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DETERMINANTS OF SOURCE SEPARATION OF MUNICIPAL SOLID WASTE IN DEVELOPING COUNTRIES: THE CASE OF GHANA

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ABSTRACT

Source separation of municipal solid waste, (rarely practised in Ghana and Africa) which holds great promise to usher the country and continent into the realm of integrated and sustainable solid waste management is reviewed in this study. The study examines the determinants of source separation as the technical heart of a sustainable solid waste management option. The research was conducted mainly through interviews and survey across the socio-economic divide to determine willingness and ability to separate waste at source. Emphasis was placed on the degree and category of separation, and motivational measures likely to promote public acceptance and increase efficiency and coverage of future source separation processes. The study showed that residents have the ability and are willing to source separate waste into at least two streams. Biodegradables and plastics are the most preferred components of separation. Major anticipated challenges of the process include bin storage space and consistency of collection of segregated waste. Motivational expectations towards a future source separation program include provision of free storage bins to householders.

Keywords: Municipal solid waste, Determinants, Source separation, Sustainable solid waste management Developing economies, Tema, Ghana.

INTRODUCTION

Municipal Solid Waste Management (MSWM) is considered to be one of the most immediate and serious problems confronting urban government in most developing and transitional economies (UN-HABITAT, 2010a). Ghana's main MSWM system has been collection, transportation and eventual disposal of co-mingled Municipal Solid Waste (MSW) unto uncontrolled to semi-controlled dumpsites. "The system has often been characterized by inadequate service coverage, operational inefficiencies of services, limited utilization of recycling activities, inadequate management of non-industrial hazardous waste and inadequate landfill disposal" (Zurbrügg & Schertenleib, 1998, p. 2). Such management practice has always come along with adverse public health effects and financial burdens. Environmental sanitation related diseases such as malaria, diarrheoa, intestinal worms and acute upper respiratory tract infections constitute about 70%-85% of health problems reported at outpatient facilities in the country with seasonal epidemic outbreaks of cholera (MLGRD, 2010a). The service consume 35% of municipal budgets besides periodic financial support from development partners with no marked improvement (MLGRD, 2010b). Clearly the system is neither integrated nor sustainable. It is neither environmentally friendly nor economically viable. The system has become more challenging in recent times with rapid population growth, urbanisation, competing needs and diminishing availability of disposal sites especially in urban centres of countries with developing economies (UN-HABITAT, 2010b).

The existing MSWM situation and associated adverse impacts are best addressed by establishing a sustainable and integrated solid waste management option where all types of municipal solid waste and all facets of the waste management process are considered together (EGSSAA, 2009). (McDougall, White, Franke, & Hindle, 2001) recommends for adoption and implementation in countries with developing economies, a sustainable and integrated solid waste management (SISWM) system that requires, the collection of solid waste composition data; progress from uncontrolled dumping to the use of sanitary landfill; separation of organic waste from MSW, which can then be composted; and formal involvement of scavengers in the recycling of materials. A step toward the adoption of such a sustainable and integrated system has already begun in Ghana with the introduction of engineered landfills in some major metropolis of the country (MLGRD, 2010a). A bigger technical picture of SISWM whereby waste minimization; source separation; hygienic storage, efficient collection and transportation, composting, recycling, incineration and sanitary landfill disposal would complement each other in an economically viable, socially acceptable, and environmentally friendly manner however still remains evasive.

The necessity of reducing the level of emission and the cost of managing sanitary landfills in Ghana and other countries with developing economies calls for a comprehensive review of the state and category of solid waste that ends up in them. Currently, mixed (co-mingled) MSW with approximately 67% by weight of biodegradables, 20% plastics, 5% textiles and 8% combinations of silt, paper, metal, glass and household hazardous waste end up in Ghana's landfills (Oteng-Ababio, 2011). Mixed MSW has not helped the management of the first and only composting plant in the country since 1980. The mixed nature of the waste, with plastics, metals, and raw faecal matter, especially in low income areas has been a major problem of the plant (Boadi, & Kuitunen, 2004).

Source separation of MSW into various components is an important option towards achieving a sustainable and integrated solid waste management system in Ghana. Such a system is one aligned to all three pillars (economic, social and environmental) of sustainable development. It encompasses stakeholders, elements, and aspects and seeks to manage all three components in a sustainable manner (Khatib, 2011). To achieve system sustainability, all required aspects, such as financial, social, institutional, political, legal, and environmental that assesses the feasibility of the management needs to be addressed in a sustainable way. SISWM considers the technological system in addition to other elements including the socio-economic settings, the physical environment and growth in public demands and management scenarios. The success of such a system depends on the sound planning, administration, and management of the entire MSWM system. It begins with an institutional and policy environment that views MSWM as an important component in the sustainable development plans of a city (UNEP, 2000). It is designed on regulations that protect human health and the environment and funded based on the needs of the system. The system is coordinated in a holistic manner to provide a vital public service that does not compromise human health and the environment.

