradually been misplaced in face of today's "prosperous society" (ISWA, 2012).

Provided nations continue to afford raw materials and energy with ease. It is therefore, likely, that this situation will not change. Nevertheless, some governments and enlightened civic groups are promoting successful incentives and tactics to ensure that people take better care of global possessions. Today's MSWM practices do not adequately fulfill this objective. Hence, the need to further develop or enhance the effective management of resources used in manufacturing processes, should be designed to take into account resource conservation goals, even if this seems to conflict with economic benefits (EGSSAA, 2009; ISWA, 2012).

Efforts and rigorous technological mechanisms to increase waste streams efficiency are being employed particularly in high-income nations, although not enough. The appropriate pattern is not necessarily the use of more technology. For example, while a rear loader compactor waste vehicle or waste reducer will significantly decrease the size of packaging waste in high-income countries such as the USA or Canada (Kaoussis, 2012). The contrary prevails with the wet organic waste of low and some middle-income nations. Likewise, a state-of-the-art sanitary landfill will have a minor contribution to public health, if the streets are still littered and heaps of uncollected waste abandoned all over the city. Therefore, integrated solutions of technology and human expertise should take place, coupled with improvement strategies such as waste prevention, constant education and communication, and waste planning, as expressed on the MSWM enhancement pyramid (Figure 8). Great emphasis should be laid on waste prevention, and learning and communication strategies.

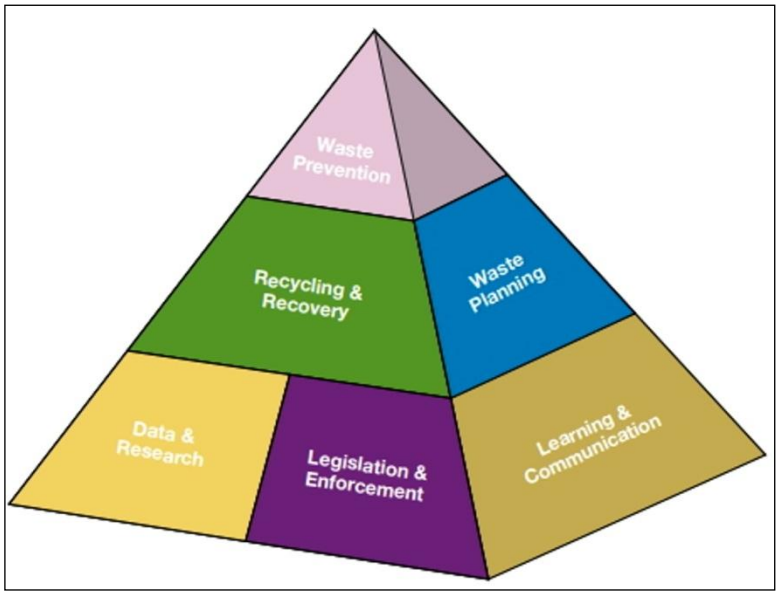

Figure 8*- The waste strategy pyramid, illustrating polices that enhance a sustainable MSWM system (*Rooker*, 2006).*

4.1 WASTE PREVENTION

Waste prevention is the reduction in the amount and/or toxicity of materials entering the waste stream prior to recycling or disposal. Preventing refuse before its creation, provides an alternative in managing waste. Besides, it gets to the roots of our society over-consumption and extravagant use of resources. Therefore, instead of spending time, effort, and money on short-term solutions to the problem of what to do with waste, more and more determination should be apply in advocating the following:

4.1.1 Pay-As-You-Throw (PAYT) / "Earn-as-you-throw (EAYT)"

PAYT or variable role pricing is a waste strategy employed in high-income countries, where households are charged for the collection of MSW based on the amount they throw away. This plan operates in the same formats as water, electricity, gas, and other utilities taxing techniques. This way, families pay a variable rate depending on the amount of service used. Therefore, residents are billed based on the weight of the waste. This way householder with smaller waste volume to throw pays less and vice versa. Every thing being identical, these programs are simple and fair (EPA, 2012d).

In opposition, EAYT or waste for money is the contrary of PAYT, often applied in low-income regions, where source reduction is very high but waste collection is rather absent or inefficient. This tactic boosts the householder's ability to supply separated waste for money (UNEP, 2011). Advocating each of these strategies in its corresponding environment will greatly enrich waste reduction, recycling and prevent open dumping. These methods further enhance the economy of local population and boost the installation of other recycling amenities due to the availability of materials (EPA, 2012d; Whitfield, 2010).

4.1.2 Green public procurement (GPP)

Green Public Procurement (GPP) is a plan by which governments and individuals integrate environmental criteria into all stages of their acquisition processes of goods or services. It is aimed at encouraging the spread of environmental technologies and the development of environmentally sound products, by seeking outcomes and solutions that have the least possible impact on the environment throughout the life-cycle. Additionally, GPP is a win-win tool, which leverages economic and environmental objectives. On the one hand, it enables the production and procurement of low-carbon, environmentally friendly goods, and services (OECD, 2009). Nonetheless, GPP represents a business opportunity for the suppliers of goods and services, as it encroaches rapidly the boundaries of the growing market for environmentally positive products and services.

Furthermore, though GPP is a self-conscious/personal initiative tool, its usage and impact are being felt in most OECD and EU countries, particularly; Austria, Denmark, Finland, Germany, Netherlands, Sweden, USA, and the UK, operating under certain umbrellas like, eco-labelling and eco-certifications of goods and services. Likewise, with an EU public investment budget of 16%, it can help stimulate production of more sustainable goods and services which otherwise would be difficult to get onto the market. Endorsing on green consumption/purchasing attitude in this manner, will value Directive 94/62/EC on packaging, and packaging waste. Additionally, the utilisation of biodegradable packaging products by consumers enhances the quantity, quality, and composition of waste that the MSWM systems have to deal with (EC, 2012; EPA, 2010).

