Composition, Generation and Management Method of Municipal Solid Waste in the case of Addis Ababa city, Central Ethiopia: A review

Abstract

Municipal Solid Waste management is one of the most fundamental issues in the contemporary urban environments particularly in developing countries like Ethiopia. Huge generation of waste coupled with unbalanced waste management services is the major challenges facing the City of Addis Ababa. A continuous increasing of production of more wastes and change in composition of waste into complex, the waste management practice is challenged by low prioritization of waste management, limited revenues for financing waste management with the ever increasing population of this city. This paper reviewed composition, generation and current waste management system in the case of Addis Ababa. The mechanism of Addis Ababa city Sanitation, Beautification and Park Development Authority to coordinate stakeholders has played a vital role in waste management. However, the daily monitoring of waste management by the community development section has not been sufficient because of poor governance where accountability, participation and transparency are lacking. It is also unauthorized solid waste dumping practice problem in different locations and has an effect on water sources and its resources. Effective involvement of both private and public sectors should improve waste management and provide door-to-door collection, street sweeping and facilitate drainage disposable canals. Therefore, an integrated solid waste management practice should be implemented for the City and also for the surrounding environment. As a result, strong political will, multi-sectorial approach, public awareness and participation, strategic planning, adequate funding and the adoption of Integrated Solid Waste Management is recommended SWM system required in Addis Ababa city.

Keywords: urbanization, waste management, municipality, open landfill, collection

1. Introduction

Solid waste management (SWM) is one of the development environmental challenges facing city authorities in the word and that is a major concern to every nation of the world(Craig *et al.*, 2002; Hoornweg & Bhada-Tata, 2012; Miezah *et al.*, 2015).Waste management issues are coming to the forefront of the global environmental agenda at an increasing frequency and it is an issue mostly witnessed in urban areas(Al-Khatib *et al.*, 2010; Javaheri *et al.*, 2006; Zerbock, 2003). As a consequence of population expansion, urbanization, economic growth, intensive use of packaging goods, informal

settlement, urban agriculture, improvement of living standard and food habit has been taking place during the 20th century virtually transformed world in to communities of cities facing resulted in the substantial increase in the amount of solid waste being generated and variation in solid waste composition(Ezeah & Roberts, 2012; Zarate *et al.*, 2008), and which making SWM more challenging in urban areas continues increasing (Hoornweg *et al.*, 2013; Shen *et al.*, 2011).

The burden of increased waste generation poses on the municipality budget as a result of the high costs associated to its management, lack of understanding over a diversity of factors that affect the different stages of waste management and linkages necessary to enable the entire handling system functioning (Desta *et al.*, 2014; MALENYA, 2015). Municipal solid waste management (MSWM) problems have become more pronounced in recent years coupled with inadequate financial resources, has led to indiscriminate dumping of solid waste into roadsides, open spaces, football fields, river banks, drainage channels and even grave yards as dumping sites and causing flooding, environment pollution and public health issues because as long as humans have been living in settled communities, solid waste generation has been an unavoidable and critical issue (S. Abdulwahid, 2006; Marshall & Farahbakhsh, 2013; Perera, 2003; Vickers *et al.*, 2006).Due to lack of means the collecting of waste is not always done on a regular basis and dumping on sites is still the most common way to dispose the wastes (Babyebonela, 2013; Schübeler *et al.*, 1996; Werner *et al.*, 2011).

The production of worldwide solid waste is projected to increase with world´ s population growth and urbanization (Kasa *et al.*, 2011; Zerbock, 2003). Global MSW generation levels are approximately in 1900, 110 million tonnes and 1.1 billion tonnes in 2000, which is tenfold. The worldwide municipal solid waste production is projected at almost 1.3 billion tonnes annually, and anticipated to grow to about 2.2 billion tonnes annually in 2025. Global urban population likewise grew to 1.5 billion by 2010 from 1 billion in 1960 and is estimated to be 4.5 billion in 2025. A substantial rise of waste production proportions per person is likewise estimated from the present 1.2 kg per person daily to 1.42 kg per person daily by 2025 (Hoornweg *et al.*, 2013). A substantial rise of waste production proportions per person is likewise estimated from the present 1.2 kg per person daily to 1.42 kg per person daily by 2025 (Benti, 2007; Scarlat *et al.*, 2015).

Municipal solid waste, that is any material discarded by primary users in urban areas, contributes to about 70 percent of total waste generated in Ethiopia (Kneeland & Knutson; Otu, 2011). Both biodegradable and non-biodegradable waste products can produce negative environmental, social and economic effects. Biodegradable pollutants are waste materials that can decompose naturally, but these pollutants can still become a problem when added to the environment faster than they can decompose (Filaba, 2008;

Kneeland & Knutson). Although the Ethiopian government has begun taking steps to address the environmental and social challenges associated with municipal waste management, there remains a great deal of inefficiency in, and environmental degradation as a result of current waste management systems (Asmamaw, 2015; Thabrew *et al.*, 2009). However, this has not been the case, as many towns in Ethiopia lack of financial resources and institutional capacity to provide the most basic infrastructures and services including solid waste management. Therefore, solid waste management is a complex task that requires appropriate organizational capacity and cooperation between numerous stakeholders (Desta *et al.*, 2014; Lohri *et al.*, 2014); otherwise poor environmental quality in a city can deprive people of good quality of life (Abas & Wee, 2014; Habitat, 2013).

According to Environmental Protection Authority (EPA) and World Bank study conducted in 2004, per capita amount of waste generated in Ethiopia ranged from 0.17 to 0.48 kg/person/day for urban areas to about 0.11 to 0.35kg/capita/day for rural areas. The range depends on several factors such as income and season(Getahun *et al.*, 2012). The total generation of municipal solid waste in Ethiopia in 2003 is estimated to be 2.8 to 8.8 million tones. This can be split to approximately 0.6 to 1.8 million tons from rural areas and 2.2 to 7 million tons from urban areas(Birke, 1999; Kuma, 2004; SBPDA, 2003).The population of Ethiopia is growing at a rapid pace. In 2000, the population was 63.5 million; the current population is more than 100 million, second largest in African countries next to Nigeria and by 2025 projected to be more than 125 million (Asgedom, 2017; Holden *et al.*, 2004). Addis Ababa City, being the largest city in the country, Population increasing from time to time and showing impressive economic growth trend and one of the swiftly urbanizing centers in Africa, has been grappled with an increasingly growing urban waste management problem(Yntiso, 2008).

Waste management in Ethiopia is important because only a small percentage of the country's inhabitants have access to safe drinking water: 21% in rural areas, 84% in urban areas, and 30%country-wide. Additionally, only 7% of populations in rural areas, 68% in urban areas, and 15% of people country-wide have adequate access to latrines or other improved human waste disposal options (Kumie & Ali, 2005). In this regard, a review survey was carried out on the solid waste generation source, assessment of SWM systems, waste disposal and problems of SWM. Thus, this review revised documents from books, thesis works, annual waste management conference reports, journals on waste management, newsletters, abstracts and proceedings which can properly address the main factors that strongly hinder proper waste management and the extent to which community is aware of appropriate waste disposal systems in Addis Ababa city.