Source separated materials readily makes available the necessary raw materials for recycling and composting plants. A relatively small portion of solid waste in addition to the inevitable by-products of composting and recycling will end up on landfills. According to McDougall et al. (2001), separation of organic waste from the MSW stream represents an opportunity to reduce the quantity of waste entering landfills in developing countries by up to 50% by weight. Source separation increases the value of MSW and promotes cost recovery schemes in addition to prolonging the lifespan of the landfills.

However, source separation of MSW into many components as done in most developed economies would be difficult to implement in Ghana where such a system has never been practiced. There is always the need for waste management authorities and stakeholders to really understand existing waste management issues and find solutions that are appropriate to specific local situations (UN-HABITAT, 2010a). The introduction of such a system as part of integrated solid waste management would thus require a thorough research study to determine the extent and category of separation in addition to the willingness and ability of the masses to effectively and efficiently carry out the separation process. This paper seeks to determine all the necessary factors required to facilitate the smooth introduction of source separation of MSW in Ghana. The aim is to determine all the factors that will easily facilitate and promote a successful source separation system in the country and other countries with developing economies. The result is intended to serve as a guide to planners, policy makers and waste management authorities in developing countries towards the attainment of a sustainable and integrated solid waste management system.

DESCRIPTION OF TEMA METROPOLIS

Tema is a coastal city situated about 30 kilometres south-east of Accra, the capital city of Ghana. The metropolis shares common boundaries with Accra Metropolitan Assembly on the west, the Ga District Assembly on the North West, the Dangme West District on the northern and eastern borders and the Gulf of Guinea (Atlantic Ocean) on the south. The metropolis covers an area of 356 km^2 and lies within the coastal savannah zone (Ghanadistricts, 2012).

Tema is situated on the Greenwich meridian with 0^o longitude passing through it and serves as the administrative capital of the Tema Metropolitan Assembly (TMA). It is home to the busiest harbor of the nation (the Tema Harbour) and has most of the country's industries located there. This is largely due to the presence of the harbour and the availability of industrial lands and infrastructure. (Tema Metropolitan Assembly, 2006),

Tema is characterized by a dry equatorial climate. It is the driest part of southern Ghana with an annual rainfall of about 790 mm. Generally; temperatures are high all year round. The total population of the metropolis as of the year 2000 stood at 511,459 (Ghana Statistical Service, 2005). At a growth rate of 2.7%, the current population is estimated to be around 726,495.

Figure 1: Map of Tema, Ghana

OVERVIEW OF MUNICIPAL SOLID WASTE IN TEMA

The waste management department of the TMA is responsible for waste management in the metropolis. The main MSW management strategy has been collection, transportation and disposal on dumpsites. 10,700 tonnes of municipal solid waste is collected and disposed off every month in the metropolis. Collection of MSW- largely undertaken by private contractors- has been house-to-house where compactor collection vehicles move from one house to the other collecting stored solid waste at least once a week at a monthly cost to service beneficiaries. The other mode of collection has been central communal container collection where skip trucks go in to hoist skip containers that has been placed at sanitary sites within the communities. Such containers are filled with waste by householders who cannot afford the house-to-house services. The frequency of collection here depends on the rate at which the containers become full. In some cases collection can be eight times in a day. Collected MSW is transported over an average distance of 15 km to the only dumpsite at Kpone (a nearby community). The dumpsite, an old borrow pit of area 6 km^2 from which gravel had been removed over the years is being

reclaimed with refuse. The site has been operating for 15 years and is scheduled to close in the year 2015 (Africa Development Bank, 2002).

Any salvageable items are removed from the waste by 50 to 70 scavengers operating at the site. Disposed refuse is compacted but no soil cover is applied. A strong odour of decomposing organic waste, flies and windblown litters are permanent features at the dumpsite and its surroundings.

Industrial establishments are responsible to dispose waste in their own terms. No waste transfer station exists in Tema. Waste recovery and recycling of metals, glass and certain types of plastics are carried out on a small scale by scavengers. Since 2005, plastic recycling companies have been set up by private investors to recycle the highly increasing amount of high density plastics in the waste stream to low density equivalents which are used as carrier bags. The absence of source separation of solid waste a part of the MSWM system has been a major challenge to recycling companies. Raw materials for recycling plants are recovered by scavengers after dumping, increasing the cost of recycling operation with an associated decrease in value of recycled products.