Achieving long-term success in GPP will need clear and verifiable social and environmental criteria for products and services. A number of European and OCED countries already have

national criteria. The upcoming challenge as GPP becomes widespread, is to ensure that the principles are compatible between countries and continents in the world. A suitable universal playing ground will boost a single market, and ensure that, what is valid for the EU is also decent for the environment, according to EU Commissioner for Environment Janez Potočnik (EC, 2012).

4.1.3. Extended producer responsibility (EPR)

Article 8 and 14 of the EU's waste framework Directive 2008/98/EU evokes the polluter-pays principle, a requirement for the costs of discarding waste to be handled by the current holder of the waste, by previous holders or by the producers of the product from which the waste came from (EC, 2012b). The idea behind EPR is voluntary, and this places the burden upon the manufacturer to reduce the environmental impacts of the product at each stage of the product life cycle. Furthermore, the producers and/or importers of the goods take responsibility for the waste (CCME, 2009; ISWA, 2012).

This would not only ease the burden of waste collection and disposal, but provides an incentive for companies to produce fewer wasteful products and packaging. Complementarily, EPR does not consider only the manufacturers accountable for environmental impact. The responsibility is extended to all those involved in the product chain, from manufacturers, suppliers, retailers, consumers, companies and disposers of products. This impact can be felt in electronics such as NOKIA electronics and packaging materials firms in Europe (Moyes, 2010; Nokia, 2011).

EPR also comes with specific conditions and challenges necessary for its efficient operation. Proper functionality will request urgent responses to identification of all producers, collectors, treatment services, and collective compliance systems that could lead to administrative burdens. Nonetheless, manufacturers are individual firms in competition, but EPR often addresses the producers as a group. This collective compliance may need to be organized, and competition between firms must not be hindered (EC, 2012b).

4.1.4 Waste Reuse

Reuse according to "Zero waste Scotland" is the act of using items as many times as possible, this helps save resources landfilled. This concept is already practiced in low and some middle-income countries to its limit, favoured by community lifestyle and "poverty." Moreover, the activity focuses on the usage of components with economic and social values, and it is experienced at all levels of society.

Household within low-income peri-urban areas uses recovered materials, which include reuse of plastic bags, bottles, paper, cardboard, and cans for domestic and commercial purposes (Mbeng et al., 2009). The duration of reuse of these materials is high, and the materials return to the formal waste collection stream simply when they are no longer fitted to be reclaimed. Additionally, in high-income homes, only domestic servants and/or wardens carry out recovery. The extent to which these transactions occur depends on the availability of local market and materials needs (UNEP, 2011; 2005).

Last but not least, in high and some middle-income countries like Russia, the act of reuse faces a different direction. With the economic power at hand, goods are bought virtually on a regular base. This often results in the creation of huge volumes of waste per person awaiting disposal as displayed in Figure 2. Further handicapped by the capitalistic and individualistic lifestyle, reuse practices become impossible, and people rather prefer a brand new item than to repair and use the old ones. Additionally, maintenance/repairs costs are more expensive than those of new products. This somehow inhibits reuse and promotes usage of newer goods (Maria, 2008; OECD, 2009; Pires et al. 2010). To counterweight this attitude, most OECD, UK, USA, and EU countries have in place the following reuse strategies, powered by the government and private bodies (EPA, 2010b; c; OECD, 2009). The most prominent of all is the online waste exchange services.

Waste exchange, is another way for of business, individuals and industries to divert waste from the landfills for beneficial purposes. More than 50 waste exchanges services exist in major city centers across North America, Canada and some OECD nations worldwide. Furthermost, they are provided as a free online service to industries and individuals, and most exchanges centers have web sites on the Internet with links to other exchanges sites where users can post or receive goods. (See Table 2) (EPA, 2010a; d).

This service promotes reuse and waste diversion from landfills. For instance, a person might not want his old stereo set any more and, rather than throwing it out in the bin. He/she puts it online and the person who needs it simply gets into contact with the holder and collects it in person or pays for the shipping fee. Notwithstanding, other sites enhance sales of second hand or used items at giveaway prices (Andrews and Maurer, 2010; Whitfield et al., 2006). LIPOR (*Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto*) sorting centre of Porto-Portugal, offers a service to facilitate waste exchange , and has created a market for waste materials where individuals can dump bulky and white home goods for money (LIPOR, 2008).

Table 2: List of some online waste exchange links and the respective countries

Waste type	Links	Country
Industrial wastes	http://www.recycle.net/	USA
	http://rcbc.bc.ca/services/materials-exchange	Canada
	http://www.wastexchange.co.uk/	United Kingdom
	http://www.greenstarinc.org/	America
Household waste	http://www.zerowastescotland.org.uk	Scotland
	http://www.recyclexchange.net/	Canada
	http://www.greenspanworld.org/waste%20exchange%20program.htm	
	http://www.lipor.pt	Portugal

4.2 SUSTAINABLE DESIGN

Tools have been applied to evaluate and help in decision making in MSW systems, based on branded issues with prospects of having great potential to integrate other aspects, like economics or social impacts. Other tools, like regulations and legislation have been important in environmental impact assessment (EIA) in MSWM. The inclusion of EIA has been well accepted by decision makers at the national, regional, and local levels. As a consequence, the primary stage of decision analysis includes management choices, evaluates management and strategic plans, collects and shares information.

Climate change and resource depletion are evolving problems of great anxiety. Therefore, engineering research models are studying waste production processes and assessing the interactions in numerous sorts of MSW planning, evaluating the impacts from technical, social and economic viewpoints. However, often these models are not geared toward helping decision makers' needs (Mohsen, 2009; MUDI, 2012).