2 Literature Review

2.1 Description of the Study Area

Addis Ababa is the capital city of Ethiopia at the horn of Africa, was founded in 1887 by emperor Menelik II (and his wife) located in its own region (of the same name).Despite its early establishment, the city of Addis Ababa started its SWM 71 years later after its establishment with the aim of ensuring the health of its residents. Yet, the city is still faced with a number of waste management problems(Abiye *et al.*, 2009). It is located at the heart of the country as shown on the figure (1), and is one of fastest growing cities on the continent and the largest as well as the dominant political, economic, cultural and historical city of the country (Bustos *et al.*, 2004; Mossu, 2015).

Currently, Addis Ababa city is a seat for both Federal Democratic Republic of Ethiopia and Oromiya National Regional State Government. It is bordered with Oromiya National Regional State in all directions and also it is the largest urban center in the country (already fourteen times larger than the second largest city Dire Dawa). It is also where headquarters of some continental and international organizations like the Organization of Africa Unity (AU) and the United Nation Economic Commission for Africa (UNECA) and regional headquarters for UNDP, UNICEF, UNHCR, FAO and ILO. The city is sub-divided into three layers for administrative purposes namely City government, sub-cities administrations and Woreda (local name for District) are found. Moreover, due to its natural beauty, its location along the northern historic route as well as the availability of standardized tourist facilities, it has become one of the major tourist and gate way for diplomats of the country due to variety of attractions. The city has expanded rapidly throughout the 20^{th} century. At the same time, as the city modernizes, it is converting more and more land into streets, parking lots, hotels, etc., increasing the amount of surfaces that cannot absorb the seasonal rains in the area. This storm runoff overflows sewage systems and creates an influx of contaminated rivers (D Fikreyesus *et al.*, 2011).

Addis Ababa city accommodates about 30% of the total urban population in Ethiopia. Its population amounted to 2.1 million in the 1994 census, and estimated 2.3 million in 1997. The population census of 1984 gave a population at that time of 1.4 million, revealing an increase of 60% over a decade, at an annual growth rate of 3.79%. Most of this growth is due to in-migration from all direction of the country in search of employment opportunities and services (SBPDA, 2003; Un-Habitat, 2012).The city has currently a population of about 3.5 million with density of 5936.2 km^2. Average household size was 5.1% in 2007 (CSA, 2007), and projected to be 12 million in 2025(Potter, 2012).Demographic pressure has led to a high rate of unemployment, high concentration of slum dwellers, and very poor quality housing infrastructure and sanitary development (Bihon, 2007).Today it is facing ever increasing environmental

problems, which include changing temperature patterns, eradication of green areas, unsolved problems of solid and liquid wastes, etc. However, Addis Ababa's main environmental problems are not the "green" issues (natural resource degradation) but it is the "brown" issues (pollution and other environmental problems) that are damaging the health and life of the residents (Basha, 2007).

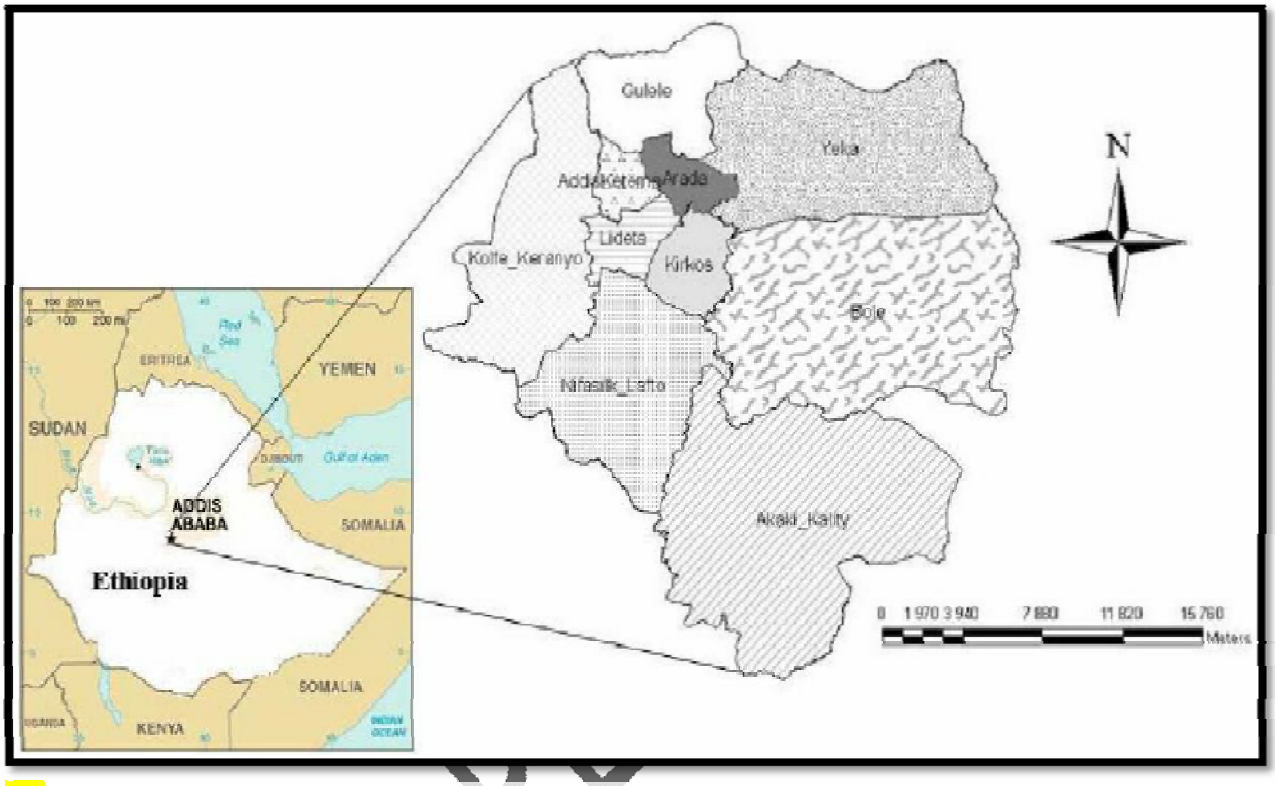

Figure 1: Location of Addis Ababa city Administration. Source: Adopted from (Desta *et al.*, 2014)

A Global position of the city is between located between $8^0$55'and 9^0 05'N Latitude and 38^0 40' and $38^0$50' E Longitude. The city enjoys tropical type of climate with an average annual temperature of 19.6^{0}c, the lowest (usually occurs from November to February) and the highest (usually occurs from March to May) annual temperatures are 10^{0}c and 20 ^{0}c respectively. Average annual rainfall of the city is 1200 mm from this about 80% of the rainfall occur in July and August months, only 3% fall during the dry months, the rest fall in the remaining months(SBPDA, 2003) while the small rain occurs between March and May. The average elevation of the city is estimated 2500m meters above sea level ranging from 2000-2800 meter above sea level. It is the highest capital of Africa. The size of the city covers around 540 square kilometer (54000 hectare) of which 18.174 square kilometer is rural (Benti, 2007).