THE CONCEPT OF SUSTAINBILITY AND SUSTAINABLE DEVELOPMENT

Sustainable development is defined as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). The concept of sustainability and sustainable development has its origins as far back as 1798, when Malthus, an economist, argued that planet earth would not be able to sustain life with time if population growth and attendant consumption was allowed unchecked (Rogers, Jalal, & Boyd, 2008). The concept however gained much significance in late 20th century when the United Nations explored the connection between environmental quality and quality of life. Sustainable development embraces the idea of ensuring that future generations inherit an earth which will support their livelihoods in such a way that they are no worse off than generations today (Pearce & Atkinson, 1998). According to the CEE (2007), sustainable development requires the maintenance of balance between human need to improve lifestyle and felling of well-being on one hand, and the preservation of natural resources and ecosystems, on which current and future generations depend on the other hand. The concept assesses the success of all developmental programmes in three components, namely, economic maximisation, environmental robustness, and social and cultural stability (Rogers et al., 2008). Sustainable development is thus viewed as a three-dimensional model of development which addresses the need to sustain the environment, economy and society (Rogers *et al,* 2008). Kajikawa (2008) describes the model of sustainable development as three pillars in which the pillars refer to the economy, the environment, and society. (Obeng, & Agyenim, 2011) argues that a "sustainable system or development is one which satisfies environmental sustainability (the sustainability of the planet), economic sustainability (the sustainability of prosperity or profit) and social sustainability (the sustainability of the values and cultures of people)". A sustainable integrated solid waste management (SISWM) option is one thus aligned to all three pillars of sustainable development where the three components complement each other towards the attainment of a sustainable outcome. (McDougal et al., 2001, Rogers et al, 2008). It is a waste management system that best suits the society, economy, and environment in a given location. SISWM stands for a strategic long term approach that does not only take technical and financial sustainability into

account as is conventionally done but it also includes socio-cultural, environmental, institutional and political aspects that influence overall sustainability of waste management (van de Klundert, & Anschiitz, 2000).

FRAMEWORK FOR SOUND SOURCE SEPARATION PROCESS

UNEP (2005) defines source separation of solid waste as the setting aside of compostable and recyclable material from the waste stream before they are collected with other MSW, to facilitate reuse, recycling, and composting. This practice, totally absent in the solid waste management practice of most developing countries has long been part of the integrated solid waste management system of developed countries. Source separation in addition to central sorting techniques has been the bedrock of successful materials recovery and recycling programmes in developed countries. The process goes along with an initial increase in the cost of solid waste storage, collection and subsequent transportation (UN-HABITAT, 2010a). Increased cost, however, is offset by cost recovery benefits of recycling and composting in addition to extra gains achieved as a result of a decrease in levels of solid waste to landfill sites. According to UN-HABIATAT (2011), waste management authorities in developing countries must put in much effort to encourage source separation of municipal solid waste. Although limited by technical and financial resources, McDougall et al. (2001) recommends for countries with developing economies, a two-stream source separation process which will separate the highly dominating organic from the inorganic.

UNEP (2000) recommend frequent public education and convenient collection services as a necessary requirement for successful household solid waste source separation programme. The educational campaign must be comprehensive and simple and must come out from the implementing municipality or group of municipalities. Illustration of the process must be picture oriented and must continue even after the launch of the scheme in an advisory and supportive manner. The degree of source separation achieved in any integrated solid waste management scheme is a function of both the ability and especially the motivation of householders (McDougall et. al, 2001).

Participation rate in new source separation programmes are very difficult to measure, since what people claim they will do, and what they actually do are not the same. However, a convenient source separation programme coupled with reliable and frequent collection rates increases participation rate and separation efficiency (ERRA, 1996). Motivation of householders may come in the form of provision of free or subsidized collection bins. Participation rates are likely to rise if households can be offered a cost reduction for having less non-recoverable waste in their restwaste bins (UN-HABITAT, 2010a). For the system to be cost effective, the collection cost associated with a source separation programme should be less than the revenue obtained through the sale of the materials (UNEP, 2005). A very good approach to the education plan is to explain to householders, the benefits of composting and recycling to the entire solid waste management system and the environment. The system is likely to be sustained if it is made convenient, hygienic and beneficial to the householder. In almost all cases, readily markets for the purchase of the recyclables must be sought before the separation process.