The contribution is limited to the use of algebraic functional models, structured to derive strategic guidelines and/or orientations in a MSW process. At times, mathematical research findings are contradictory with existing ideas embedded in the minds of decision makers. For that reason, engineering models have not been applied to the same extent as system assessment tools (EPA, 2010c; Pires et al., 2010). Therefore, MSWM planning, policy, research, recovery or recycling process, should be designed based on the reality of the area of application. There must be no "copy-paste" models as has been the case over the past decades, because of the uniqueness of each environment.

4.3 LEARNING AND COMMUNICATION

Communication is a procedure by which to dispense and transfer wisdom in an attempt to create or share understanding. It demands a vast inventory of skills in intrapersonal and interpersonal processing, akin to listening, observing, speaking, questioning, analysing, and evaluating (OSPI, n.d.).

For the time being, resource management literature refers to learning as, a collective process with emphasis not only as a prerequisite for individual behavioural change but for collective action (Muro and Jeffrey, 2008 cited in Šrot, 2010). For that reason, this conceptualization agrees that education requires communication and participatory interaction of all stakeholders. MSWM is an increasingly complex challenge, involving all stakeholders' particularly waste producers. Teaching and exposing them to the degrading effects of the different sorts of waste impact on various entities, such as land and soil, water, air, and directly or indirectly in humans and MSWM systems, reduces their ignorance. Ignorance is the root of all problems and only those who are aware of the harms seek for the solutions (Foldvary, 1998). Therefore, educating the masses remains the sole solution to all MSWM problems.

All the same, experience has proven that every new reform usually witnesses barriers. Campaigners must first eradicate their own inexperience to educate themselves, and gain knowledge of the basic causes and remedies of sociotechnical problems. Consequently, when educating others, they must invoke their opposition to the problem and arouse their understanding with the remedy. By irritating the masses with concern and being armed with knowledge of the therapy, the few moderate opponents will be influenced to either join the righteous battle, or be overcome by the greater force of the ethical revolution (Foldvary, 1998; OECD, 2009; OSPI, n.d; Rooker, 2006).

A linear model was developed based on the additive correlations between the amount of municipal solid waste generation (MSWG), populations, GDP per capita and illiteracy rate (after communication, and evaluation), and it is expressed as

$$MSWG = a + \beta X_1 + \alpha X_2 + \gamma X_3$$

Where: MSWG is the amount of municipal solid waste generation, X_1 is population, X_2 is GDP per capita and X_3 is illiteracy rate, and a , β, α, and γ. are the coefficient of correlation variables.

This linear model could serve in the estimation of the effect of communication, on the MSWG after the education process and equally support in decision making in MSWM (Weber, 2004, cited in Anupam et al., 2010).

5. CAMEROON WASTE FRAMEWORK

5.1 INTRODUCTION

MSWM is a multifaceted system that requires suitable managerial aptitude and cooperation among all stakeholders, both in the private and public sectors (EC, 2012; UN, 2011). The scope of MSWM encompasses planning and management systems, waste generation processes, organizations, and procedures for waste handling. Strategies development for management of municipal solid waste comprises specific objectives and measures in all these areas. The need to consider the precise interests, roles, and responsibilities of all participants is the ultimate goal for this tentative MSWM Framework in Cameroon.

With a population of 19,711, 291 inhabitants and over 240 ethnic groups are spread over 10% of the national territory of 475, 650 sq. Km. Regional headquarters are densely populated, particularly Douala and Yaounde (CIA, 2011; PRC, 2011). As any other middle-income country, Cameroon possesses a high rate of uncontrolled urbanisation estimated at a 5% annual growth, and has a vast network of dirt roads. Less than 40% are adequate to conveyance of heavy waste trucks (Evouna, 2008).

Furthermore, the immense and diverse nature of the country is pinpointed in the number of ministerial departments related to waste handling exist: Ministry of Territorial Administration and Decentralization (MINTAD), Ministry of Mines Industries and Technological development (MINMITD), Ministry of Economy and Finance (MINEFI), Ministry of Urban Development and Housing (MINDUH), Ministry of Environment and Nature Protection (MINENP), and the Ministry of Public Health (MINPH) with duties as display in Table 3.

Table 3 - Roles and responsibilities of key ministerial departments related to solid waste management in Cameroon (Manga et al., 2008; PM, 2011).

Ministry	Principle liability in MSWM	Legislation
Ministry of Territorial Administration and Decentralization (MINTAD)	Follow-up and implement regulations for the organization and functioning of Councils; Oversees the execution of the budget of the government's council support fund (FEICOM); Restoration of hygiene and public sanitation; Supervises Urban Councils which are responsible for follow-up and control of industrial waste management; management of all public spaces and infrastructure; Sweeping of streets, collection, transportation and treatment of household waste.	Circular letter No. 0040/LC/MINAT/DCTD of 04/04/00 Order No. 00072/MINAT/MINVILLE of 21/05/00, Law No. 714/23 of 5/12/74 Law No. 2004/18 of 22/07/04
Ministry of Mines, Industries and Technological Development (MINMITD)	Develop strategies for industrial development and the control of classified and commercial installations for pollution, security, hygiene and industrial nuisance; Define norms for industrial pollution; List of dangerous, obnoxious and polluting facilities in order to inform the public; Develops regulations governing the installation and exploitation of facilities classified as dangerous, obnoxious and polluting.	Decree No. 99/818/PM of 9/11/99 Order No. 13/MINMEE/DMG/SL of 19/04/77 02/MINMEE/DMG/SDAMI of 4/01/9
Ministry of Economy and Finance (MINEFI)	Financial control of organizations benefiting from supplementary budgets and autonomous public establishments, i.e. Councils; Responsible for managing the Finance Law as enacted by Parliament.	Constitution Decree No. 2004/320 of08/12/04
Ministry of Urban Development and Housing (MINDUH)	Develops and implement urban restructuring, management strategies, sanitation and drainage; Defines and enforces norms of hygiene/sanitation, collection and/or treatment of household waste; Liaises with international agencies for urban development.	Order No. 00072/MINAT/MINVILL of 21/05/00
Ministry of Environment and Nature Protection (MINENP)	Collaborates with other agencies to define measures for the rational management of natural resources; Effective control of the investigation and pollution in the field; Specifies the criteria (project specific) and supervises environmental impact assessments.	Decree No. 2005/0577/PM of 23/02/05 Order No. 006/MINEP of 08/03/05
Ministry of Public Health (MINPH)	Creates Hygiene and Sanitation Units in Councils; Renders technical support to the Hygiene and Sanitation Units of Councils, Proposes norms for collection, transportation and treatment of industrial, domestic waste and emptying of septic tanks; Designs and implements public education campaigns on hygiene and sanitation.	Order No. D67/NS/NN/ST/SG/BMPHP/ NNPA of 11/08/87

