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Strategic Options for Disposal of Domestic Solid Wastes in Kisii Town, Kenya

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Abstract: Urban domestic solid waste is increasingly being generated in many urban centres including middle-sized towns.In many urban areas in developing countries, there's a growing need and awakening for meeting the waste disposal needs for the ever increasing population. This paper examines and analyses the varied treatment and disposal methods of domestic solid waste employed in Kisii town. The mainobjective of the study is: to assess the treatment and disposal methods of the domestic solid wastes in Kisii town.A mixed methodological approach was taken into consideration. Data was obtained from a sample of 110 households using the multi-stage stratified sampling method. Data collection methods for the sampled size involved the use of questionnaires to household members and direct interviews ofthose County officers in charge of DSW, in addition to a observation integrated with photography. Data analysis and presentation was carried out using methods such as use of tables, use of graphs through SPSS, and other descriptive statistics such as the use of measures of central tendency. The results indicate that 84.4% of the residents dispose their waste by dumping; 9.7% by burning and 5.9% dispose their DSW in own-dug pits within the residential estates**.**In conclusion, treatment and disposal of the domestic solid waste in Kisii town is mainly done at the overfilled *Nyambera* dumpsite. It is recommended that, the County government should embrace better methods of waste disposal such as composting for organic wastes, landfilling for non-combustible wastes, incineration for combustible wastes and re-use and recycle. Further it's recommended that if dumping should be done the County government should relocate the dumping site from the central business district (CBD) to another area with sparse human habitation.

Keywords: Strategic options, treatment, disposal, domestic waste, Kisii town, Kenya.

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I. INTRODUCTION

Solid waste is produced in all residential areas where people live. The management of the waste thus has become a critical problem to different Counties and towns especially in developing countries.In many urban areas in developing countries, there's a growing need and awakening for meeting the waste disposal for the ever increasing population (Foster 2011). This may remain as one of the most crucial, expensive and even difficult duties of many urban authorities such as Counties currently in Kenya, and in particular Kisii town.Domestic solid waste management in middle-sized towns such as Kisii has become a vital problem to local authorities and municipal authorities especially in developing countries. Consequently, UNEP (2006) observed that the impact of solid wastes in urban environments has become more and more intractable. For example, it's estimated that more than five (5) million people die annually in urban areas worldwide from diseases related to inadequate waste management systems (UNDP, 1991).

There has also been a gap in the separation of the domestic solid waste generated in the town such that there is no separation of the waste at the source points which would enable easier and safer collection and disposal of the domestic solid wastes generated (UNEP, 2015). It is noted that treatment of the collected domestic solid waste is another gap evident in Kisii town such that the recyclable materials and organic materials are not separated before dumping, thus making the collected waste unmanageable.Kisii town has experienced rapid population growth and physical expansion. The area has increased rapidly in the recent past resulting to the expansion of its boundaries due to high rural urban migration and natural increase. The population has increased three times from 64,000 in 1989 census to 183,000 people according to 2009 census, (KMC 2010). This increase of population in the town has consequently increased the generation of domestic solid waste in the town, such that it poses overwhelming challenges to the existing treatment and disposal methods.

The status of Kisii town was enhanced with the coming of the devolved government and elevated to be a County headquarters.At the same time; the generation of domestic solid waste has increased to an alarming level that requires urgent attention. However, the treatment and disposal methods employed in the recent past need to be re-examined and improved to conform to the new population requirements in Kisii town (James, Paul *et. al* 2013).The level of natural systems, the interaction between waste handling procedures and public health conditions is influenced by climatic conditions and characteristics of local natural and ecological systems. The degree to which uncontrolled waste dump sites become breeding ground for insects, rodents and other disease vectors and a gathering place for dogs, wild animals and poisonous reptiles - depends largely on prevailing climatic and natural conditions (Bradshaw 1992). In practical terms, climate determines the frequency with which waste collection points must be serviced in order to limit negative environmental consequences.

Environment health conditions may also be indirectly affected through the pollution of ground and surface water by leachates from disposal sites. Open burning at dumps often causes air pollution, and foul odours as well as wind-blown litter are also common. Methane, an important greenhouse gas, is a by-product of the anaerobic decomposition of organic wastes in landfill sites. In addition, waste dumps may also be a source of airborne bacterial spores and aerosols. The suitability of a disposal site depends upon many factors, including specific characteristics of the subsoil, ground water conditions, topography, prevailing winds and the adjacent patterns of settlement and land-use (Bachman 1993).The domestic solid waste in most urban areas in Kenya is noted that it is disposed in open dumps, crude sanitary landfills, burned or decomposed. However, in low income areas, where the collection services are very poor, the most common mode of disposal is dumping along the streets; playfields and between houses. This is done during the day or at night. Burning as a method of disposal is commonly practised in the estates at night with or without separating the combustible materials. These crude methods of disposal are common in Kisii town, hence facilitating the need for a more comprehensive domestic solid waste management in the town (NEAP 1994).

