

Review Paper

Rethinking of the Solid Waste Management System of Addis Ababa, Ethiopia



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Citation Diriba DB, Meng X-Z. Rethinking of the Solid Waste Management System of Addis Ababa, Ethiopia. Journal of Advances in Environmental Health Research. 2021; 9(1):7-22. <http://dx.doi.org/10.32598/JAEHR.9.1.1198>

doi: <http://dx.doi.org/10.32598/JAEHR.9.1.1198>



Article info:

Received: 09 Nov 2020

Accepted: 15 Mar 2021

Publish: 01 Jan 2021

Keywords:

Incineration, Landfill, Organic waste, Waste management, Addis Ababa

ABSTRACT

Municipal solid waste management is an important component of urban services that is often handled by local governments. Addis Ababa, the capital city of Ethiopia faces rapid urbanization leading to overcrowding and the development of shantytowns and poor neighborhoods. The general aim of this study was to appraise the present dry waste service provision of Addis Ababa. This study used an integrative literature review method with critical analysis to investigate the current solid waste management status in Addis Ababa. The results of this study show that the delivery of the service does not keep pace with the city's solid waste generation and the city's municipal disposal of solid waste is found in actual, low status and spatial coverage. This humble status of city garbage management is also heightened by three critical factors, i.e. poor institutional structure, inadequate disposal site and transfer station, and poor households' solid waste handling practices. Besides, the city households dominantly created decomposable solid wastes (60%) through generation amount of 0.45 kg/person/day and the main source are residential wastes, which account for 76% of the total waste. The study concluded that, the main problem with the incompetence of this sector in the city was the lack of trained labor and inadequate service delivery. In order to improve the status, there should be awareness creation, improvement of the city government, and implementation of an incorporated method to the management of metropolitan solid waste that respects and involves all stakeholders in the metropolis.

1. Introduction

S

olid waste is something that is not liquid or gas and discharged as unwanted, and its processing, transport, storage, recycling, or disposal in a dumping site is no longer op-

erational [1, 2]. Waste management is a current and complex issue. More or less, all social actions generate waste. Since the industrial revolution in the mid-18th century, the amount of waste produced increased hugely worldwide. Not only has it increased in volume but also in the type and toxicity [3, 4]. Waste management is a problem for

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most countries around the world. Leftover handling in a given nation is associated with the country's economic, political and social status. The difficulty of management is harder for middle and lower-income countries [5].

Solid Waste Management (SWM) is a cross-cutting topic that affects numerous aspects of development in three sustainability areas: the environment, the economy, and society. Living situation, sanitation, public health, aquatic and terrestrial habitats, access to profitable jobs, and natural resources' ecological use are among the areas affected. A total of 17 Sustainable Development Goals (SDGs) of the 2030 sustainable development agenda were adopted by the 193 United Nations (UN) member states in September 2015. At least 12 SDGs are related explicitly to SWM and their relevant objectives [6]. Overlooking a high-level sustainable development target in its own right could theoretically threaten to reduce the visibility of SWM as a political priority. However, the recent Global Waste Management Outlook (GWMO) [7] of the UNEP created the opposite argument of cross-cutting essence of SWM and its effect on not only one but 12 sustainable waste management outlook. Five of these SDGs are presented in Table 1 with their related targets and their ties to SWM.

In developing countries, people usually begin their urban lives under tough conditions in slums or similar informal settlements without basic infrastructure and services. They leave their villages for job opportunities and generally "a better life" for themselves and their families in the cities. Their specific needs are addressed by target 11.1: "By 2030, ensure access for all, some suitable, safe and affordable housing and basic services and upgrade slums". One of these basic facilities is the collection of solid waste, which is part of cleanliness. This activity will considerably change the survival of billions of people worldwide, probably those who most need growth. Usually, the uncollected garbage is discarded in watercourses or barren land or burned near dwellings in the open air. These activities pose health threats to the occupants, with children being particularly affected. Dumped waste also blocks drains, exacerbates flooding, and its consequent damages to public health and infrastructure [8]. The waste may end up discarded in low-lying areas or somewhere outside the city, including the locations where waste is collected. This means that open dumping will affect local water sources and adversely affect the environment. More than 3 billion people lack access to well-ordered disposal of their waste [6]. As a result, resolving this global waste crisis, ensuring access to appropriate, secure, and proper garbage collection facilities for all, and eliminating unregulated discarding and open burning, as

described in the United Nations SDGs, will establish the main contribution to sustainable development.