The National Environmental Management Plan (NEMP) framed an operational MSWM for municipal councils (MC). This plan was developed to govern MSW activities like street sweeping, collection, transportation and disposal of household wastes, as well as the management of all public spaces and infrastructure. Health and safety issues related to waste are under the jurisdiction of the health and safety officers in the hygiene and sanitation units of each MC. The supervisor is the uppermost qualified staff, which is often a health worker. This resulted in uncoordinated planning, no clear demarcation of specific responsibilities, regulations or delivering of a sustainable waste handling system (Manga et al., 2008; PM, 2011).

MSWM in Cameroon has remained the same (Figure 5) for the last 40 years, in spite of the economy and irrespective of the new MSWM strategy of 'waste resource management' of 2010. This recent strategy, to be carried out by the leading waste management firm HYSACAM, implies generation of electricity from waste incineration and landfill biogas (ERACAM, 2011; HYSACAM, 2011; Manga et al., 2008).

Nevertheless, an appropriate scenario would be a structured waste framework, with objectives focused on policy, management and social and technical tools, that would provide highlights/guidance and pathways to planning, development, implementation and administration of MSWM projects in Cameroon. It anticipates that MSWM schemes should be endowed with organised legislation (MINENP), Assessment (IMCMWM) and management tools (SHMIN, SCLIN, PPPs) in the development and implementation phases to all stakeholders (See Figure 9).

5.2 MINENP (Legislative Tools)

The ministry of environment and nature protection (MINENP) is responsible for the national environmental management plan (NEMP). To intensify the complexity of management issues, Decree no. 95/230/pm of 31/04/95 created an Inter-Ministerial Commission for Municipal Waste Management (IMCMWM) in Cameroon, responsible for the governance of MSW activities under the jurisdiction of the Prime Minister (PM). Its precise objectives are to be accountable for MSWM, policy development of appropriate MSW strategies (Manga et al., 2008; Mbeng et al., 2009).

In addition, Law No. 96/12 of 5/08/96 of Decree No. 2005/0577/PM of 23/02/05, and Order No. 006/MINENP of 08/03/05 relating to environmental management, defines the duties/role of the NEMP associated with the protection of the atmosphere, marine and continental waters, soils, subsoil and human settlements; It regulates installations that pose dangers to the public; Stipulates modalities in conducting Environmental Impact Assessments (EIA) and categories of operations subject to EIA; It specifies air emission and waste water discharge standards; Sets conditions for issuing authorizations for a share and management of land for uses. It draws Conditions for refuse handling (collection, storage, recycling, etc.); Enterprises prescription relating to waste elimination by persons producing or treating waste; and Specifies the terms of reference for the supervision of "municipal dumps" by the competent authorities (PM, 2011). There exist related laws regarding MSWM in Cameroon, for the scope of this work, only this shall be considered tantamount to its broad coverage of MSWM policies.

MINENP defined the goals of the established NEMP, and coordinates the legislative, and administrative (control units) tools for MSWM. Likewise, policies should be available and applicable to all establishments concerning with MSW within the national territory. Nonetheless, the NEMP should strive towards eradication of open dumps, streets littering, back yards and river dumping, installation of landfill liners, and endorse the policy on waste recovery and recycling. Moreover, it should create backup plans like tax reduction, to attract public-private partnerships (PPP) whom often have had the highly needed funds and technology. In addition, merging of municipalities would facilitate the implementation and control of strategies by the regulatory body.

5.3 REGULATORY BODY (Assessment tools)

The Rule of Law Initiative is based on the belief that the instruction of law is the most effective long-term antidote to the pressing problems facing the world today, including poverty, economic stagnation, and conflict (ABA, 2012). The IMCMWM, under the jurisdiction of the MINENP will supervise, control, implement, and heavily sanction all defaulters instantly. More so, it accounts for all transactions made within the MSWM sector. Furthermore, it oversees the operational status of the municipalities and all stakeholders.