Indiscriminate disposal of domestic solid waste is common in many towns and cities in developing countries. Most waste generated domestically are improperly disposed whereby some are dumped in the rivers, along the river valleys, behind the estates, along the pathways or roads, open dumps, crude sanitary landfills, along streets, playfields, between houses and some are even disposed off near the latrines and toilets (NEAP 1994). This poses a great danger to the environment, both physical and human especially when the waste is uncollected; causing pollution of all kinds such as air pollution, water pollution and land pollution (Otiso 1996). The practice of a safe disposal system- may require the use of sacks to collect the solid waste and dispose them all since they are biodegradable. However, the use of large containers should be avoided to ease loading and off -loading of the domestic solid waste.To guard the public against any injury, scavenging and sorting of the waste should be prohibited at the dumping site but should be encouraged at generation/storage points. It is expected that such efforts will protect the workers collecting the domestic solid waste from collecting harmful and contaminated materials.

Compacting of domestic solid waste in the sanitary landfills should be encouraged to: minimise the spatial extent of the solid waste; cater for bad odours from the site which would adversely affect the neighborhood residents, causing respiratory diseases; minimise the scavengers on the site such as birds, rodents, street families and insects such as mosquitoes and flies which bring about malaria and plague respectively.Burning of domestic solid waste in collection areas and in the landfills should be prohibited since it leads to the release of poisonous gases into the atmosphere which in turn leads to the destruction of the Ozone layer, hence contributing to global warming (Vergara and Tchobanoglous 2012). The gases released when burning waste include: carbon monoxide, carbon dioxide, sulphurous gas and sulphur dioxide, among others. These gases are harmful to the environment as well as to human life in case they are inhaled. We note that gases such as carbon dioxide, when they combine with rainwater, cause acid rain that corrodes iron sheets, retards plant growth and causes a scorching effect to animals.

Bad odours from the uncollected waste and the dumping sites have adverse effects on the respiratory system of the residents and the people living around- near these areas. The respiratory diseases in turn greatly affect the population and may even result in death of individuals (EMCA 1999).

The predominant lack of comprehensive planning policy for the urban infrastructure, water and the sewerage system in most urban areas in Kenya; as it was noted in Thika, has affected Kisii town to a level that the town lacks adequate infrastructure to cope with in terms of: tractors, vehicles, collection bins and the proper disposal facilities and methods. This has in turn aggravated the dire need for a comprehensive planning policy for the town so as to come up with appropriate strategies that will enable conducive and proper management of domestic solid waste (Shibanda 1980).Many towns in the developing countries experience inadequacy of disposal sites which results in the vehicles and tractors collecting the waste criss-crossing within the town centre from the collection points to the few available disposal sites. This has led to wastes spreading in the town due to poor packaging of the waste and spreading the odours in the town, hence air pollution since most of these vehicles are open (Omondi, 1998).

In disposal of DSW, this study focused on determining the disposal methods that are used in middle sized towns and now County headquarters which are peculiar to them unlike the large towns whose studies are evident. In addition, the study aimsat bringing out and highlighting the impacts of dumping in such towns considering their limited space for expansion and the effects to the physical and human environment.

II. METHODOLOGY

The study area

The study area

Kisii town is geographically located on Latitude: 0° 41' 0 S and Longitude: 34° 46' 0 E. The town is a driving distance of 309 km (192 mi) from Kenya's capital city of Nairobi, located east-southeast, on Class B3 all-weather road. Other major urban centres in the immediate neighborhood of Kisii town include: Kisumu City which is 114 km (71 mi) to the northwest, Nyamira at 23 km (14 mi) to the immediate north; Keroka at 25 km (16 mi) to the east; Kericho at 101 km (63 mi) to the northeast, Kilgoris at 46 km (29 mi) to the southeast; Narok at 165 km (103 mi) to the east, and Migori to the south-west at 67 km (42 mi) which otherwise connects the town to the Kenya /Tanzania border at Isebania town located a further 31 km (19 mi) south.