Solid waste management is an emerging challenge to many fast urbanizing regions in Africa [9, 10]. The pace of urban dry waste development is currently expected to be faster than urbanization. In the coming decades, even urban centers will carry a significant burden of health problems due to inadequate waste management [3, 11].

Addis Ababa faces many difficulties in the handling of solid waste. The city's generated solid waste, which amounts to 30%, is not collected. Enlarged expansion and population growth in Addis Ababa, combined with a deficiency of resources to deliver basic facilities and urban services, have led to a series of problems such as the increased production of waste and inadequate collection, transportation, and dumping of solid waste. This condition has become the main threat to the urban environment and the health of the citizens in Addis Ababa [12]. Despite this increased pace of dry waste production, its collection rates in unindustrialized countries are less than 70%.

Similarly, in Addis Ababa, the efficiency of the city's collection of garbage and dumping system has remained low. More than 50% of the collected waste is regularly disposed of by unregulated landfilling, while 15% is managed by insecure and informal recycling [13]. The pollution of rivers and underground water, soil, and air because of the garbage produced from several sources has increasingly become a concern for the city's administration. The condition is aggravated in shanty towns where families cannot make use of refuse collection containers.

An insufficient city solid waste managing system may have significant adverse environmental impacts, such as transmittable diseases, contamination of land and water, sanitation barriers, and harm to biodiversity. Its environmental damages include pollution of groundwater and shallow water by leachate and air pollution from the burning of waste that is not appropriately collected and disposed of. There are gaps between what is needed and what is on the ground. The researcher has realized that the gap has not been well studied. Therefore, this analysis is intended to assess the present solid waste service provision of Addis Ababa and recommend an appropriate solution.

2. Materials and Methods

The study area overview

Addis Ababa is situated between 8°55' and 9°05' N Latitude and 38°40' and 38°50' E Longitude. Located

in Ethiopia's center, the city was built in an area of 540 km², of which 18.174 km² are rural, and its altitude varies between 2000 and 2800 m above sea level (Figure 1).

Addis Ababa is a seat for both Oromia National, Regional State Government, and the Federal Democratic Republic of Ethiopia (FDRE). Oromia National, Regional State in all directions, borders it. There are ten sub-cities and about 119 woredas (districts). The temperature is mild afro-alpine and warm temperate weather with an annual average temperature between 10°C to 24°C. The average annual rainfall is 1200 mm. It is centered on modern economic, political, and social activities. Also, the infrastructure services are relatively in a better situation than other cities of Ethiopia.

Research approach

This analysis used an integrative study of the literature method to investigate solid waste management measures in Addis Ababa. An integrative study of the literature summarizes past research, draws overall conclusions on the topic in question, highlights unsolved problems and areas, and then provides directions for further research [14]. The rationale for choosing to perform an integra-

tive literature review in this study stems from the shortage of research on this topic. Before modeling and policymaking, it is essential to have a detailed and reliable picture of the historical and the current state of dry waste managing practice in Addis Ababa. Further, integrative literature reviews past endeavors, summarizes major issues and provide a relevant way to disseminate insights generated through individual studies. Besides, the literature review approach aligns with and can meet the purpose and objectives of the present study. Publications identified in environmental and social science were critically analyzed before the inclusion in the study.