METHODS

Research Design

The research was designed using a stratified multistage probability sample. The explicit stratum was the Tema metropolitan area. The primary sampling units were 12 communities of the area. 6 communities were drawn from the sample. The secondary sampling units were approximately 834 households systematically drawn from each community. In all, a sampling size of 5000 households was used to first determine the willingness and ability of the citizens to source separate waste as part of a sustainable and integrated solid waste management option in Ghana. The focus of the research was to also assess all possible determinants to a successful source separation process for a people who have never practiced it before. Of importance was the determination of the degree and or category of source separation that would be initially convenient to all participants, in addition to the major motivational factors that could increase efficiency and participation rates. Further emphasis was placed on the significance of source separation to the waste management system, the extent and category of separation; the challenges likely to be encountered by participants and implementers; and possible educational and motivational measures that may promote public acceptance and increase coverage of the process.

Interview and Development of Questionnaire

The focus of the interview with waste management authorities was to obtain first hand information relevant to the cause of the development of the questionnaires and also to have a foreknowledge of the solid waste management practices in the metropolis. Specific information and documentary evidence of relevance sought in the interview included the spatial distribution of households in the metropolis; the number of houses and households, the population densities and economic divide of the residents; the per capita solid waste generation rate; and evidence of any source separation process in the metropolis.

The questionnaire was designed taking into consideration the various present challenges confronting solid waste management in the metropolis and the level of literacy of certain households in the various communities in the field of solid waste management. The questionnaire explicitly explained the need for source separation of municipal solid waste and the subsequent benefits that could be derived from the process. It was also intended to create awareness on the current solid waste management practices and its associated consequences to the environment and public health. The questions were prepared to meet the objectives of the study. Other questions of importance to the process were the degree and category of source separation that would be convenient to the participants and the means of provision of extra storage bins for the source separation process. Questions relating to motivation and reliability of the collection system after separation as a function of participation rates were also asked. Although not specifically related, respondents were given the chance to comment on the quality of solid waste services they receive from the assembly and their expectation for an improved service.

Administration of Questionnaire

Questionnaires, printed in English were administered by 2 trained and experienced research assistants proficient in English and at least one native language to households in 6 communities within the metropolis. The communities were carefully selected to cut across the economic divide. Two each of the communities fell within the low, middle, and high income categories. In each of the selected communities, a sample space of 3 out of every 5 houses representing 60% was used in the

enumeration process. With respect to households, 2 out of every 3 households was the enumeration threshold. A total of 5000 questionnaires were administered. The target of enumeration was the head and most importantly the female head of each household. This target was influenced by the fact that, in almost all households in the country, females held the responsibility of solid waste management. An average of 13 minutes was spent per questionnaire per household during the process. The process was carried out each day for a period of 12 weeks. Re-visitation forms were developed as reminders for heads of households who were absent during enumeration. A major challenge to the enumeration process was the absence of majority of households heads in the middle-income and high-income areas hence re-visitation rates increased by day.

OBSERVATION AND DISCUSSION OF RESULTS

The result of the survey, analysed statistically has been organised and discussed under the following headings: willingness to participate and ability to source separate, degree of source separation and category option of convenience, responsibility of bin purchase, and expectation and possible challenges to householders.

Willingness to Participate and Ability to Separate

Amazingly, 95.40% of the respondents were willing to source separate solid waste whilst 4.6% thought otherwise (figure 2). The high percentage of people willing to partake was probable due to the explanation given to them on the benefits of source separation to the existing solid waste management system. People seem not to be happy with the existing management system and wanted to say that if source separation was the answer to the solid waste challenges facing the metropolis and the country, then they were willing to help solve the problem. Questions on the ability to source separate solid waste was intended to find out if householders knew the differences between the components of the waste stream they generate so as to increase separation efficiency. 68.20% of respondents knew the difference between biodegradable waste and plastics with 83.64% having an idea of the differences between paper and plastics. In some areas, monitors of computers were considered to be plastics with central processing units as metals.

The level of understanding of the differences in components of the waste stream was relatively weaker in low income but densely populated areas than the middle-to-high income areas. Most householders in low income areas considered silt as part of biodegradable solid waste. A carefully planned educational program on the differences between the various components of solid waste streams would be beneficial to the cause of an efficient and sustainable source separation system in the near future. Householders who were unwilling to participate were not convinced of the fact that source separation was the way forward to solving the solid waste management challenges of the metropolis. Various reasons ranging from incompetent to corrupt authorities and lack of planning were given as the main solid waste management problems.