Kisii lies at an altitude of 1,700 m (5,577 ft) above sea level on the slopes of Kisii highlands. Kisii town is the County headquarters of Kisii County in the Nyanza region in western Kenya. The town covers 8 km^2 (3 sq mi) and it has recently expanded rapidly to cover a peripheral extent of 29 km^2 (11 sq mi), making its total expanse of 37 km^2 (14 sq mi). Kisii receives frequent convectional rainfall and enjoys a highland climate. The location of Kisii town on the highlands facilitates the growth of a vast vegetation cover making the region produce a lot of food crops and vegetation which form a large part of the domestic solid waste generated in the varied residential areas of the town. The rapid expansion of the town has resulted in the creation of more residential estates such as *Ufanisi, Getare, Milimani* and *Nyanchwa* which have enhanced the stratification of the residential areas and also contributed tremendously to the generation of domestic solid waste which in turn exerts pressure to the existing solid waste management systems.

Figure 2.1: A map showing location of Kisii town in Kenya and its various estates.

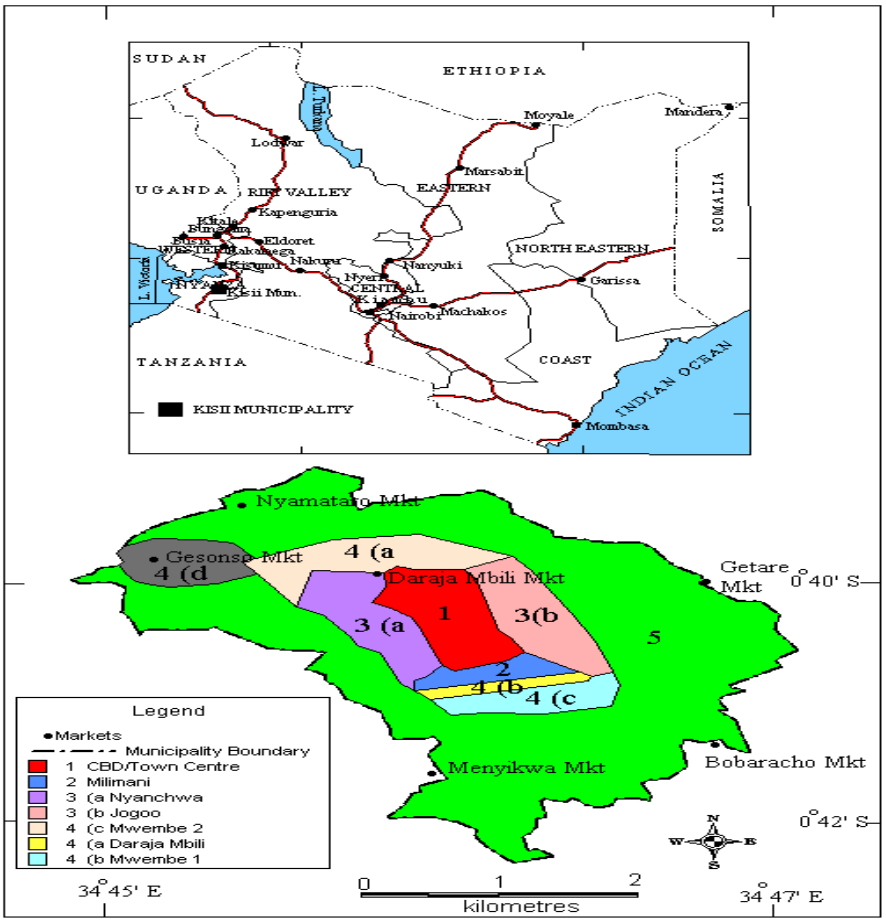

Figure 1: Map of Kisii Municipality *Source: Kisii Topographical Sheet 130/2* G.O.K (1991).

Research Design

For the study to meet the set objectives, the researcher took into consideration a household descriptive survey design, which covered selected residential estates within Kisii town. Kisii town has been chosen as one of the rapidly growing County headquarters in Kenya. In order to carry out the design effectively, the researchers recognise the need to classify the town's residential areas into distinct environmental neighborhoods based on the income levels of the residents. This catered for differential respondents' perceptions and activities on the research subject. Therefore, this entailed the categorization of the area into different major zones of residential/environmental areas using the multi- stage sampling method. The researchers administered questionnaires to the residents in the sampled estates in Kisii town and in depth interviews were conducted to County officers in charge of public health, town planning, refuse collection and environmental management with a view to making the survey design in depth in its findings. This facilitated investigations into the role played by the County in household solid waste management in Kisii town. The officers were interviewed were randomly picked from different County and municipal departments especially those in the public health office in charge of solid waste management in the town to minimise cases of biases on the responses and improve on the level of accuracy of the information.