Data analysis method for the rethinking of the solid Waste management system of Addis Ababa

This study has been used a combination of approaches for qualitative and quantitative data collection. All the data collected from the sources have been analyzed using simple descriptive statistics and then both quantitative and qualitative techniques. Quantitative methods include percentages, graphical maps, and tabular forms. Qualitative techniques also were applied to the data collected from different kinds of literature. Besides, direct physical observation has been analyzed by describing

Table 1. Relationship between Sustainable Development Goals (SDGs) and Solid Waste Management (SWM) [6, 7]

Sustainable Development Goals		Solid Waste Management
Sustainable Development Goal (SDG)	Specific Target	SWM related 'Virtual SDG's
SDG 3: Good health and well-being	3.2. End avoidable deaths of children under five years. 3.3. End malaria and combat waterborne diseases. 3.9. Reduce illnesses from dangerous chemicals and air, soil, and water pollution and contamination.	Goal 1. Ensure access for all, sufficient, secure, and accessible collection services for solid waste. Uncollected waste is sometimes discarded or combusted in the exposed air in wetlands, causing direct emissions and contamination. Waste also blocks the drain, which exacerbates overflows, keeping stagnant water, and contributes to waterborne diseases and malaria. Children are among the most vulnerable, so they are affected the most.
SDG 6: Clean water and sanitation	6.3. Improve water quality by reducing pollution, eliminating dumping, and minimizing the release of hazardous materials.	Goal 3. Environmentally friendly management of all waste, mainly dangerous waste (chemical or biological hazardous waste), is achieved.
SDG 7: Affordable and clean energy	7.2. Increase the part of renewable energy in the global energy mix.	Goal 3. SWM technologies can derive renewable energy from waste.
SDG 8: Decent work and economic growth	8.1. Promoting equitable and sustainable growth of the economy, jobs, and fair work for everyone.	Goal-1 and Goal-4: Reuse and recycling have significant potential for the creation of jobs. In developing countries, individuals, small, and micro-enterprises often provide SWM services. Any measures applied to support them will improve livelihoods and directly contribute to SDG's 1 and 8.
SDG 12: Consumption and production responsibly	12.4. To mitigate their adverse effects on human well-being and the atmosphere, the environmentally sustainable control of chemicals and all waste	Goal-2. Eliminate uncontrolled discarding and open burning as the first stepping-stone to achieving environmentally friendly SWM practices. Goal-3. Achieving sound environmental management of all waste, specifically hazardous waste (either chemical or biological hazardous wastes).