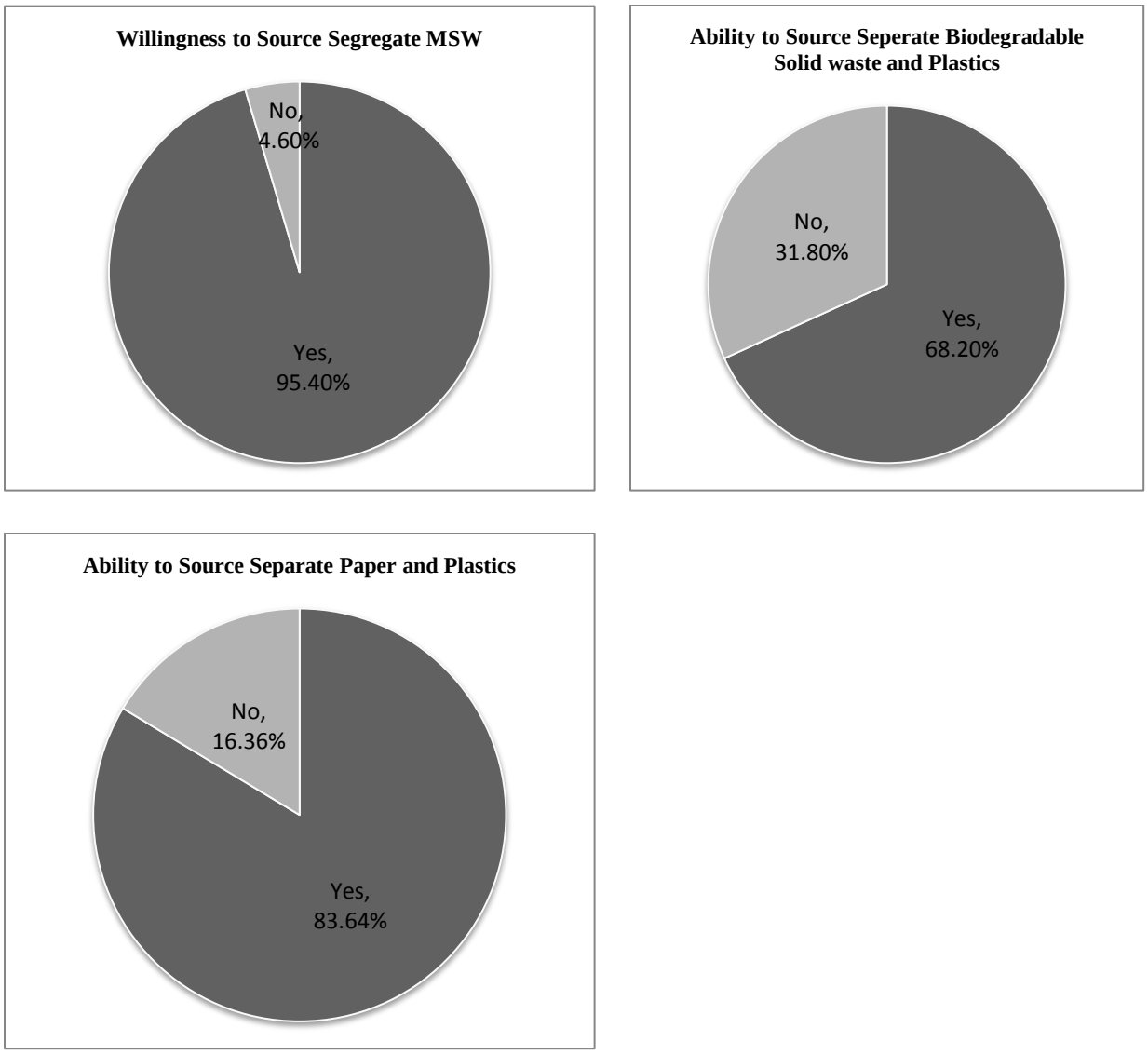

Figure 2: Willingness to participate and ability to source separate solid waste

Degree of Source Separation and Category Option Preferred

One of the main objectives of the study was to find out the degree of source separation that would be convenient to householders and also the waste stream category into which the preferred degree of separation would be executed. The available options for the degree of separation were two streams, three streams, four streams and more than four-streams. 57.20% of respondents' preferred two-stream source separation to all other options (figure 3). This decision of respondents may likely be due to the relative ease and simplicity to which two-stream source separation would be, compared to the other streams in addition to the flexibility and availability of space required for two bins compared with three or four. 37.30% however, preferred three-stream sorting. The relatively higher percentage of respondents for the three-stream sorting provides a good platform for any future move from two-stream source separation to a three-stream option. Preferred category options skewed towards biodegradables (B) and plastics (PL) than to metals (M) and paper (P), (figure 4).