Kisii town has currently more than 20,000 households in all estates. Using the multi-stage sampling three estates were chosen by dividing the entire study area into different major residential areas based on the environmental indicators such as the structures of the existing households; the assumed levels of income and the prevailing environmental conditions. Consequently, the residential zones were stratified as those of high income residential (HIR), middle income residential zones (MIR), and low income residential zones (LIR). This was done in collaboration with the County and municipal authorities that helped in this classification since their determination was more precise. This facilitated the selection of the households that were interviewed. The household population in the three estates is not uniform such that *Nyanchwa, Jogoo* and *Mwembe* have more than 300, 600 and 800 households respectively. From the three residential classifications, estates were selected through stratified sampling criteria from the existing estates namely: *Menyinkwa, Gekomu, Nyanchwa, Jogoo, Mwembe, Campus, Gesonso, Daraja Mbili, Nyamataro, Bonubi, Egesa, Bochura, Omosocho, Milimani* and *Getare* among others. The table below shows the selection of the estates according to their income levels.

Table 2.1: A Table showing the sampled estates in Kisii town

Low Income Residential Estates	Middle Income Residential Estates	High Income Residential Estates
★ Mwembe	Menyinkwa	Milimani
Daraja Mbili	★ Jogoo	Nyamataro
Bonubi	Gekomu	★ Nyanchwa
Bochura	Getare	Gensonso
	Egesa	
	Omosocho	
	Campus	

★ Sampled Estates.

Different number of households were systematically selected after a K^{th} household has been randomly selected based on each estate's total number of households according to the County statistics which were provided by the County and town administration statistics department.