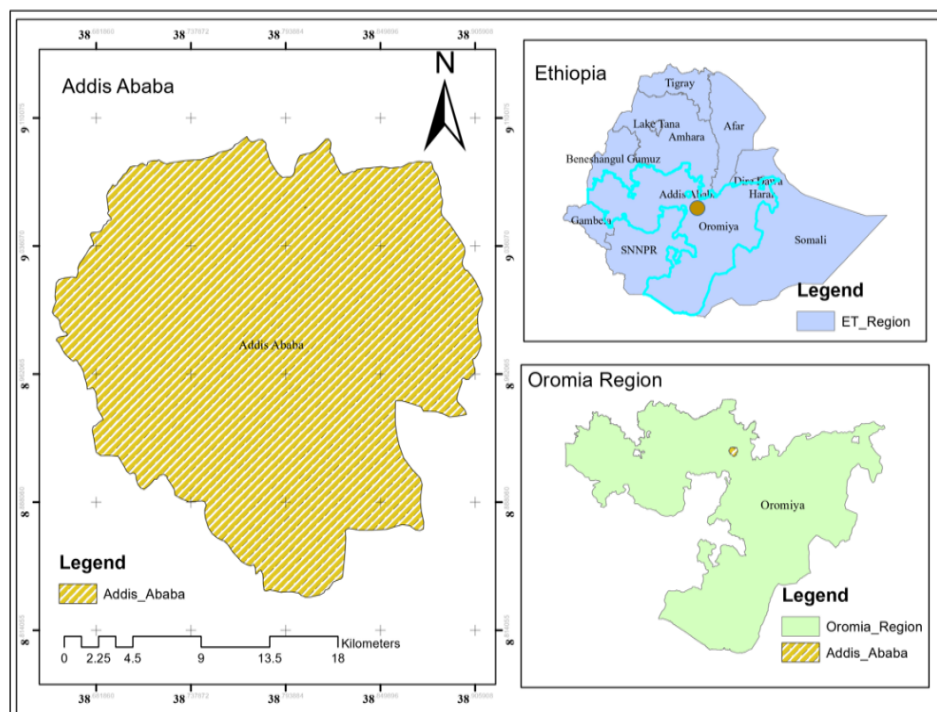


Figure 1. Location of Addis Ababa in Ethiopia

Source: Developed using ArcGIS.

the phenomena using personal judgment and supported by photographs. The study provides a critical investigation of the data collected to justify the approaches that have been employed to arrive at new, valid and reliable knowledge.

3. Results and Discussion

The rate of solid waste production

The recent rise in the production of various kinds of waste in different quantities and qualities is due to industrialization [15]. Technological development and fast population growth have caused increased consumption and household waste production level [16]. This condition, in turn, may lead to crises such as water and soil

pollution, greenhouse gas emission. These activities have negative impacts on the quality of human life [17].

Garbage handling has become one of the major tasks of the municipality. It is directly linked to the community's well-being and ecological concern and affects all occupants. In Ethiopia, 20% of the urban residents get proper waste collection services [18].

Das and Bhattacharyya [19] in their study stated that solid waste collection ranges from 40% to 70% in developing countries. On the other hand, according to the result of Henry et al. [20] within urban centers in developing countries, 30% to 60% of the generated solid wastes are left uncollected. This is factual in Addis Ababa because only 70% of the waste generated (792 tons/day out

Table 2. Each country's solid waste generation rate [5, 13, 22]

Country (City) Name	The Produced Solid Waste kg/cap/day	GDP Per Capita of the Country (US\$)	The Population of the Country (in Millions)
Ethiopia (Addis Ababa)	0.45 kg/cap/day	1000.10	114963588 (as 2020)
Namibia (Windhoek)	0.43 kg/cap/day	5675.11	2280700 (as 2015)
Nigeria (Lagos)	0.58 kg/cap/day	2233.45	206139589 (as 2020)
Ghana (Accra)	0.51 kg/cap/day	2262.57	31072940 (as 2020)