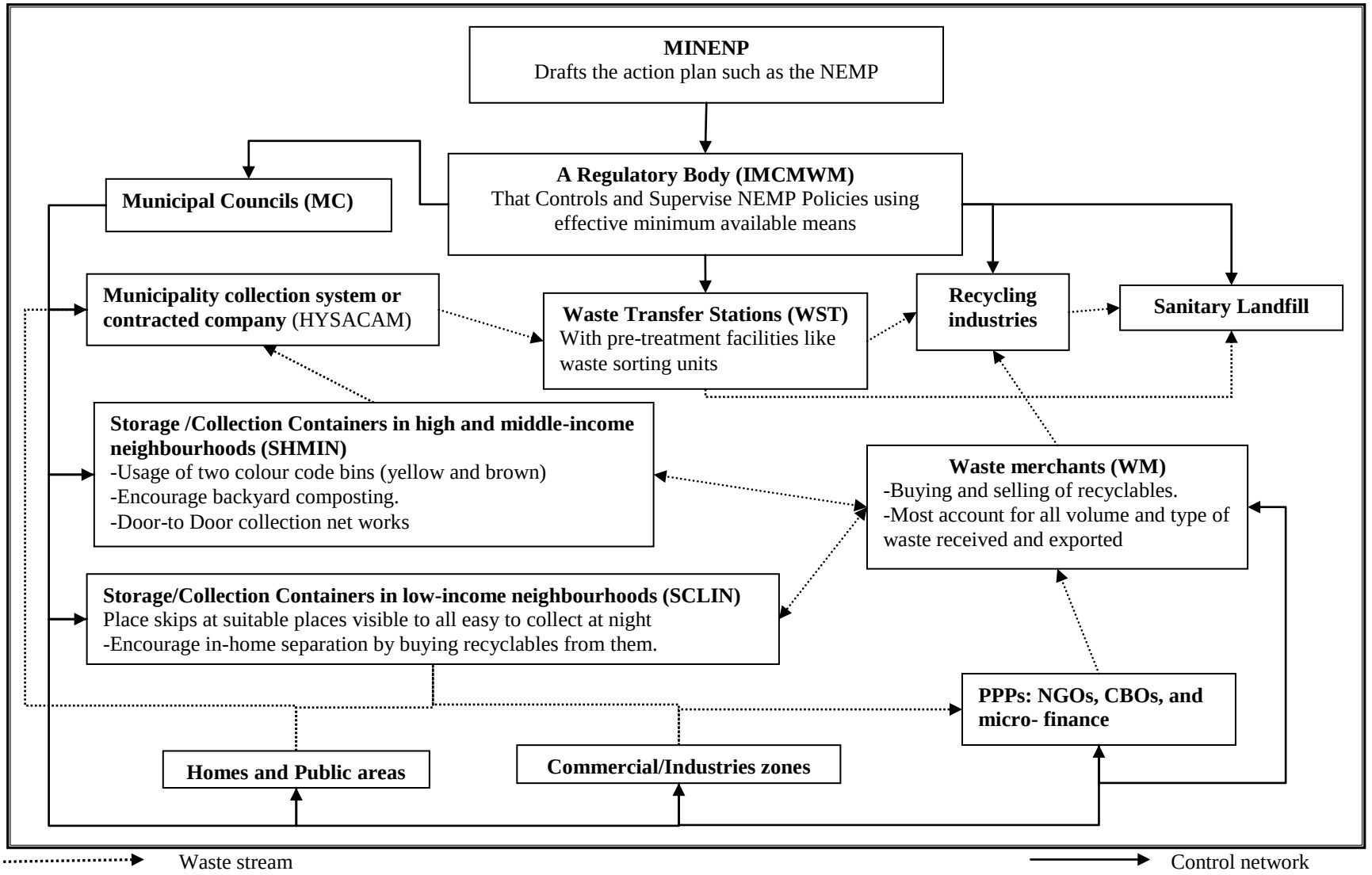

Figure 9 *- The proposed operational MSWM Framework and Responsibilities for municipalities in Cameroon*

MINENP should offer Municipal Councils (MC) the flexibility to decide whether to consent to the regulatory body to oversee the development and implementation of MSWM activities within its municipality. In addition, the MC should be allowed to choose the scope of any MSW project that could cover one or a combination of the various environmental, socio-technical risk sharing and mitigation mechanism, to provide an appropriate working environment for PPPs. Moreover, a wide range of individuals, groups, and Organizations are concerned with MSWM as service users, service providers, and intermediaries. The municipalities should regulate the activities executed by these actors both formally and informally, present in HMLI localities operating within the municipality. Besides, each municipality is answerable to the IMCMWM and MINENP.

5.4 MANAGERIAL AND SOCIOTECHNICAL TOOLS

The primary and secondary waste collection activity in Cameroon has been mandated to a private company by the name HYSACAM. Created in July 1969, HYSACAM gears towards continuous upgrading of the quality and security in gathering and treatment of MSW, in more than twelve towns/cities. The major concern of the company has been the achievement of complete satisfaction of all participants. It is also firmly and perpetually committed to advancing services in a progressive manner and to achieving excellence in hauling schedules, reduction of immobilization time of trucks and equipment (1000 collection containers, 80 trucks partially adapted to the waste type, 1000 human force) (HYSACAM, 2012). Nonetheless, to acquire these goals, HYSACAM develops a work environment, promoting individual and collective performance, strives in improving relations with the population, and complies with environmental standards (Ngapanoun, 2007).

Case studying HYSACAM's waste stream in Yaounde, the city of Yaounde has an urban growth rate of 4% per annum and a population of two million inhabitants spread in seven municipalities. The city generates an average MSW of 1,200 tonnes/day, with a rough average of 0.6 Kg/person/day. For suitable collection, HYSACAM distributed the city into 40 collection circuits, taking into account, the high and middle-income vicinities (Administrative areas, Bastos, Santababara, etc.), low-income (highly dense neighbourhoods) and homes within and along areas with practicable roads. These circuits permitted the collection of 60-70% of total waste generated, while operating 24/24h and 7/7 days with the assistance of the above-mentioned equipment (Folefack, 2008; HYSACAM, 2012).

The collected refuse is taken directly to the legal control discharged at Nkolfoulou. The site has a natural pedologic profile of a lateritic layer, a coating of iron and a layer of silty clay. This gives the landfill's basement and sections of the flanks, an average permeability of 1.35×10^{-6} m/s, higher than the required value of 10^{-9} m/s. Nevertheless, portions of the waste are sent to a composting experimental site for research, due to its more than 65.79% of organic content (see Figure 10 and Appendix C) (HYSACAM, 2012; Ngapanoun, 2007). To enhance collection, HYSACAM/municipality would have to revise the characteristics of equipment like collection containers, vehicle specification, routing, creation of waste transfer stations (WTS), recovery and recycling, as well as final disposal sites such as sanitary landfills, with energy recovery from landfill gas.