Figure 2.2: A map showing the sampled estates

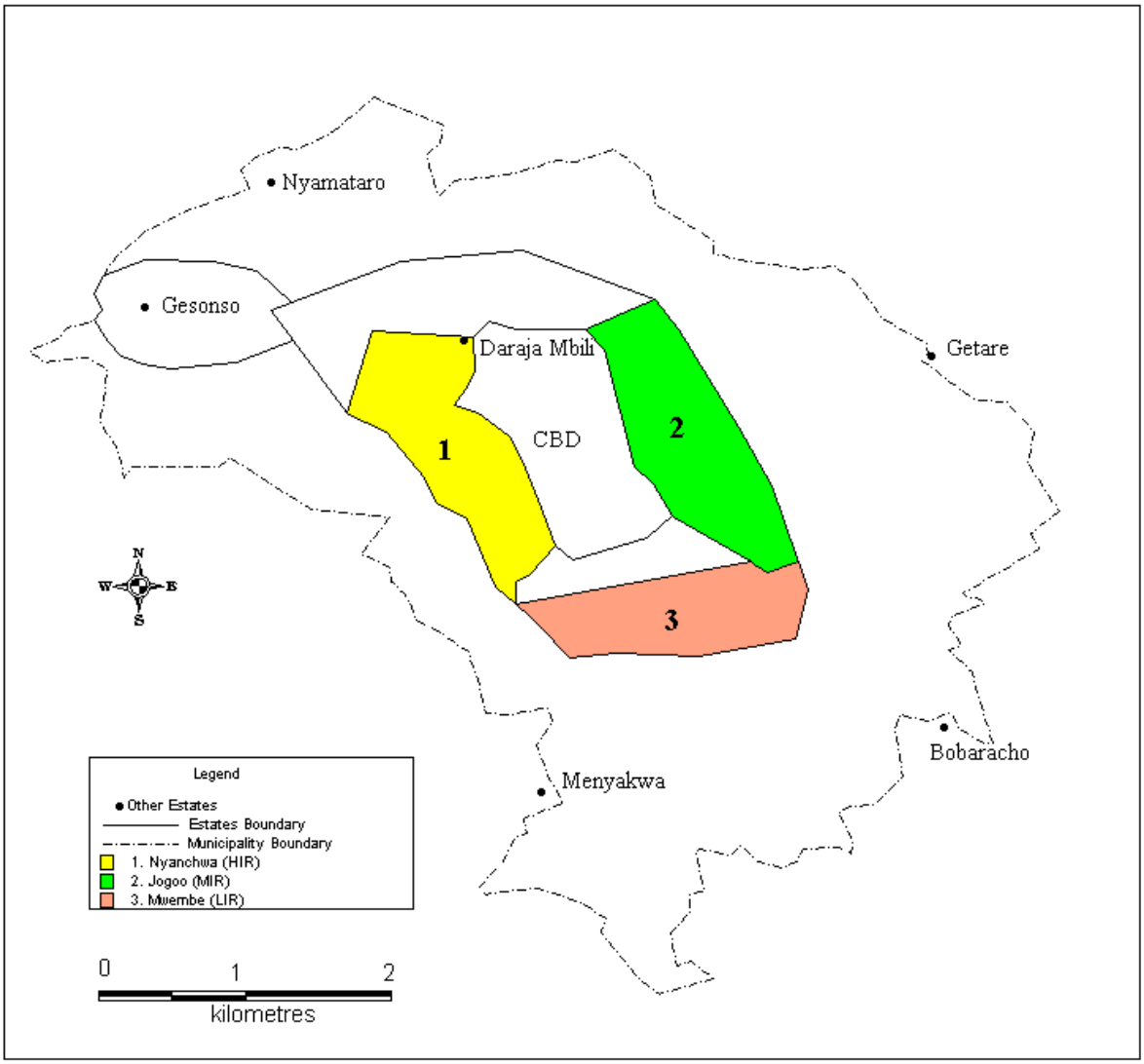

Figure 2:2 Map of Kisii Municipality showing the three sampled Estates

2.4: Sampling procedure

The sampling procedure used by the authors largely depended on the research design. Consequently, questionnaires were issued to the residents in the identified areas and estates; while interviews targeted Kisii County staff as in depth informants.

The sample size was 110, and was calculated according to Yamane's formula: $n = N/1+N (e)^2$,

Where n- is the required sample size

N- is the population size

e- is the error margin

In this case N was 1700 and e was 0.09

Hence $n= 1700/ 1+1700(0.09)^2$ n= 110

The sample size of 110 made up 6.5% of the households of the sampled estates. The sample size was differentiated in the sampled *Mwembe*, *Jogoo* and *Nyanchwa* estates based on the 6.5% according to the stratified method.

Table 2:2: A Table showing the sampling procedure of the questionnaires used.

Estate Class	Estate Name	Target household population	Sample size
LIR	Mwembe	800 *0.065	52
MIR	Jogoo	600*0.065	39
HIR	Nyanchwa	300*0.065	19

TOTAL		1700*0.65	110

Both primary and secondary data collection methods were employed for the research study. Primary methods of data collection used involved the collection of raw data from the field. Questionnaires, interviews, measurements, use of photographs and direct observation were used. The use of multiple techniques was aimed at ensuring that accurate and reliable data was collected. Since the major consideration in the research was to obtain data; that would allow accurate descriptions of situations or relationships between certain variables, information adequacy and efficiency (Busha and Harter 1990). The reliance on multiple data techniques usually provides better results. Questionnaires were the preferred data collection tools since they gave a close analysis of research objectives, research questions and the research hypotheses. A questionnaire covering a wide range of issues on household solid waste management was administered to respondents at household level as shown in appendix I, and another to the County/ municipal authorities as shown in appendix II. Babbie (2004).

After data had been collected, the raw data was systematically organised through coding to facilitate analysis. This was done by converting data to numerical codes representing attributed or measurements of variables. Statistical Package for Social Sciences (SPSS) program was used as an analytical tool to produce the result required for the interpretation and discussion of the subject matter. However, some data obtained from interview schedules, observation and photographs were presented directly as obtained. Various inferences were made from the analysis for the purposes of verifying and testing the results to confirm the research question. In analysing the data, descriptive and inferential statistics were employed, where the measures of central tendency such as mean were used to summarise the scores of variables of solid waste generated in the varied residential estates, percentages were also used to gauge the proportions of waste generated and the corresponding responses given.

The data was presented using tables, figures, photographs and calculated percentages and frequencies/means. The data was also presented by means of discussions and explanations of the study findings so as to make valid conclusions.

III. RESULTS AND DISCUSSION

Disposal of the collected Domestic Solid Waste

The household solid waste is disposed off in three ways that include burning, the council doing it on behalf of the residents and disposal by others in estate dug pits. Burning was observed to be common phenomena in *Mwembe* and *Jogoo* estates due to delayed collection of the DSW by the County management. On the other hand, disposal in the estate dug pits is practiced in *Jogoo* estate making the estates with dug pitshave foul smell, have sight sores, scavengers, flies and unhygienic conditions. For example, 86.7% of the residents of all the estates entirely depend on the County government to dispose off their DSW from the various estates. However, 8.9% of the residents, especially those in *Jogoo* and *Mwembe* burn the waste they generate without classifying them into the various types and a paltry 4.4% of the residents dispose off their wastes through dumping into estate- dug pits.