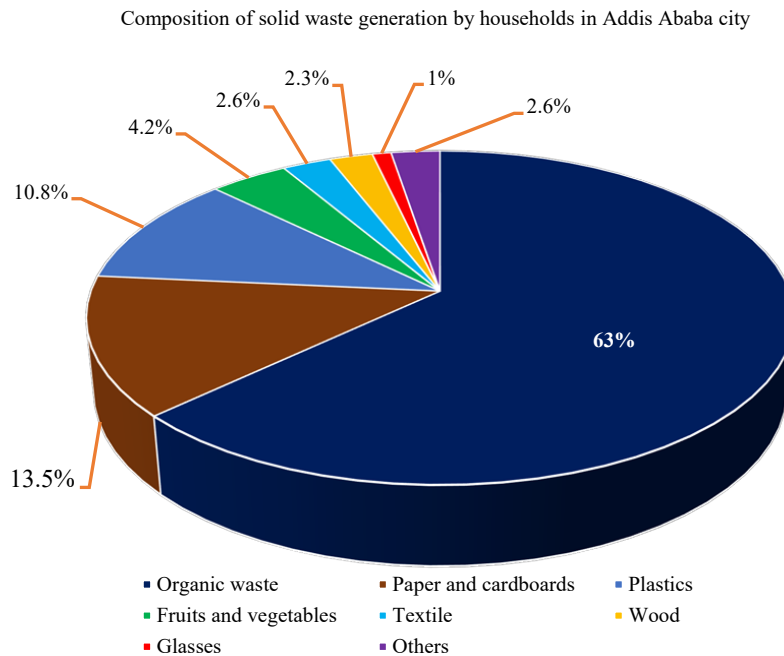


Figure 2. Solid waste composition

of a total of 1132 tons/day generated) is collected and transported, and deposited at the country’s largest landfill. The remaining 30% is left uncollected and burned, buried, or disposed of informally in a way that pollutes the environment. They are dumped in non-alloy spaces, like exposed areas, channels, drains, roads, streets, sides, rivers, sanitary drainage channels, and other unprotected areas, becoming a rising fear in the city. This condition is due to various factors, such as awareness status of the community, lack of the involvement of stakeholders in the service provision, and lack of basic infrastructures.

This finding implies that small portions of metropolitan populations are only served, and a substantial volume of garbage is left uncollected. We can infer that garbage management cannot be addressed only by the sheer effort of the municipal government. In Addis Ababa, each person’s solid waste generation amounts to 0.45 kg/capita/day, and as a total, more than 413180 tons per year are produced. There is a 5% increase in urban waste production per year [13]. As a consequence of this enormous generation of solid waste, city residents should consider urban dry waste managing an essential and vigorous urban service. Inadequate municipal and industrial dry waste collection and dumping creates a variety of environmental problems in Addis Ababa [21]. A large quantity of waste is disposed of in open garbage dumps or drainage systems, threatening the quality of both surface water and groundwater and causing flooding, which provides a disease breeding ground-carrying pests [22, 23]. Exposed air burning of waste and impulsive burning in

landfills cause air pollution. The condition is aggravated in shanty towns where the family unit cannot make use of garbage collection containers [24].

Comparison of four African countries regarding solid waste generation rates

Key assumptions that waste generation increase is primarily based on two factors: GDP growth and population growth. As a country advances economically, its rate of per capita waste generation increases. Economic growth is reflected on GDP per capita, with purchasing power. As a country’s population grows, amounts of total waste produced rise accordingly. However, Namibia (Windhoek) has a better GDP per capita than that of the three other countries, as listed in Table 2. Ethiopia is a low-income country and produces a solid waste of 0.45 kg/cap/day, which is greater than that of Namibia, which is a middle-income country and generates 0.43 kg/cap/day. Likewise, Nigeria and Ghana are middle-income countries, and they generate 0.58 kg/cap/day and 0.51 kg/cap/day, respectively, which is greater than that of Namibia (Windhoek) [5, 24]. However, their GDP per capita is less than that of Namibia. Therefore, there should be another additional factor that affects the waste generation rate per capita of the countries, which would be confirmed by research.