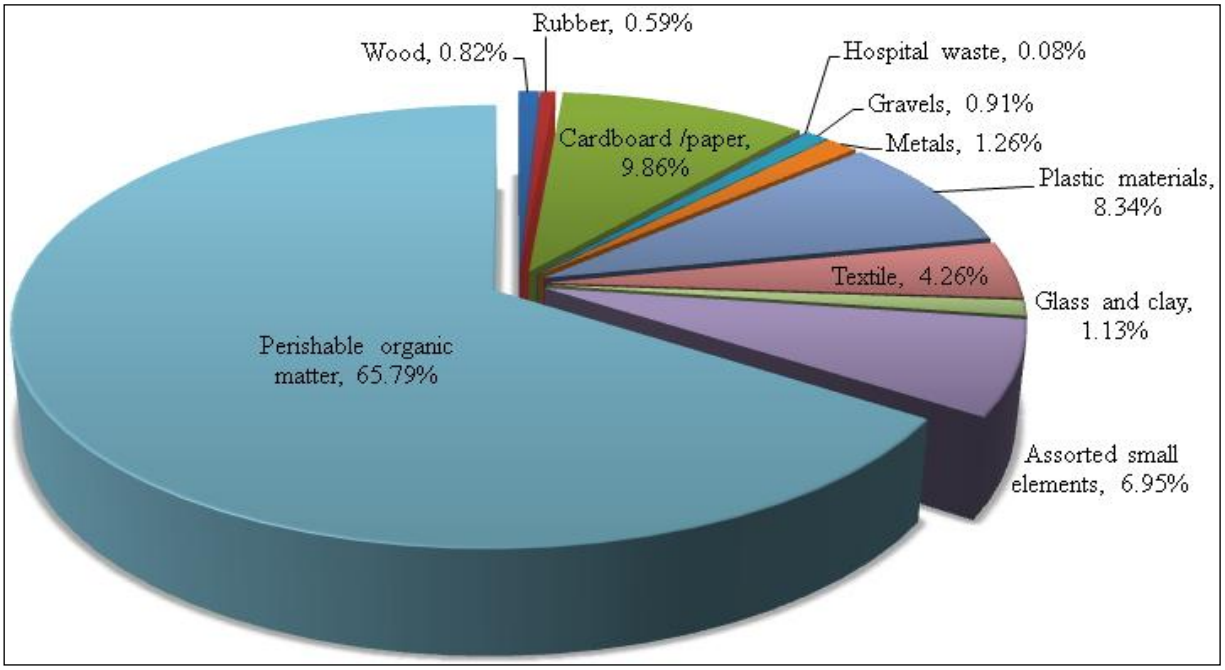

Figure 10 *- MSW composition of the city of Yaounde with a high concentration of organic matter.*

5.4.1. Storage/collection containers in high and middle-income neighbourhoods (SHMIN)

Groups of citizens with high and middle-income harbour the low density, structured and well-planned residential areas of the city. Endowed with all basic facilities and gardens, they tend to copy the European and American lifestyle. Constituting approximately 20% of the city's population, they generate wastes with less than 18% of organic material (Folefack, 2008; Mbeng et al, 2009). Consequently, a double waste collection stream should be developed in

this zone, and in-home sorting promoted. Moreover, inhabitants should be encouraged to practice backyard composting that could serve as fertilizer for the flowers or gardens. Nonetheless, the low-income home-mates transfer some of the recyclables to the low-income quarter where they live.

5.4.2. Storage/collection containers in low-income neighbourhoods (SCLIN)

This portion of the society constitutes 80% of the population, and essentially receives this service for free (HYSACAM, 2012). Living in a highly dense populated vicinity, coupled with the difficult mastery of urban growth, decentralized urban public, inefficient and less adapted land management strategies, induces the population to build and reside in non-viable zones. Construction is lawless, without appropriate urban planning and with no respect for urban rules.

The consequences are the lack of basic urban services like roads (unpaved, richer in potholes, often less than two meters wide), water, and electricity. Furthermore, the homes are far-away from the nearest practicable street (Ewodo et al., 2009; HYSACAM, 2012; Mbeng et al., 2009). Consequently, HYSACAM allocates central containers (skips) at designated points along paved (practicable) roads, irrespective of the numbers of inhabitants, and distance (often above 400 m) from the skip, for households to deposit mixed domestic waste (Figure 11). Roll off Skip trucks collect the containers as needed (twice a week), but the service is variable because these collections are less lucrative, not as much reliable, and decelerated by traffic during the day (Achankeng, 2004; Ewodo et al., 2009; Manga et al., 2008 ; Mbeng et al., 2009). Therefore, HYSACAM/Municipality should address the following:

5.4.1.1 Relocation of waste containers (WC)

In order to assure the collection of the missing 40-30% of waste, HYSACAM has to identify appropriate placement for the WC. To achieve this, it must employ a diverse range of holistic criteria, incorporating criteria from the social, spatial, political, economic, and the ecology of the vicinity. Uncooperatively overcrowded societies may transform containers into open dumps as resident uses the surrounding space for overflow refuse (Figure 11). More so, the Public must be willing to use the chosen sites, if not, they will prefer to empty the waste in open dumps as before. Lastly, the optimal frequency of collection is decided by the quantity

of solid waste generated, the climate, the cost involved in collection, and public demand. If visibility studies of the areas do not permit such approach, then, the "Earn-As-You-Throw" tactic can be employed.

Figure 11 *- Illustrates a 16 m^3 waste skip of HYSACAM placed on the sidewalk for waste storage/collection (*Achankeng, 2004)

5.4.1.2 "Earn–as-you-throw (EAYT)"

With an annual income of less than $150, earning money from waste will not only boost in-home sorting and recycling but will also improve the economy of the local population and freeze all the surrounding open dumps, to ensure at least 80% waste collection. Notwithstanding, comparable methods have been used in Curitiba in Brazil and the most recent took place in 2011, in the poorest zones of the Douala IV Urban Council of Bonaberi-Cameroon, and this proved to be an effective strategy. All the same, this strategy features problems and uncertainties, depending on the inhabitant's counter reaction when the plan ends (UNEP, 2011). More so, the separated waste is transported to the necessary treatment units hence, enhancing recycle and promoting in-home sorting. Moreover, for projects of this nature to have long-term success the participation of PPPs is greatly required.