Results indicate that disposal of DSW is mainly done by the County government where the residents dispose off their wastes in the County bins. However, in some residential areas the residents dispose off their DSW in personal polythene bags or bins provided by the landlords in their estate. In estates such as *Jogoo*, some residents dispose off their wastes in estate- dug pits.For example in LIR/ *Mwembe* estate, 92.1% of the residents collect their DSW and dispose it to the nearby county provided bins. In areas where the County bins are far the residents dispose off their DSW in personal polythene bags which are placed by the roadside at night to be collected by the County personnel into the County provided bins during the next day. Also, 6.5% of LIR residents dispose their DSW by burning while1.4% of *Mwembe* estate residents dispose off their wastes in dug pits within the estates.In MIR/*Jogoo*estate, 78.4% of the residents dispose off their DSW in the County designated areas whether there are County bins or not, since these specified places are the official collection sites for the County. However, due to inadequacy of bins, several disposal centres for the residents have cropped up. Up to 5.3% dispose their waste using personal polythene bags which they place by the roadside at night to be collected later by the county government. In addition, 10.1% of the residents dispose off their DSW by burning while a further6.2% of the residents of *Jogoo*estate dispose off their DSW in home dug pits within the residential areas, depending on the landlord organisation. However, this method has been found inadequate since these home dug pits get overfilled within a short time leading to unhygienic conditions in the estate.

In HIR/*Nyanchwa* estate, 66.6% of the residents dispose off their wastes in personal provided bins where the wastes in an estate are disposed in a large wheeled bin within the estate provided by the landlord and the caretaker or a person assigned by the landlord who empties the bins to the County provided bins or sometimes transports them directly to the County designated dumpsite. This has led to reduced overdependence on the County provided bins for the disposal of DSW in this estate. However, 10.7% of the residents especially those who are near the county provided bins, dispose their off DSW there. This proves that the County provided

bins in *Nyanchwa* are inadequate. Besides, 12.4% of the residents dispose off their wastes by burning while a further 10.3% of the residents dispose off the DSW in estate dug pits organised by the landlords.

Table 3.1: A Table Showing Disposal of DSW in Kisii Town.

Disposal method	**% in HIR**	**% in MIR**	**% in LIR**	**Overall/average %**
Bins for dumping	77.3	83.7	92.1	84.4
Burning	12.4	10.1	6.5	9.7
Estate dug pits	10.3	6.2	1.4	5.9
Total	100	100	100	100

Source: Field Survey by Authors (2015)

The results from questionnaires and interviews indicate that the wastes from various estates disposed off by the County government are not separated before disposal due to inadequacy of personnel and proper structures for separation. Therefore the DSW is disposed off in the common dumping site at *Nyambera* without any form of sorting taking place. However, informally the street children separate the water bottles after dumping and disposal has taken place, and they collect the water bottles to be re-used for other purposes such as paraffin fetching, oil and glues collection. In some cases, these bottles are recycled for water refilling used for drinking water in some small- scale water cleaning and packing industries.

ccording to the results of the interviews, the County government disposes off its collected wastes from the estates by dumping at the *Nyambera* dumpsite. This dumpsite is overfilled, thus prompting the County government to look for alternative dumping site for the County leading to the identification of *Etora* dumpsite which is yet to be established and put into use.The interviews results also show that the County government of Kisii also regularly uses grinders and compacters to compress the waste at the *Nyambera* dumpsite to suppress the levels of the usually overwhelming wastes. Similarly, the County government applies the method of burning at the *Nyambera* dumpsite to reduce the levels of the wastes at the overfilled dumpsite.

The results from interviews, direct observation and photographs indicate that the dumpsite is faced with many challenges such as being usually overfilled, lack of expansion space in the area, concentration of the scavenger birds, street families, bad odour to the travellers as it's by the roadside and the people residing and working nearby, overflow of the wastes into the river *Nyakomisaro* that is adjacent to the dumpsite whenever it rains, heavily affecting the water users downstream.Results from the interviews note that dumping is the major disposal method used by the County in DSW in Kisii town where the wastes are disposed at *Nyambera* dumpsite. The wastes are not separated before disposal for recycling or any other purpose. This non- separation of wastes and inadequate space for dumping are the major problems facing the County government in DSW disposal. There are future plans for sorting, recycling and re-use of the DSW before disposal so as to minimise the wastes. The following photographs indicate the varied methods of disposal of DSW in Kisii.

Plate 3.1: A view of *Nyambera* dumpsite

This photograph shows the current status of the Nyambera dumpsite where all the DSW in Kisii town is disposed off. In the photograph, there are cattle scavengers indicating the environmental hazards it poses to domestic animals.

Plate 3.2: A photograph showing section of the overfilled *Nyambera* dumpsite with motorists

The photograph above indicates that the dumpsite is already overfilled though disposal is done here. Also, the dumpsite is next to the road affecting the motorists and travellers through bad odour that is emitted and eyesore to onlookers.