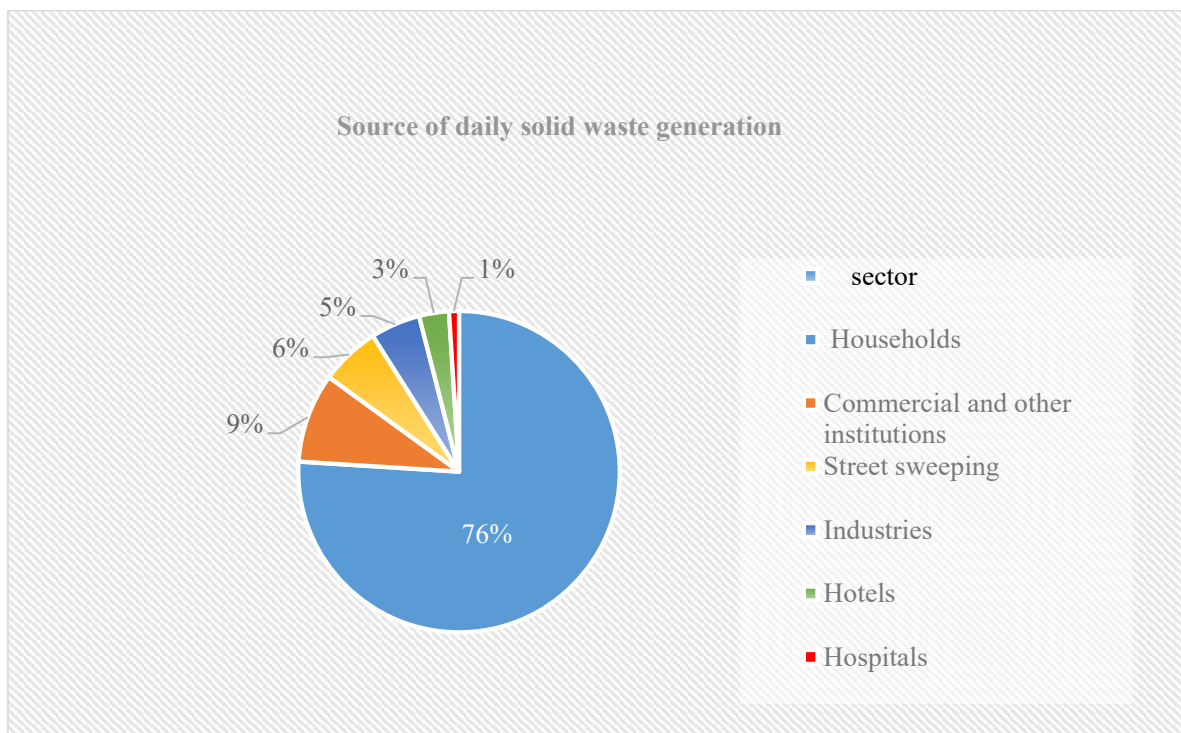


Figure 3. Source of dry waste production per day

The physical composition of solid waste in Addis Ababa

The composition of domestic waste is the primary consideration before applying any method for its treatment, burning, or recycling. In Addis Ababa, the physical composition of solid waste is 60% organic, 15% recyclable, and 25% others [25]. Likewise, according to Abebe the waste constitution of Addis Ababa is 64% organic, 5.3% paper and cardboard, 5.2% plastic, and 25.5% others [21]. Cheru [5] in his study stated that the physical configuration of dry waste produced in the city varies seasonally. However, most of the waste is compostable, 47% ashes, leaves 15.7%, 4.2% vegetables, and the remaining wastes that can be recycled are plastics 2.9%, cardboard and paper 2.5%, metal 0.9%, and glasses 0.5%. Another study conducted by Tassie et al. [26] indicates that about 86% of the total waste generated is degradable (easily decomposable). Different studies have shown different compositions of waste in Addis Ababa. Based on these findings, no matter how varied the results, organic waste has the highest proportion in the composition, followed by paper and cardboard. This trend indicates that most of the waste generated by households may be used to manufacture compost, biogas, and other types of waste that can be recycled. Thus, the city government should give priority to building composting, biogas plants, and recycling centers. The primary constituents of its composition are shown in Figure 2.

Sources of wastes generated

The sources of urban dry waste produced in the city are households, streets, commercial institutes, industries, hotels, and hospitals. Domestic solid wastes are of wide variations generated from household chores such as food preparation and feeding, garden wastes sweeping, burning, and used objects. Domestic solid waste created in housing areas from day-to-day activities called “household” solid wastes [13]. These wastes in lower-income countries like Ethiopia are mainly dominated by nourishment and residue wastes and account for the uppermost volume of urban solid wastes, for example, about 75% in unindustrialized countries [23]. Similarly, from the total generated, the major source of dry waste in the metropolitan is households, which accounts for 76%, as discussed in Figure 3.