2.1.1 Solid Waste Collection

Waste collection service is one of the chief components of municipal SWM practices. Huge generation of MSW coupled with unbalanced waste management services is the major challenges facing the City of

Addis Ababa(Amiga, 2002).Waste collection and disposal in Addis Ababa follows formal and informal approaches. The formal approach is the sole responsibility of the city government. This is handled in two ways: door-to-door collection for households along accessible streets done by micro and small enterprises(Amiga, 2002; Regassa *et al.*, 2011). The number of enterprises organized to work on solid waste collection is 750 with a total number of 5815 operators(Ababa, 2010; Basha, 2007).These pre-collectors have a formal agreement with the municipality to do the activity and get payment for that. Most of the areas in the city are inaccessible for motorized collection. Therefore, the human powered collection system is mostly used. With regard to the transportation of wastes to the containers is possible using hands and hand pushed carts (see **Figure 2**). In each Kebele, strategic locations are assigned where collectors make ready for the motorized collection. The container system under which residents are expected to carry and dump their waste in containers located at accessible sites (see **figure 3**).Once these are full, municipal trucks dispose of this waste in the landfill site of Addis Ababa, called Repi or Koshe (Mahiteme, 2005).

Door-to-door primary collection is carried out by pre-collectors' associations and street sweepers (see **figure 2**), and this too is put in containers for final disposal by the waste management agency, SBPDA. So in practice, the majority of waste is collected via the containers system, but the efficiency of this method is limited because of a lack of capacity of the city government to deploy adequate numbers of vehicles and waste containers (see **Figure 3**). Besides, containers are not protected from rain and sun, which makes the rubbish rot and smell, creates unsightly urban spots, and leads to the deterioration of neighborhoods and a disturbance of human activities. The site is also exposed to stray animals that scatter the waste while scavenging. So, these are created bad smell, unsightly urban picture, and deterioration of the neighborhood(I. Abdulwahid, 2003).

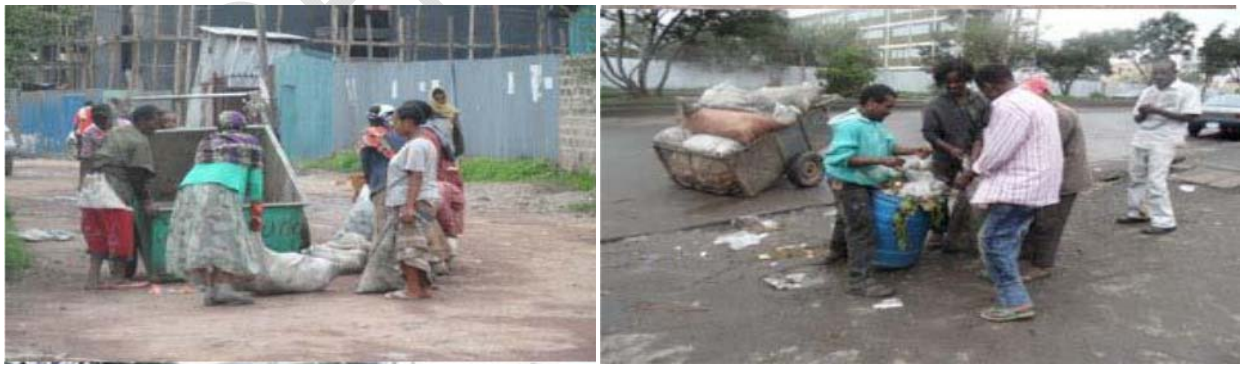

Figure 2: waste pre-collectors in Addis Ababa. source:(Mohammed & Elias, 2017)

Figure 3: Primary solid waste collection in Addis Ababa city. Source: (Ababa, 2010; Amiga, 2002; Cheru, 2016)

Addis Ababa city residents pays for cooperatives per month based on volume of solid waste generation rate into consideration in the area in which cooperatives provide solid waste collection services for dwellers(30 birr per m^3= USD1.70/ m^3) (Bjerkli, 2013). Most residents (91.02%) are willing to pay for service improvement while 8.98% of residents are not willing to participate in cost share for better solid waste management services supply in the city. The amount of money respondents were willing to pay towards improved collection service ranges from 2 to 100 Ethiopian birr with mean of 18.46 Birr. Moreover there is clear difference among different economic groups concerning the willingness to pay for improved service; the willingness to pay more is 72%, 51% and 28% for high, middle and low income households respectively(Tilaye & Van Dijk, 2014). The government in financing SWM Service charges is collected with water consumption bill. Services charges are fixed according the amount of water consumed in terms of the ability and willingness to pay residential houses 20%, Commercial houses 42.5% of the total water consumed Collection is regular and full coverage (Amiga, 2002).The second approach is the informal recovery and recycling system. Qoralés[1] buy waste materials door-to-door from households and institutions. Waste pickers collect waste materials from municipal containers and from Repi dumpsites. Once the materials have been collected by Qoralés and waste pickers, they are taken to the market at Minalesh Tera, the central market of Addis Ababa, and sold to middlemen or wholesalers. These then sell the materials to recyclers(Amiga, 2002; Bjerkli, 2005; Cheru, 2016). Due to shortage of containers collected wastes are improperly stored on open spaces and roadsides (**see figure 4**).

[1]**Qorales-**refers individuals who purchase recyclable solid waste door to door and resell for factories and whole sellers

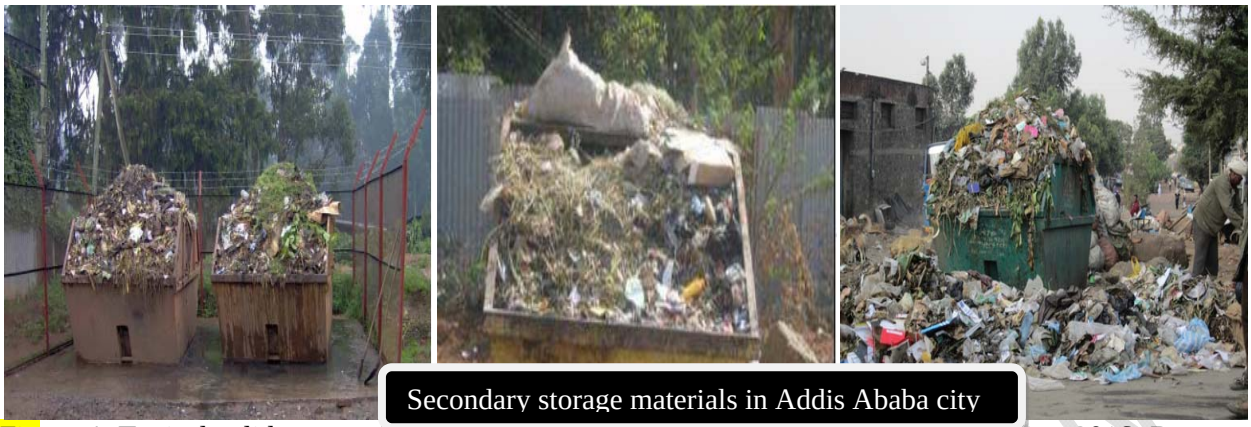

Figure 4: Typical solid wastes collection containers in Addis Ababa city. Source:(Cheru, 2016; Desta *et al.*, 2014)

The storage bins used in the city of Addis Ababa are not standardized bins, and dust bins are located only on main roads with the assumption that those roads are the popular ones. For temporary storage, households prepare different types of receptacles such as baskets, card boxes, bamboo made containers, cans, plastic bags, barrels, etc. Majority of households (70%) stock up solid wastes in sack (Figure 5), 14% used plastic container, 10% used basket, 3% used private pit, 2% used metallic container and 1% of households used other materials to store wastes temporary (Amiga, 2002; Tilaye & Van Dijk, 2014).