Plate 3.3: A woman burning DSW in *Mwembe*

The above photograph indicates the use of burning as a method used by residents to dispose off their DSW. This method has its own challenges. Some of these challenges include the fact that not all wastes are combustible, by burning smoke produced from some types of wastes may have harmful toxins to the environment, both human beings and animals and may even lead to acid rain.

Strategic options suggested for management of DSW in Kisii town

This research suggests an integrated domestic solid waste management using several options such as 3Rs- Re-use, Reduce and Recycle, combustion and landfill technique to dispose off the solid and municipal waste (EPA1989). It is also, suggested the use of is the recovery of energy from the domestic solid waste, composting and landfilling for efficient and sustainable handling of DSW.

Recycling

USEPA, (United States Environmental Protection Agency 2002), notes that sound environmental management is achieved when the 3Rs approach is implemented according to the order: first, source reduction; second, recycling and composting and third, disposal to the landfill or waste combustors.The recycling as an alternative of managing domestic solid waste improves the efficiency of use of diminishing and limited resources of the world. Recycling is very vital in solid waste management as its aims are to: reduce waste at the production and consumption levels, increase the waste utilization at all levels and have environmentally safe disposal of non-recyclables (Wolbeck 1992).

Recycling in industries in USA and Great Britain has reached a level of production of refuse- derived fuels which is aimed at sustainable development of these industries (Bonnie 2006). Recycling is therefore important both as a waste reduction strategy as well as an economic activity. The analysis to determine whether recycling is done in Kisii town will be critical. In developing nations high national recycling effort is largely attributed to the activities of the private reclamation industries that concentrate their activities on industrial and commercial waste flows. Recycling entails the making use of secondary raw materials attributed to the increased awareness of re-use and scarcity of raw materials, the increasing prices of raw materials and the high cost of production and exploitation (Grosse 2010).In developed countries such as Germany, their statistics reveal that up to 80% of production residuals are being utilised by the plastic industries while paper mills are utilising paper waste to an average of about 43%. Thus, solid waste is highly recyclable to give other new products or even to produce energy (Turner, 1994). In Brazil according to (Edmundo, 1993), recycling is highly recommended and valued such that Brazil has 12 plants for processing solid urban wastes into compost while the other wastes such as scrap metal, plastics, cartons and polythenes are separated to their respective plants for recycling. This practice in Brazil saves the raw materials, energy consumption, employs semi-skilled personnel and moreover contributes to the urban and environmental protection and conservation of the country.

Effective recycling can be achieved through separation of different types of wastes at the collection points (Turner 1994). For example, Germany uses separate containers for collection; vehicles for transportation of the waste have designed separate chambers for each type of waste. Thus waste collection through sorting is very critical in urban domestic solid waste management.

The research suggests that recycling plants of varied domestic solid wastes and other wastes generated in Kisii town should be established as an option of disposal of the waste. These plants should be located around the incineration sites so that the incinerators can provide the required energy for the recycling plants. The recyclable wastes should be collected separately and transported separately to the plants. This could be a better option for the rampant waste problems, not only in Kisii town but also in many towns in Kenya and developing nations.

Re- use

Re- use entails the use of the same wastes without modification of any form but only after disinfecting them. Some of the domestic solid wastes in urban areas can be collected, disinfected and re-used to curb the menace of heaping the garbage. For example, plastic bottles such as drinking water bottles, sodas and beer bottles among others, can be collected, disinfected and then re-used. This should begin by sorting them out during household collection into the bins before they are collected by the municipal or County officers in charge of collection to the disposal sites. In some cases, the street families have been used to collect plastic bottles and then hand them over to private firms, who in turn disinfect them and re-use them. This should be encouraged and even the county government should establish the infrastructure necessary to facilitate the re-use of these waste products. Some can be used to sell with Kerosene in small scale, package drinking water, and juices among other uses.This research suggests that the County government of Kisii should consider developing cleaning sites for re-usable domestic wastes so that theymay be re-used. These include bottles, tins, cans and other forms of re-usable wastes. These cleaning sites will provide an ample and safer way of disposing off the enormous wastes generated in this category.

Reduce

The reduction of the domestic solid waste generated is another alternative in the management of domestic solid waste. Families should be encouraged and even educated through: mass media, posters, banners, street walks and internet among other means to buy and cook what they can manage to consume so as to avoid

the excesses which in-turn turn out to be waste. Through buying what the family can manage to consume completely to their fill without the production of enormous waste, the quantity of domestic solid waste generated would be reduced. Similarly, by cooking food stuffs that the family can consume completely with minimal left-overs, the amount of solid waste generated would be protected and reduced. Thus a general reduction in the waste at the collection points can be realized for effective management of the household waste.