5.4.2 Public Private Partnership (PPPs)

Significant improvement in MSWM could be achieved with development of public-private partnerships involving both formal (CBOs, NGOs, and micro finances) and informal (waste merchants and waste pickers) actors. Emphasis should be applied on strategies for preparation of contracts and bidding documents, along with technical support for such functions as performance-based specifications, payment mechanisms, corruption, clear bidding procedures, and enhancement of competition between service suppliers, quality and performance control, as well as required changes in the policy and in the legal framework (Scriber, 2011).

5.4.2.1 Community based organisations (CBOs)

Community administration occurs when civil population receives the authority to execute, manage and maintain a service benefitting its members (Corporate reputation). As a result, measures such as source separation, recycling and waste disposal within targeted areas need major efforts to raise inhabitant's awareness and widen their participation in all sectors of the waste stream. Local municipalities or/and NGOs are required to effectively coordinate civil participation and awareness-raising plans, and encourage development of micro enterprise.

5.4.2.2 Micro enterprises and NGOs.

Micro enterprises and NGOs, partners of the waste stream, can enrich waste collection rates and recycling in low-income households, and overcome the waste collection loopholes. The above goals could be achieved by setting up civil owned collection cooperatives, with initiatives such as door-to-door collection, or point collection, where people from an area bring waste to the collection container by means of wheelbarrows, tricycles or small vehicles. The waste is weighted before being emptied into the secondary collection bins, and the hauling firm/Council, pays for the service. More so, the micro enterprise could receive payment directly from the waste producers for the waste collected or disposed. Nonetheless, the main aim is to provide good MSWM service and a healthy and clean environment at a very cheap cost (Dong et al., 2010; Okot-Okumu and Richard, 2011; Ranjith, 2012).

5.4.3 Waste Transfer Stations (WTS), Recycling, and Landfilling

The actual state of road infrastructures of the country and of Yaounde in particular, conditions waste managers and truck drivers to make use only of the shortest practicable road possible. With this in mind, a roll off skip truck covers a distance of 54.2 Km for a round trip in 58 minutes, excluding traffic holdups, from a collection point with satellite coordinates (3.802424, 11.45133) and to the Nkolfoulou landfill with coordinates (3.927665, 11.570742) (These measures were taken thanks to Google maps). In this situation, more than half of the collection time is spent driving to and from the landfill.

Therefore, constructing a WTS facility midway, where waste collection vehicles discharge their loads. The load may be quickly consolidated, pre-treated (segregated), compacted, and then loaded into big vehicles, like transfer trailers, intermodal containers, railcars, or barges of larger capacities for long-hauling night shipment to the landfill, waste-to-energy plant (anaerobic digesters), or a composting facility. Nevertheless, the WTS may be cost-effective when located near a collection area. The usage of transfer stations lowers collection costs, as crews spend less time travelling to and from the collection areas, and hence, devote more time for waste collection. This reduces costs for, fuel and vehicle maintenance (EPA, 2012c; WTT, 2012). Likewise, it ensures that all the generated waste in Yaounde and Cameroon in particular, is collected, reused, recycled and the trash appropriately disposed of in a sanitary landfill assuring a cleaner/healthier Cameroon.

6. CONCLUSIONS

Municipal solid waste management problems have been fossilised as far back as the industrial revolution and aggravated by economic development, rapid urbanization, and population growth, resulting in huge volumes of waste to handle. Waste quantity has been increasing continuously and significantly as well as complexity of its components. This waste size has sparked challenges in MSWM trends, respective of the local economic potentials.

This study revealed that municipal solid waste management challenges ranges from waste collection, waste prevention, landfills acquisition, landfills tipping fees, recycling, source reduction, source sorting, waste storage and containers to involvement of the private and informal sector, legislation, assessment tools, and participation of all stakeholders.

Low recycling rates, accumulation of waste, illegal dumps, and proliferation of control dumps are observed in all regions, particularly in low and middle-income countries. Nevertheless, though different sectors of the society are hoping to resolve some of the problems through various initiatives such as those distinct in this research. The piecemeal approach does not manage to address the endemic waste management problems, of waste generation and education of the stakeholders.

Waste generation and separation is the critical component of a successful and sustainable waste management system. The waste needs to be sorted at the source as much as possible in order to reduce the amount of waste requiring disposal. Organic waste with high moisture content should be separated from inorganic recyclables. Furthermore, improvement will require accessible recycling conveniences, and the use of colour-coded containers for designated waste types. The endorsement of waste fee levying system can recover the costs and raise funds for investment in new facilities, and promotion of adequate economic incentives for the public to reduce MSW generation and modify their waste management behaviour.

All the same, the overall assessment projected additional light on the thesis statement. Actually, in today's world, the quantity of waste a person generates depends on him/her income. Moreover, the intensity of MSWM problems in every nation relies on the country's GNI, as nations with low GNI find it difficult to afford the viable machineries for appropriate

collection or transportation and treatment of waste, though they possess all the ideal political tools.

Cameroon, a low-income country in Africa, has been pressing issues towards municipal solid waste management, with a complex framework with stakeholders, including six ministries, municipal councils and various types of organizations (PPPs, NGOs, CBOs), besides the general public).

The occurrence of the notion of sustainable development, which orchestrates substantial importance in the conservation of natural resources, has posed many challenges to those involved in MSWM in Cameroon. This does apply to municipal solid waste management and also encompasses the social, environmental, and technical perspectives. The work here presented assessed waste management practices in Cameroon for sustainability, and presented tools to respond to Cameroons specificities.