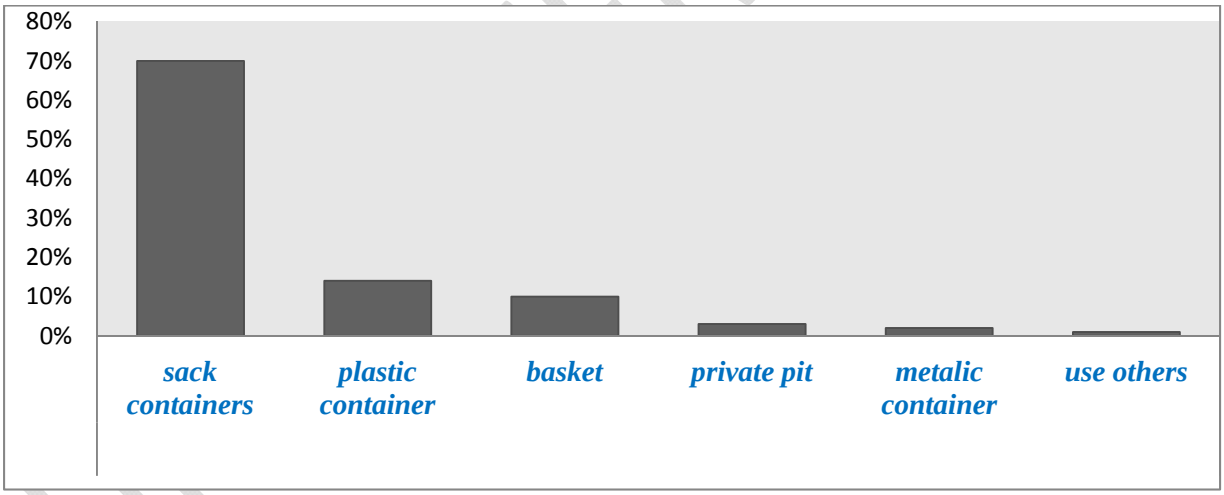

Figure 5: Types of primary solid waste storage materials of households. Source: (Amiga, 2002)

2.1.2 Sorting of waste

Sorting is an essential component of solid waste management. It is a kind of activity which is separating different types of wastes in their respective nature. It makes waste management easy and simple(Poon *et al.*, 2001). Sorting of waste takes place at various levels in the waste management process; The first level of source separation is at household: plastic materials, glass, bottles, are considered as valuable and usually sorted out for reuse Several collectors represent the second stage: Street boys, private sector

enterprises, scavengers at municipal landfill, and the korales (Mata-Alvarez *et al.*, 2000).Solid waste segregation at the point of generation is not carried out, 80% of the waste produced is dumped with a low percentage being reused or recycled at the household level (Amiga, 2002). On the contrary, there are households who separated at the household level into organic and inorganic only (Kuma, 2004).

The purpose of separated waste is different for different areas and income group. Inorganic wastes like cans are usually sorted for sale (Figure 6). In few households, organic wastes like plant origin are sorted for the purpose of reusing in their gardens and as fuel after the waste gets dried; this is seen in low income households. Animal source (meat and bone) is used to feed domestic animals like dogs. Some households give the waste away to their neighbors who use it for different purpose like for animal feed. The manure is to plaster walls and floors and for fuel when dried up, whereas the grass and chatt leaves is fed to domestic animals in rural Kebeles (Basha, 2007). In Addis Ababa city, from households who separated waste at source level 40% for selling; 8% for recycling; 16% for reusing; 36% easing for collection(Debere *et al.*, 2013).

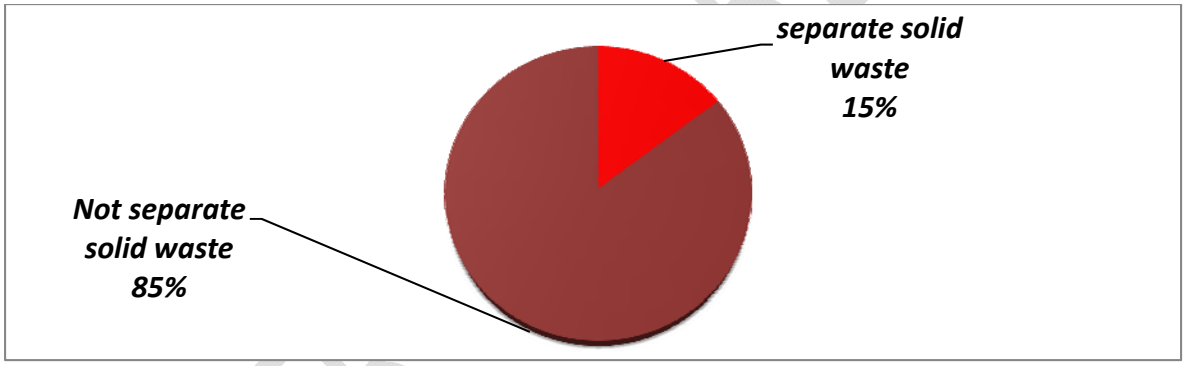

Figure 6: Households solid waste separation practice in Addis Ababa city. Source: (Desta *et al.*, 2014)

2.1.3 Transportation

Cities in low-income countries often lack sufficient transportation and equipment to collect wastes(Segosebe & Vanderpost, 1991). Waste collecting trucks are not available to the level demanded as indicated in **Table 2**there are about 79 trucks the department uses to collect and transport the refuse from the source of origin to the final disposal site. According to (Bogale & Tefera, 2014), the truck work efficiency was estimated to be less than 40% of work truck-days (there are 26 work truck days in a month excluding Sundays) capacity indicating larger proportion of working days are lost due to maintenance problems, negligence of drivers, frequent accidents during traffic concentration. All the trucks carry only a single container of maximum capacity of 8 m^3 or 2160 kg at the time of disposal. Most of the trucks

have no cover for waste containers so that they are dropping wastes in the city in their way to the disposal site as shown in **Figure 7** (Regassa *et al.*, 2011).

Table 1: Current solid waste collection trucks in Addis Ababa

Sub –cities in Addis Ababa	Container lifter	Side loader	Hino compactor	Renault compactor	Total
Arada	3	2	2	1	8
Addis Ketema	6	3	1	1	11
Lideta	2	2	1	1	6
Yeka	3	2	1	1	7
Kirkos	2	3	1	1	7
Bole	7	1	1	1	10
AkakiKality	3	1	1	0	5
Nefas-Silk Lafto	5	1	0	1	7
Kolfe	3	2	1	2	8
Gulele	6	2	1	0	10
Total	40	19	10	10	79

Source: (Mohammed & Elias, 2017)

Each sub-city is responsible for transporting to the final dump site "Rapi" (final dumping site) by means of trucks from garbage containers. The highest level in the transportation system is represented by municipality. The role of private sector on transportation of solid waste is highly limited (Desta *et al.*, 2014).

Figure 7: partial view of solid waste transportation trucks.