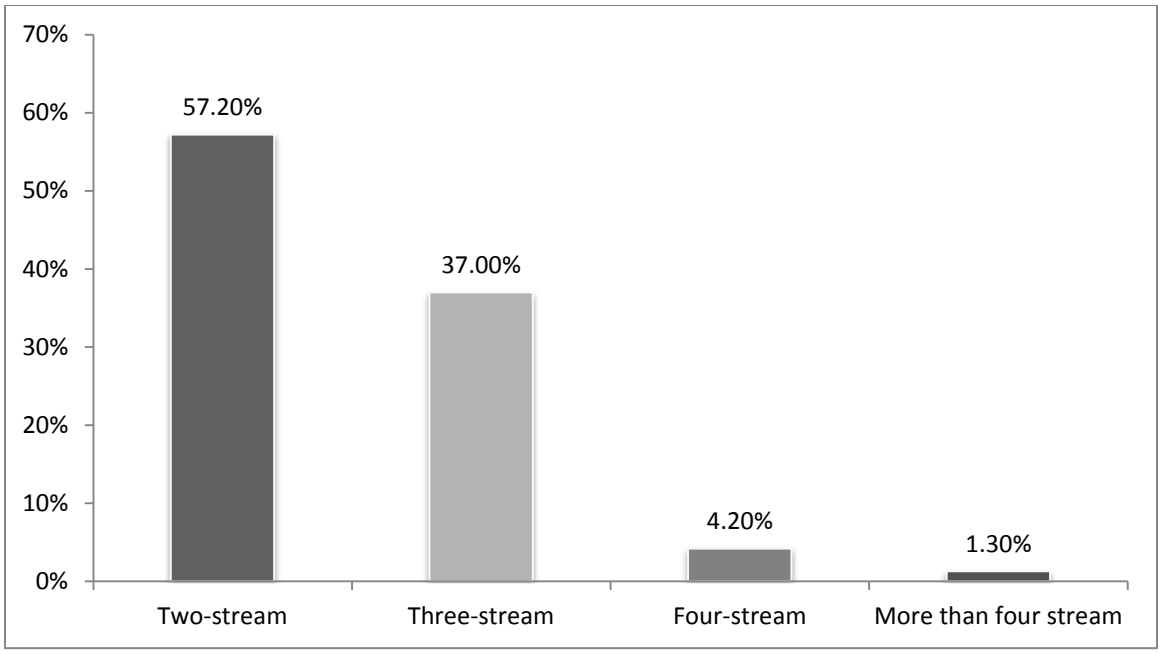

Figure 3: Preferred degree of source separation

This may be favourable to any future source separation process and the entire solid waste management system due to the high percentage of biodegradables (B) and the ever increasing amount of plastics (PL) in the solid waste stream of the country. Metals and papers form an insignificantly lower percentage of the solid waste stream. Municipalities and Metropolitan Assembly's would have to work hand in hand with stakeholders to establish markets, recycling and composting plants as part of an integrated solid waste management option to recycle the plastics and compost the organic fraction of the waste. Without the plants, source separation of biodegradable solid waste would not be technically and financially sound.