Moreover, families should use baskets in purchasing items from shops and supermarkets; whereby one carries his/her basket to the shop, market or supermarket so as to minimise the use of plastic containers and the paper bags (polythenes papers). This would aim at reducing the use of non- biodegradable materials especially the paper bags that are very rampant in the town, as is the case in most towns in developing world.

Energy recovery/ incineration

The innovation of the incinerator in 1876 was a means of effective and hygienic method of disposal of solid waste. Currently, almost 98% of refuse incinerators in developed countries are equipped with energy recovery devices. This increased generation of un-compostable waste coupled with increased demand for energy and the ever- increasing prices of energy necessitated the energy recovery from the solid waste. Energy can be recovered from the domestic solid waste in the landfill sites that generate methane gas by an aerobic digestion, biological fermentation, from agricultural waste and livestock effluent. The heat from the incineration chamber for domestic waste is viable since it produces similar energy to brown coal. The County government should embrace the use of incineration for the combustible solid waste. This would reduce the wastes disposed at the common dumping site. Incineration will further provide the energy required for the recycling plants such that the location of the recycling plants be in proximity to the incineration sites. This would further enable easy transportation of the collected domestic solid wastes from the town; turning challenges of the waste into opportunities hence cleaner, safer and sustainable environment to the anthropogenic and animal life.

Composting

Large-scale composting systems are used by many urban areas around the world. Owing to the fact that Kisii town is rich agriculturally, vegetative wastes are common phenomena comprising of a large percentage of the domestic solid wastes disposed. These vegetative wastes from the rich agricultural environment should be disposed off through composting as a better option. This research suggests that composting should be incorporated by the County government as a means of disposal and also using varied digesters that generate manure and fertilizer for agricultural inputs for those practicing farming. Through composting, the County government can generate revenue and help its large agricultural based population to produce more. Therefore, composting is suggested by this research as a safer, economic and sustainable means of domestic solid waste disposal in Kisii town and other towns especially in developing countries.

Landfilling

Landfills have been the most common methods of organized waste disposal and remain so in many places around the world, and this should be applied to Kisii town as well. Landfills ought to be incorporated as mode of domestic solid waste disposal since it utilizes small space bearing in mind that the town is located in minimal acreage with little space for expansion. In addition, landfills compact the volumes of waste into small manageable amounts and these wastes are usually covered hence reducing the effects of the waste as is the case currently in *Nyambera* dumpsite. This research suggests that the non-combustible, non-recyclable, non-reusable, non-reducible and non-vegetative domestic solid wastes should be landfilled. This will be a strategic option for such kind of wastes in the town. Landfilling could help the County government manage the enormous heaps of DSWs that are prevalent in the dumpsite located in the central business district (CBD) of the town, thus creating room for other critical developments in the minimally spaced town while also ensuring efficient, clean, healthier and sustainable management of the town environment.

IV. CONCLUSIONS

Disposal of DSW is done at two levels: at the householdlevel and beyond the estate. At the household level residents dispose off their wastes in three ways: disposing in bins/skips/self-purchased bins, polythene bags; burning and disposing in estate dug pits. Beyond the estate, disposal is done by the County dumping the DSW in the *Nyambera* dumpsite located in the CBD.

The DSW is disposed off mainly through dumping at *Nyambera* dumpsite located in the town's CBD. The tractors and compactors dispose off the wastes once collected in the dumpsite. In the dumpsite, further compacting is done using County caterpillars since the waste is already overfilled. Besides, burning of the DSW at the dumpsite takes place to reduce the quantity of the waste in the dumpsite.There is no segregation done while disposing the DSW, although street families gather used bottles and other re-usable materials providing

some form of segregation. This mainly helps them to sell these materials cheaply so as to get some income for their upkeep.

V. RECOMMENDATIONS

The County government should embrace proper disposal methods that are environmentally friendly and avoid burning and dumping of the DSW. They should use and incorporate re- use by establishing sterilization/ cleaning plants and re-packaging centres for water bottles.

Further, it is recommended that recycling centres/plants should be established to put into use used bottles, polythene papers, tins, glass and other wastes so as to reduce their bulk in the town. Digesters and compost pits should be developed to utilise organic wastes such as food remains to make organic manure to be sold and used in farms. Digesters should also be used to generate biomass energy that can be used to provide energy for small scale use. Incineration plants should also be established to burn combustibles and energy generated to be used in recycling plants inorder to enhance sustenance of the plant and provide cheap energy source.

The study further recommends that the acquired *Etora* dumpsite by the County government should be put into use as appropriate measures are put in place to rehabilitate the overfilled *Nyambera* dumpsite for viable economic use considering its location in the CBD.

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