Source: (Birke, 1999; Daniel Fikreyesus *et al.*, 2011)

2.1.4 Waste Disposal

Disposal is the ultimate stage in solid wastes management system for those wastes that have no further use to society(Tchobanoglous *et al.*, 1977). Waste disposal is one of the most important management practices, needs to be carefully planned. Most low-income countries make use of open dumping as their form of land disposal(Guerrero *et al.*, 2013). Similarly in Addis Ababa city all solid wastes collected by the municipality is brought to the largest single landfill at Repior "Koshe" open landfill which is south West part of the city, and has been in operation since 1950s receiving over 750 tonnes of waste per day. It has a surface area of 25 hectares. The present method of disposal is crude open dumping (Regassa *et al.*, 2011; UN, 2010), hauling the wastes by truck, spreading and leveling by bulldozer and compacting by compactor or bulldozer (Ababa, 2010).A fee has to be paid to be allowed to dump waste at the site. This means that even if an agency or enterprise would collect the waste in a particular neighborhood and transport it to Repi landfill it will still be expected to make a payment, even though it has done the work of the municipality (Cheru, 2016).

If the waste is known to be hazardous, the Region 14 Health Bureau takes a number of precautions before dumping it at the landfill, including using a specific truck for carrying this type of waste and having it protected by police force, burying and digging waste known to be hazardous, and informing scavengers at Repi of the dangerous nature of the waste. Whatever precautions are taken, they will never completely prevent the scavengers to scratch through the waste in search of something they can eat or sell (Amiga, 2002; Teka, 1997). The Koshe dump is located adjacent to the community of Koshe, home to some 80,000 of the city's poorest people following the horizontal expansion of the city and greatly affecting the residents and institutions (see **Figure 8A**). Many in this community reportedly use the dump as a food source (Cox, 2010).

The disposal site of Addis Ababa city is associated with the following problems (Ababa, 2010; Desta *et al.*, 2014; Kuma, 2004; Regassa *et al.*, 2011; Teka, 1997):

- It is an open field disposal (Not sanitary landfill);
- No daily cover with soil;
- Nuisance and health hazard for people living nearby;
- No leachate containment or treatment protection at the bottom by a geomembrane nor other infrastructures needed;
- No rainwater drain off and migration occurs through run-off of precipitation;
- No odor or vector control; No treatment facilities;
- No fencing, the area is unprotected area for children, women and scavengers

- No large scale composting facility available as a disposal option;
- Blows litters and spreading wastes outside the site and on the surrounding;
- organic waste that goes to landfill sites not only pollutes the land and water but also contributes to global warming by producing methane (CH4);
- The site is getting full; because this At least 48 people have been killed by a landslide at a massive garbage dump on the outskirts of Ethiopia's capital, Addis Ababa, March 13,2017 (see **Figure 8B**)[2].
- Surrounded by housing areas and institutions (see **Figure 8C**);
- More than 200 - 300 waste pickers per day work continuously and obviously living nearby the site and interfering the operation of the work for collection of salvageable materials such as wood, scrap metals and discarded food **(see Figure 8D);**
- There is no any machinery (compactor or graders) that regularly works at the disposal site. In addition to these uncontrolled burning of solid waste creates smoke and other types of air pollution (there is continuous burning of the dumped waste due to internal ignition by the waste itself) (see **Figure 8E**);
- All of waste collected from the city is dumped in this single place without separation of even organic waste;
- The dump site is nearby, adjacent to the Akaki River (nearest fresh water source for landfill);
- Nuisance and health risk for persons proximate and it has poor landfill site management straight without any protection for man and animals.

[2]**Figure 8A** - Rescue workers watch as excavators dig into a pile of garbage in search of missing people following a landslide when a mound of trash collapsed on an informal settlement at the Koshe garbage dump in Ethiopia's capital Addis Ababa, March 13, 2017.

Figure 8: Addis Ababa solid waste disposal site (Koshe landfill). Source:(Daniel Fikreyesus *et al.*, 2011; Mohammed & Elias, 2017; Wondafrash, 2017)

In fact this site is now becoming in the center of the city following the horizontal expansion of the city and greatly affecting the residents and institutions (see **Figure 8**C). Yet, the city still utilizes this site as the only open disposal location(Alemayehu, 2001). As a result, the aesthetic quality of the city and the health condition of the inhabitants are under grave threat. The health hazard in turn created a financial burden to the city costing over one billion Ethiopian Birr which is more than 40 million USD every year(Debere *et al.*, 2013). Consequently, waste management is a major priority to the City Administration of Addis Ababa and is keen to solve this long-lasting problem in the city (Amiga, 2002).Due to the indiscriminate disposal of waste in the area, the organic waste that goes to this dumpsite not only pollutes the land and water but also contributes to global warming by producing greenhouse gases like methane if it is remain left untreated. The dumpsite being located on the intermittent stream, the catapult of polluted water flowing from waste disposal area can obviously inject hazards to livestock and people living in the lower basin of the stream (Alemayehu, 2001; Kuma, 2004; Regassa *et al.*, 2011).

Therefore, the existing condition is now pushing the city government of Addis Ababa authority thinking of upgrading the existing site to control the negative impacts of the existing situation

and may propose an environmentally safe sanitary landfill in accordance with local conditions and technological and financial capabilities.

2.2 Solid waste generation and composition

2.2.1 Solid waste generation

There is 5% rise urban waste generation per year. So, collection of municipal solid waste is key part in supporting public health(Desta *et al.*, 2014).In line with this, solid waste management is becoming a major public health and environmental concern in urban areas of Ethiopia though only 2% of the population received solid waste collection services(Kassa, ,2010).Currently the daily solid waste generation in the city of Addis Ababa is estimated to be 0.45 kg/capita/day, the density ranges from 205 to 370 kg m-3 and the daily waste generation has reached to 2,750 m^3 (Debere *et al.*, 2013). Therefore, considering the city's population of 3.5 million people(Ethiopia, 2008),it is estimated that approximately one million m^3 of solid waste is generated per year (Kassa, ,2010).

Within urban centers in developing countries, 30% to 60% of the generated solid wastes are left uncollected(Henry *et al.*, 2006; Ngoc & Schnitzer, 2009). This has been proved to be true in Addis Ababa as only 70% of generated wastes (which is 792 tonnes/day from a total of 1132 tonnes/day generated) are collected and transported and dumped at the biggest landfill in the country and the rest 30% is not being collected and burned, buried or disposed informally in a manner of polluting the environment because of dumped in non-allowable spaces, like exposed areas, channels, drains, roads, streets sides, rivers, sanitary drainage channels and other exposed areas, and becoming a growing concerns in Addis Ababa city(Fikreyesus, 2011; UNEP, 2010). About 86% of the total waste generated is degradable (easily decomposable). This implies stile small proportions of the urban dwellers are served and large quantity of solid waste left uncollected. From this, we can conclude that the problem of solid waste management cannot be solved only by mere effort of municipal government(Amiga, 2002).

Based on income group classification, solid waste generation rates analyzed show that a mean waste generation rate of 2.1, 1.2, 0.79 and 0.6 Kg/ capita/day for high, upper middle, lower middle and lower income groups respectively, the mean solid waste generation of lower, lower middle, upper middle and high income groups in lower boundary were 0.09, 0.16, 0.11 and 0.7Kg/capita/day respectively and the mean solid waste generation of lower, lower middle, upper middle and high income groups in upper boundary were 4.3, 5.3, 5.5 and 14Kg/capita/day respectively(see **Table 4**).