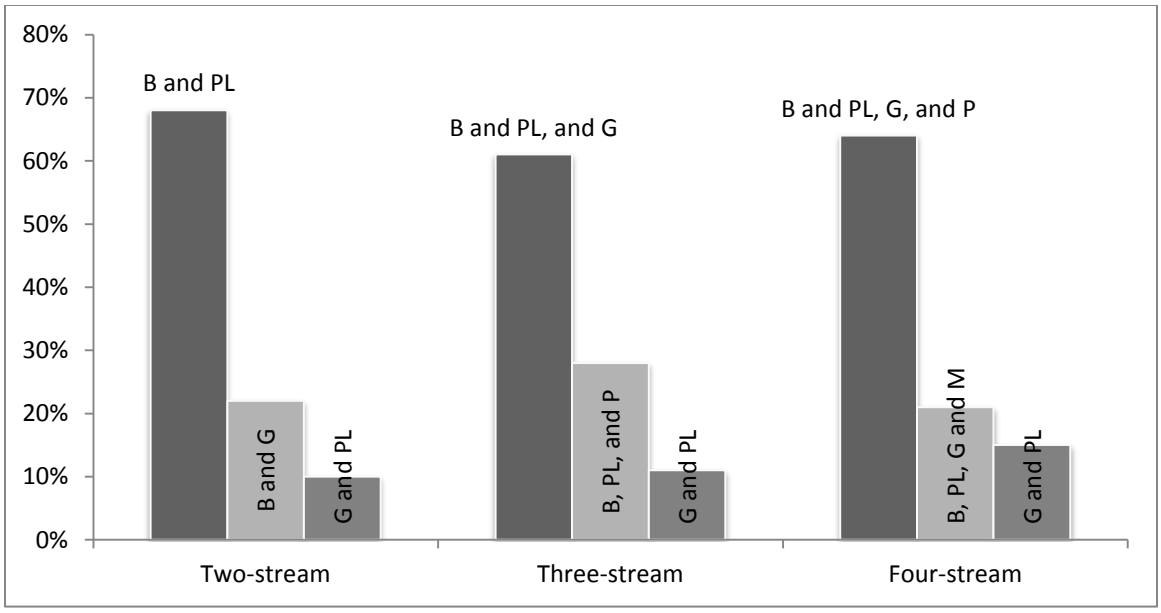

Figure 4: Preferred categories of source separation

Responsibility of Bin Purchase

A major financial implication to the introduction of source separation in the country is likely to come from the purchase of polyethylene bags and storage bins. The study sought to determine the willingness and ability of householders to purchase appropriate storage bins for the process. 19.80%, mostly from high income areas were willing to purchase their own extra bags and bins, 80.20% mainly from the middle-to-low income areas were not willing to purchase extra storage bags and bins for the sorting process. Out of the 80.20% who were not in a position to buy bins for the process, 79.50% looked forward to the TMA to purchase the bins on their behalf (figure 5)

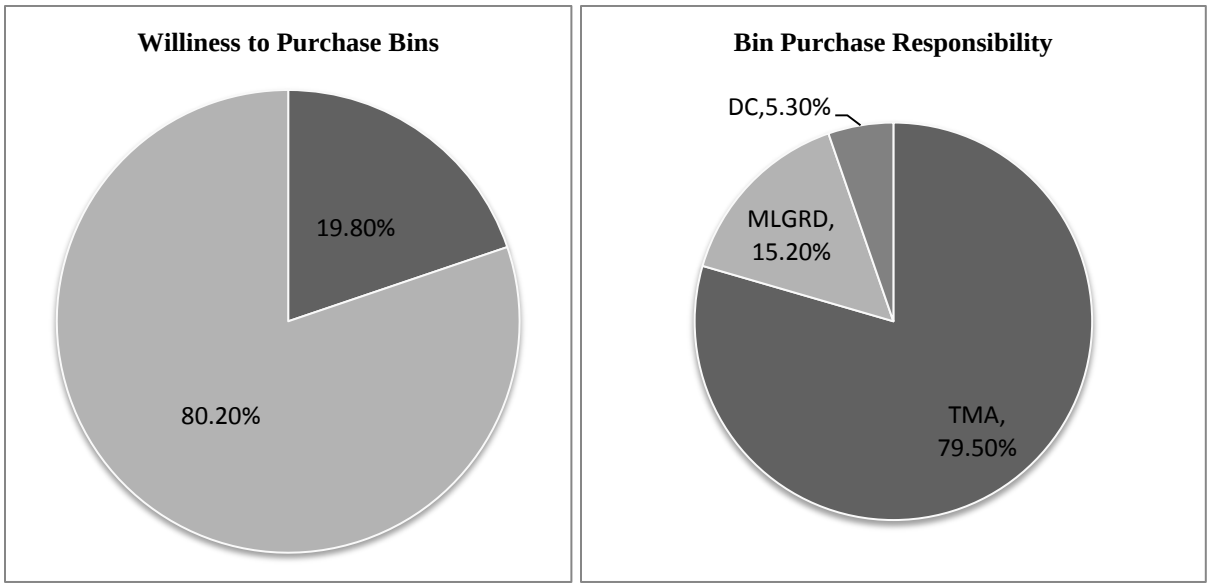

Figure 5: Willingness and preferred responsibility of bin purchase

15.20% however expected the central government through the Ministry of Local Government and Rural Development (MLGRD) to be the sole provider of bins for any future source separation programme. 5.3% declined to comment (DC) on the bin purchase responsibility. Authorities must be prepared to provide free polyethylene bags and storage bins, where necessary as a motivational tool towards a successful and sustainable future source separation process.

Expectation and Possible Challenges to Householders

As part of the objectives of the work, data on the probable challenges that may confront households during the separation process were gathered. 37.20% of the respondents, mostly from middle-to-low income areas were concerned with space for placement of bins and time involved in the separation process. The rest of respondents anticipated no major challenge to the process. On expectation of stakeholders towards a successful future source separation process, emphasis was laid on the consistency of collection, education of householders, and provision of free bags and bins. Some respondents made emphatic statements to dissociate themselves from a would-be process if implementers were not prompt at collecting the segregated waste. In all socio-economic divides, consistency of collection after source separation was of necessity. While provision of bins was a major motivational factor for the middle to low-income areas, it was the least of expectation in high-income areas (figure 5).