A centralised municipal solid waste administrative frame, responsible for the management, assessment, and tracking of sustainability within each waste stream, is indispensable in Cameroon. Achieving this would significantly demand for consensus building, consultation, encouragement, and openness in maximizing the potential available for waste reuse, waste-to-energy, waste-to-fertilizer, and recycling in Cameroon.

The out listed optimisation plans and drivers will remain affirmative provided MSWM strategies of the twenty-first century do not enhance behaviour change, by constantly involving the population in MSW projects.

Education and communication programs will promote the much-needed awareness that consumers require, to be conscious of the fact that waste is a precious resource demanding the appropriate caution in use, like any other resources. More so, education and communication is the backbone to the solutions of MSWM problems. To better analyze the complexities of this solution, extensive research is required to understand how human behaviour changes towards waste handling and how it can influence MSWM systems in the world.

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7.2 LEGISLATION

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Appendixes

Appendix A - The waste generation rates and total annual waste in thousands of tonnes of the 29 case studies and their respective income group. (NA: - Not analyse)

N^{0}	Country	Income group	Waste in Kg/Person/day	Waste in Kg/capita/year	Total amount in thousands of tonnes	Reference
1	South Africa	Upper-middle	0.7	420	20,000	Lincoln, 2011; OCED, 2010; WB, 2011
2	Nepal	Low	0.3	NA	NA	Lincoln, 2011; WB, 2011
3	UK	High	1.61	580	32,600	Lincoln, 2011; OECD, 2011; WB, 2011
4	Singapore		1.3	NA	NA	Lincoln, 2011; Tay, 2012; WB, 2011
5	Tunisia	Lower-middle	0.6	NA	NA	Khatib, 2011; WB, 2011
6	Canada	High	1.2	390	12,900	OECD, 2011; WB, 2011
7	Portugal		1.1	520	5,500	
8	Germany		1.6	560	48,100	
9	Finland		1.34	480	2,560	
10	Sweden		1.33	480	4,490	
11	Ghana	Lower-middle	0.9	417	1, 250	Thompson, 2010; WB, 2011
12	Uganda	Low	0.48	200	NA	Okot-Okmu et., 2011; WB, 2011
13	Norway	High	1.3	470	2270	OECD, 2011; WB, 2011
14	Tanzania	Low	1.1	528	1320	Vidanaarachchi et al., 2006. Cited in Okot-Okumu and Richard, 2011; WB, 2011
15	USA	High	2.01	720	250,410	EPA, 2010c; OECD, 2011; USEPA, 2010b; WB, 2011
16	India	Lower-middle	0.5	NA	188,500	Ranjith, 2012; WB, 2011
17	Australia	High	1.7	600	12,730	OECD, 2011; WB, 2011
18	Malaysia	Lower-middle	0.65	NA	NA	Troschinetz and Mihelcic, 2008; WB, 2011
19	Malta	High	1.66	600	NA	Eurostat, 2011; WB, 2011
20	Korea	Low	0.5	NA	19,010	OECD, 2011; WB, 2011
21	Belgium	High	1.36	490	5, 280	
22	China	Upper-middle	2.3	850	157,340	Dong et al., 2010; OECD, 2011; WB, 2011
23	Turkey		0.970	NA	28,010	OECD, 2011; Troschinetz and Mihelcic, 2008; WB, 2011
24	Indonesia	Lower-middle	1.12	NA	9,600	OECD, 2011; WB, 2011
25	Russia	Upper-middle	1.22	440	63,080	
26	Chile		0.8	NA	6,520	
27	Greece	High	1.33	478	5,390	Eurostat, 2011; OECD, 2011; WB, 2011
28	Fiji	Low	0.4	146	2,879	DEF, 2008; WB, 2011
29	Botswana		0.330	NA	NA	Troschinetz and Mihelcic, 2008; WB, 2011

Appendix B – Relative waste composition in low, middle, and high-income countries in the world (Dong et al., 2010 and ISWA, 2012).

Economic group	**Waste composition in percentage range**										
	Organic waste	**Paper and cardboard**	**Plastic**	**Glass**	**Metals**	**Textile**	**Rubber, Leather, etc.**	**Other**	**Moisture content**	**Calorific values (Kcal /Kg)**	**Specific weight (Kg/m^3)**
Low-income countries	40-85	1-10	1-5	1-10	1-5	1-5	1-5	15-60	40-80	800-1100	250-500
Middle-income countries	20-65	8-30	2-6	1-10	1-5	2-10	1-5	15-50	40-60	1000-1300	170-330
High-income countries	6-30	25-66	2-8	4-12	3-13	2-6	2-10	2-10	5-20	1500-2700	100-170

Appendix C - MSW composition of the city of Yaounde in Cameroon (HYSACAM, 2012)

Materials	**Average in percentage**
Wood	0.82
Rubber	0.59
Cardboard /paper	9.86
Hospital waste	0.08
Gravels	0.91
Metals	1.26
Plastic materials	8.34
Textile	4.26
Glass and clay	1.13
Assorted small elements (sand, glass, etc.)	6.95
Perishable organic matter	65.79

Appendix D - Landfill tipping fee of some countries in high-income countries and the rate of recycling.

High-income country	Landfill Tipping fee ($USD/tonne)		Recycling rate (%)	Reference
	Average amount	Year		
Germany	45	2011	65	Helou et al., 2011
UK	87.7	2011	60	Sterecycle, 2012
USA	42	2009	33.8	CSS, 2009
Portugal	NA	2010	20	EEA, 2005; Helou et al., 2011; Williams , 2011
Sweden	40	2006	49	
Finland	23	2005	32	
France	15	2005	30	
Spain	NA	2005	30	
Belgium	61.7	2005	62	

NA: - not analysis