Table 2: Solid waste generation in Kg/capita/day by income level

Income level	Waste generation per capita (Kg/capita/day)		
	Lower boundary	Upper boundary	Average
High	0.70	14	2.1
Upper middle	0.11	5.5	1.2
Lower middle	0.16	5.3	0.79
Lower	0.09	4.3	0.60

Source: (Tilaye & Van Dijk, 2014)

With regard to waste generation rate, even though the solid waste trend is expected to increase in general, recent and up to date data were not available. Based on different studies conducted so far, the amount of the solid waste generation rate in Addis Ababa city per day, month and year has been estimated based on the 1993/94 population census of Addis Ababa (see **Table 5**).

Table 3: The solid waste generation rate in Addis Ababa city per day, month and year

City	Population 1993/94	Population2017 projection by 3.97% growth rate	Solid waste generation Kg/capita/day	Solid waste generation Kg/day	Solid waste generation rate Kg per month	Total solid waste generation kg/year
Addis Ababa	2,255,000	3,595,000	0.456	851,540	$2.56x10^{7}$	$3.07x10^{8}$

Source: (Regassa *et al.*, 2011)

However, special attention has not yet been paid in the city's development plan to address the street cleaning services. However, streets requiring cleaning in the city have been increasing specially since 2003 and yet, the rates of streets cleaned each day were only 41% in 2007 (see **Figure 9**)(Basha, 2007). In addition to collection of solid waste from transfer stations, street sweeping is also included in municipal solid waste management service offered by Sanitation and Beautification of Addis Ababa city(Debere *et al.*, 2013). Street sweeping takes place every day since it needs to be done more frequently because of there is only some street dustbins and regular generation of solid wastes like napkins, pieces of paper, residual vegetables and fruits such as banana, orange etc. Although there is an increase in the coverage of street cleaning to alleviate the street sanitation problems, the service delivery has not proportionally been stretched hand in hand with the construction of new roads that require regular cleaning in the city (Desta *et al.*, 2014; Tilaye & Van Dijk, 2014).

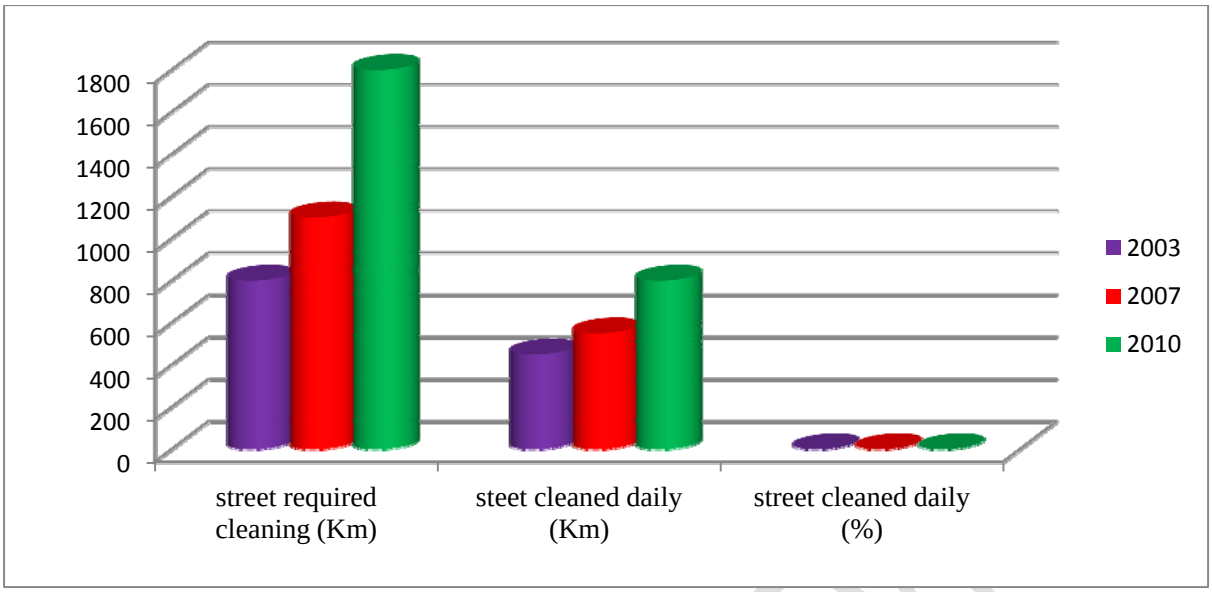

Figure 9: Length of streets being cleaned each day in different years. Source: own review (2018)

2.2.2 Sources of waste generated

The sources of municipal solid waste generated in Addis Ababa city are households, street, commercial institutes, industries, hotels and hospitals. From total generated solid waste households' account for 70% (803.72 tonnes/day), street 10% (113.2 tonnes/day) of the waste produced in Addis Ababa is collected from various corners of the city roads by street sweepers permanently employed by the city municipality, commercial institutions, 9% (101.88 tonnes/day), industries 6% 967.92 tonnes/day), hotels 3% (33.96 tonnes/day), hospitals 1% (11.32 tonnes/day) and other sources account 1% (11.32 tonnes/day) (Cointreau-Levine, 1994) (see **Figure 10**). The first level for separation at source in the waste recovery system in Addis Ababa is the household. Out of the total MSW generated 70% by weight and 50 by volume are organic wastes. Recyclable materials (metal, glass, plastics, paper, wood, rubber, etc.) are estimated to be 15% of the weight as well as volume of the municipal solid waste(Agunwamba, 1998).

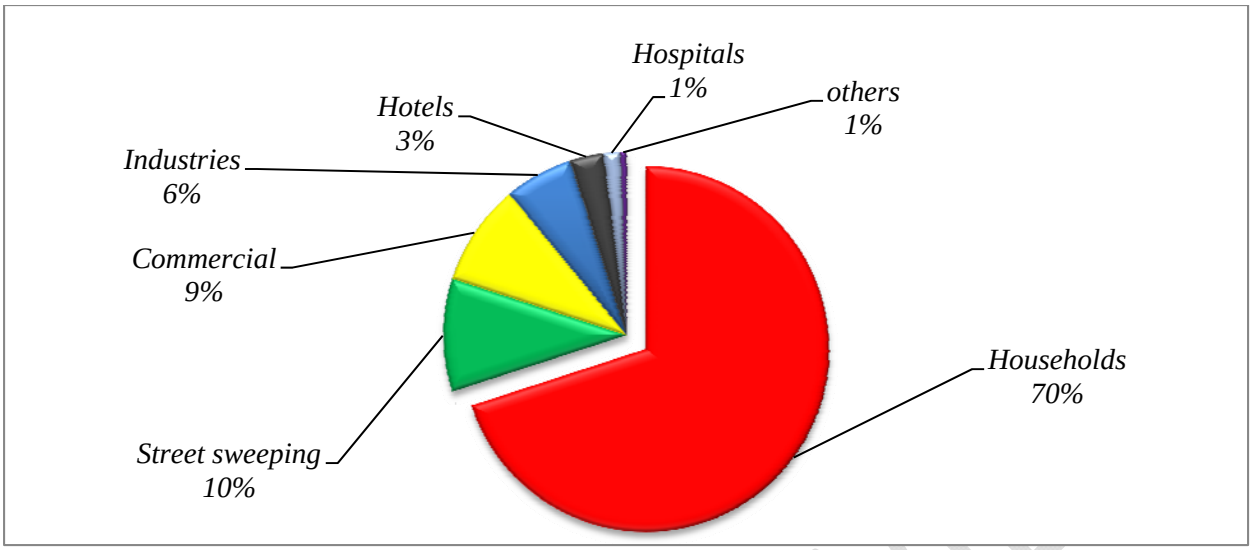

Figure 10: Major sources of solid waste generated and their percentage share

Source: (Desta *et al.*, 2014)

2.2.3 Solid waste physical composition

The physical composition of municipal solid waste in Addis Ababa has been estimated as: vegetables 4.2%, rubber/plastics 2.9%, paper 2.5% (which includes Paper Bags, Newspaper, Office paper, Magazines and catalogues, Phone Books and directories, Other Miscellaneous paper not mentioned), bone 1.1%, wood 2.3%, textiles 2.4%, metals 0.9%, glass0.5%, non-combustible 2.5%, combustible leaves 15.7%, and all fines 65% (see **figure 11**).