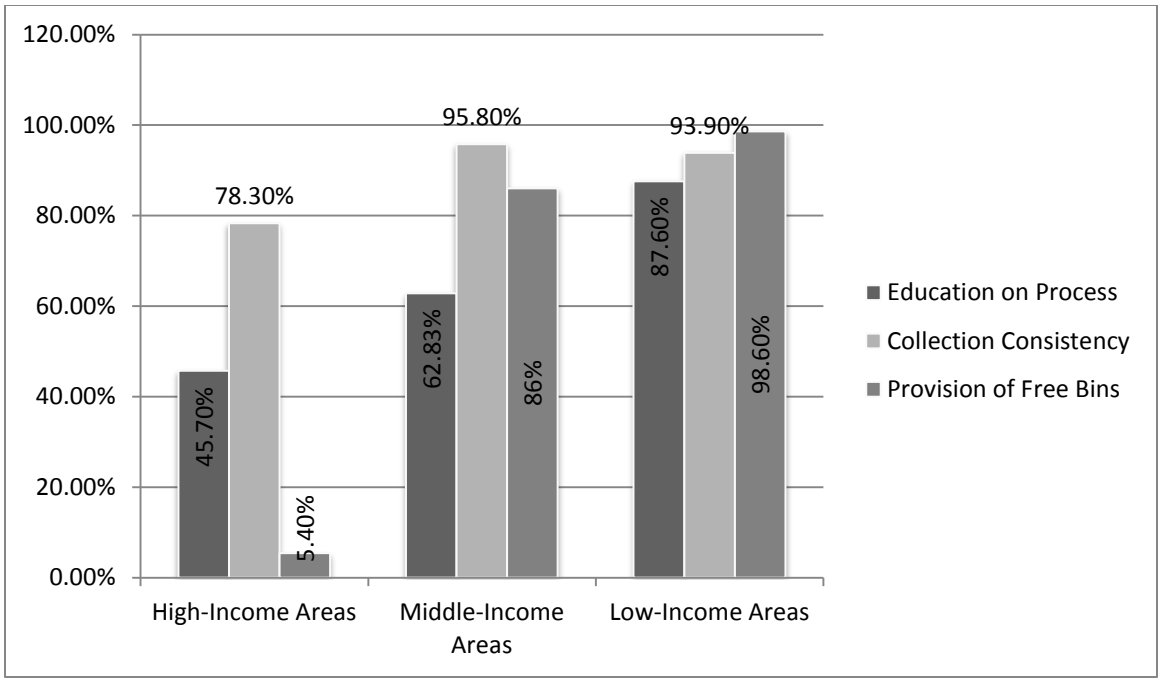

Figure 5: Preferred motivational factors towards sustainable source separation process

At any point in time, education of the masses with respect to the different components of the solid waste stream and the benefits of source separation to the entire solid waste management system must be promoted by all stakeholders to ensure efficiency and sustainability of future source separation programmes. The current solid waste collection system would need an improvement to boost householders' morale and confidence as a means of motivation towards any future source separation process.

CONCLUSION

The need for adoption and implementation of source separation of solid waste as part of a sustainable and integrated solid waste management system in Ghana and other countries with developing economies cannot be over emphasised. The benefits of such a process in reducing the financial and environmental burdens of solid waste management are evident from developed countries. The results of the study has established and provided guidelines for the implementation of the process in Ghana and other developing countries. Generally citizens are willing to participate and have reasonably proved they have the ability to source separate waste in the country. An initial two-stream source separation process followed by a three-stream process where biodegradables and plastics would be separated from all other municipal solid waste components has been established as the most preferred option. The successful attainment of future source separation system would require the provision of free or subsidised bins to householders. According to (MLGRD, 2010c), primary separation of solid waste at the household level will serve an effective response to the increasing waste volumes and changing waste streams due to varying life-styles in developing countries.

The study has also established the fact that householders play a higher premium on consistency of solid waste collection as a necessity towards their cooperation and participation to future source separation programmes. For the purpose of achieving

any practical success on source separation of municipal solid waste in the metropolis that could possibly lead to a nation-wide adoption of the process, it would be beneficial if waste managers, engineers and policy makers aim at providing the required resources and motivation to help pilot and sustain the practice. This will enable implementers to ascertain the progress and real challenges of the process since in many survey processes, what people claim they will do, and what they actually do when reality dawns are not the same.

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