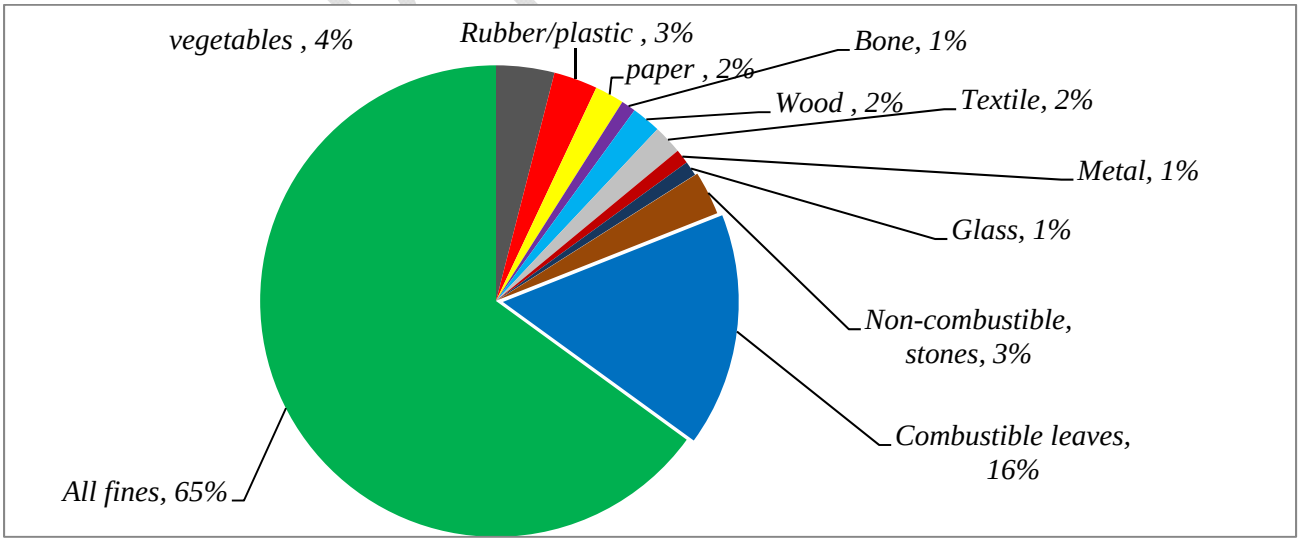

Figure 11: MSW composition streams of Addis Ababa city by percentage. Source:(D Fikreyesus *et al.*, 2011)

The waste composition of Addis Ababa is changing over time. For example, the share of organic waste is decreasing and the share of plastic waste is increasing. See the above waste composition of for comparison, although the time gap is not significant.

Table 4: waste composition of Addis Ababa over different years

Major constituents	Weighted percent composition by weight and year of information					
	1982	1994	1995	2010	2014	2015
Vegetables	8.7	4.185	2.99	4	4.2	4.5
Paper	2.2	2.47	3.37	2	2.9	2.5
Rubber	0.5	1.0	0.28	2	2.4	2.23
Wood	N.A	2.33	2.29	2	2.2	2
Bone	N.A	1.06	1.62	1	1.1	2.5
Plastics	0.7	1.93	1.98	3	2.9	3.5
Ferrous metals	1.5	2.37	1.44	1	0.9	0.35
Glass	0.5	0.445	0.82	1	0.5	0.42
Combustible	25.2	15.13	22.63	16	15.5	21
Non –combustible	6.3	2.53	2.96	3	2.5	2.5
All fines	53.6	65.58	59.44	65	65	58

Source: based on own review (2018)

Table 6 presents an overview of the composition of total municipal solid waste in Addis Ababa and depicts the origins of the waste material fractions. The large share of ash and soil component in residential waste (47%) is explained by the predominant use of firewood and charcoal in households. The ash residues are usually disposed on the ground, later put in the waste collection bag from where it is collected by solid waste collectors. The seasonal variation is expected to be minimal due to steady consumption behavior throughout the year (Cheru, 2016).

2.3 Problems of municipal solid waste

Waste is an unavoidable consequence of the consumption and production activities of a society(Papargyropoulou *et al.*, 2014).Most of the disease-causing agents that contaminate water and food come from human and animal wastes. Without proper management, they result incommunicable diseases (Rushbrook & Finnecy, 1988; Suryawanshi *et al.*, 2013). More than half of the population of less developed countries does not have access to sanitation and more than 80% of the wastewater generated is directly discharged into surface water bodies (Suryawanshi *et al.*, 2013).

Solid waste management problems in Addis Ababa are results of many contributing factors. These include unplanned construction of houses, uncontrolled location of industries and factories, migration of people almost from all corners of the country, and most importantly, of course, is the inability of the government to find efficient ways to manage and finance environment needs of the people(Kuma, 2004).More than 200-300 waste pickers per day work continuously and obviously living nearby the site for collection of salvageable materials such as wood, scrap metals and discarded food. The adverse effect of inadequate waste management service on productivity and economic development of the city is very significant(Amiga, 2002). Inadequate collection, transport or improper disposal of household waste can have adverse health impacts. Potential health hazards from accumulation of polluted water, which provide breeding grounds for mosquitoes and attract flies, vermin(Mazhindu *et al.*, 2012).

According to (Bella Sr, 2000), risks associated with inadequate solid waste management are human health, environmental and aesthetic risks. Human health risks involve disease caused by pathogenic organisms; disease caused by insects, rodent vectors, and water and air pollution related diseases. Man's first line of defense against disease is environmental health, i.e., proper management of solid waste, the provision of safe water and proper disposal of human excreta. All these will block and prevent disease causing organisms from entering the human body. But many preventable diseases and deaths are occurring in the developing world. About 90% of the diseases occurring in developing countries result from sanitary problems(Langergraber & Muellegger, 2005).The health risk from inadequate solid waste management has been felt for long in Addis Ababa. **Table 7** shows the top ten diseases that are caused through indiscriminate solid waste management in Addis Ababa. The real picture can be much worse since many cases in the city are not reported to any formal institution due to the existence of health service giving institutions in the city which do not report to the city government and the wide spread practice of self-treatment and traditional healers in the city. The overall picture calls for a major and urgent change in solid waste management in Addis Ababa.

Table 5: Morbidity report due to indiscriminate solid waste collection and disposal from2010- 2012

No.	Solid waste related Disease	2010	2011	2012

1.	Parasitic infection	57,887	36,827	36,845
2.	Bronchitis	38,100	28,849	28,780
3.	Skin disease	34,426	27,119	27,047
4.	Bronco pneumonia	30,219	25,744	25,158
5.	Dysentery	20,782	13,596	14,631
6.	Bronchial asthma and allergic conditions	11,607	7,677	6,291
7.	All other respiratory disease	7,932	3,845	7,532
8.	Typhoid	6,596	3,622	4,046
9.	Influenza	3,593	1,905	1,858
10.	Trachoma	1,619	1,015	1,346

Source: (ABABA, 2007)

2.4 Measures to Combat Waste Management Problems

2.4.1 Landfill Sites Selection

Addis Ababa has no sanitary landfill sites. With this context, the development plan of the city has proposed the establishment of four landfill sites in the eastern, northeastern, west and southwest part of the city. Though none of them has so far been established, the proposed plan to construct these landfill sites did not even properly take into account their subsequent impacts on the local environment and the inhabitants. It was simply planned to establish the sites without knowledge base and impact forecast viewpoint. That was why the city had latter recognized the problems and decided to cease this plan before implementation and set another new plan to construct the landfill site. Finding suitable sites for landfills is one of the most difficult tasks in solid waste management as the sanitary landfill site selection must address social, environmental and technical concerns. Therefore, GIS based assessment should be employed for different criteria including geology, soil, slope, land use, and stream network (Javaheri *et al.*, 2006). Similarly in Addis Ababa City, there are problems of solid waste disposal sites selection. There are no standard transfer stations in the city. Institutions and industries follow their way of removal of waste and the available dumping sites are not well planned. Applying and integrating GIS and remote sensing techniques to select the best possible solid wastes dumping is one way of solving the problem (Kabite *et al.*, 2012). By this analysis, the most suitable sites were located in southern and south east of the city and are bare and grass lands (Figure 12).

Regarding to the suitability analysis of solid waste dumping site in Addis Ababa City to Rivers, the farther lands from lake and river banks got more preferences for solid waste dumping site suitability. In Addis Ababa city, there is a river at the northern side, River Akaki. Hence, to maintain the environmental health of this water sources at least 2000 m buffered distance should be ringed through straight line

calculation. Accordingly, considering only the lake, the green shaded area was the most suitable for solid waste dumping site (**see Figure 12**).

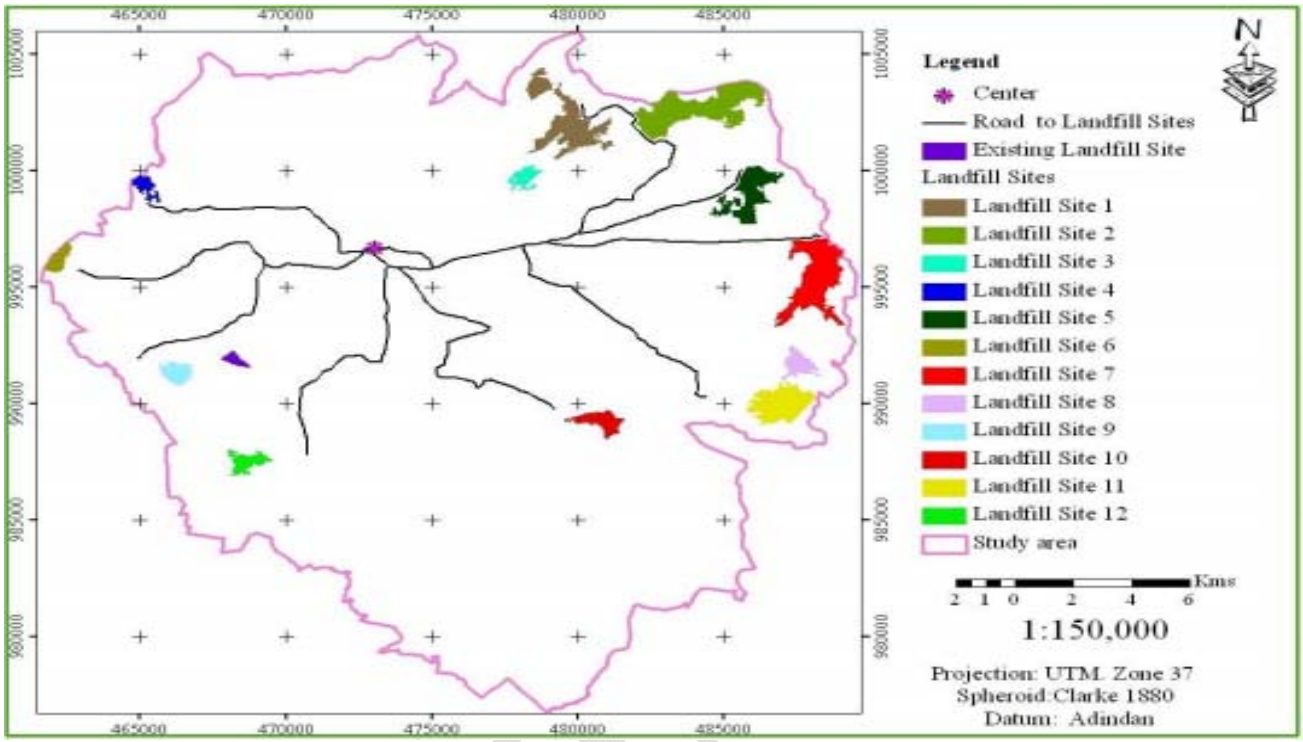

Figure 12: Final sustainability solid waste dumping landfill site selection by using GIS

Source: (Kabite *et al.*, 2012)

3 Conclusion and Recommendation

This review study has attempted to analyze the status and spatial coverage of waste management service of Addis Ababa city in general. In particular, the study explored residents' solid waste physical composition and generation rate, resident's solid waste management practice, and institutional structure and capacity of sanitation, actions or practices on waste management by policy makers, municipality, peoples, private sector, and like organizations of the city. The review shows that even though various studies and programs are undertaken to curtail the problem of solid waste, the service still falls short of the required level. In rapidly growing cities in developing countries, solid waste is a major source of concern due to lack of appropriate planning, inadequate governance, resource constraint, and ineffective solid waste management. The generation of solid waste has become an increasing environmental and public health problem everywhere in Ethiopia, particularly in Addis Ababa city. Solid waste management is mainly provided by the municipality in the city. Traditionally, SWM has been measured and evaluated based on the performance of the service supplier, while the need of the residents has been ignored. Resident households, who are the primary producers and generators of uncollected solid waste and

perhaps the main victims of its deleterious effects, should be allowed to determine their SWM providers and participate in deciding effective solutions for SWM. Very poor solid waste management practices of the city residents due to the first weakness of households is poor handling of temporary storage material of their house, that is, they drop out solid waste around it and they also exposed it to rain and light, did not well covered, and placed near to residence. Second, the greater part of the city residents did not separately store solid wastes other than salable and exchangeable with Liwach and Quraleos. They did not also carry out sustainable solid management activities such as recycling, reusing and composting. Apart from this, they regularly apply temporarily illegal solid waste disposal at about the city main streets. Moreover, they have also low emphasis to clean their surrounding area and nearby road.

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