Waste collection and transference systems

Collection and transference of solid waste contain the process of gathering waste from the place of generation, taking it to the nearest public solid waste containers or transfer stations, and finally dumping it in a disposal site [27]. This practical component is a very critical and compulsory element of urban dry waste handling because the output and efficiency of this service are greatly determined by it. The main issue facing the city of Addis Ababa is the massive production of urban solid waste



Figure 4. Dry waste gathering and transportation system in Addis Ababa

Source: Field survey (September 2020)

accompanied by unmatched sanitation services. The metropolis had begun its garbage managing about six decades ago; however, now the provision cannot meet the shifting demands. The community waste collection facility is insufficient, and scenes of distributed waste are usual in most of the city [28]. According to the present policy, solid wastes are collected by the administration workers, private companies based on prescribed agreements, and Micro and Small Enterprise (MSE). However, the regulations that the waste creators are subject to put their wastes into different containers based on the exact type of wastes are not observed in the city [29] (Figure 4).

In waste collection, there are two sub-stages: primary and secondary collection systems. Micro and small enterprises with formal agreements to collect from houses and dispose of them in specified containers conduct the primary collection. With a total number of 5815 operators, the number of companies working on solid waste collection is 750. These pre-collectors have a contractual arrangement with the municipality to undertake the procedure and be paid for it. Much of the areas in the

city for motor-driven collection are inaccessible. The human-powered system of collection, therefore, is most often used. Hands and hand-pushed carts can be used to transfer waste to containers (Figure 4b) [26]. Once these tasks are complete, municipal trucks at the Addis Ababa landfill site, called Koshe, dispose of this garbage. They use a door-to-door method to gather and dumped in an alternative container to be picked by secondary collectors, the sub-city, and private firms, and then dumped it at the city's landfill.

The secondary gathering system is a method of transferring solid wastes from the containers to the last discarding site, carry out by the municipality, which signifies the maximum level in the transportation system (Figure 5). Studies revealed that the role of the private sector in this system is limited [30]. The estimate of the United Nations (UN) in 2010 indicated that only 65% of the dry waste produced in the city is collected properly and dumped, while the remaining 35% of the waste being disposed of improperly in open spaces, drainage systems, streets, and rivers.

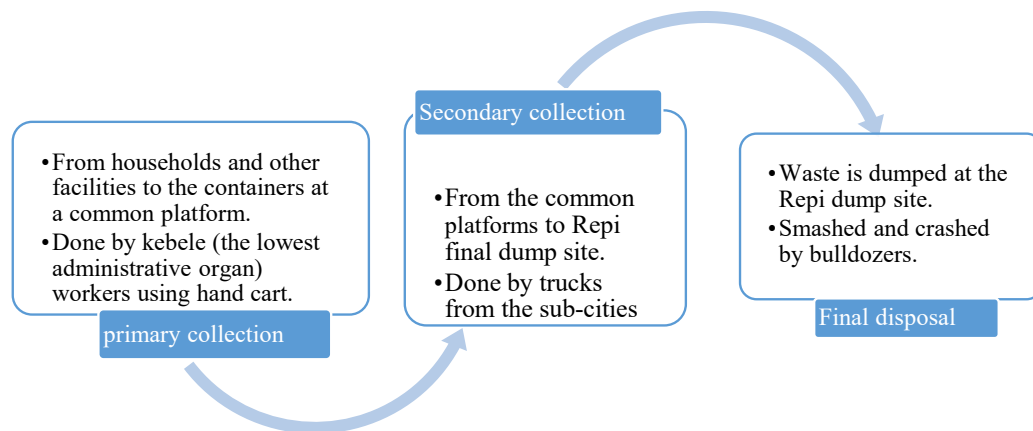


Figure 5. The formal waste management process

The current solid waste management scheme in Addis Ababa is carried on solely by the municipality, which is supposed to provide the full range of garbage gathering and disposal [31]. This is an incredible job, and except for advantaged areas, the services offered are mainly insufficient [32]. This method overlooks the many accomplishments and actors that waste management encompasses to tackle its various problems and to realize socially and ecologically accountable waste management [33]. The best solution seems to be an incorporated approach to garbage managing that is the key to an efficient and sustainable waste controlling system in developing cities like Addis Ababa.

Transportation

Cities in low-income nations also lack adequate transport and infrastructure for waste disposal [9]. According to Regassa, et al. [34], waste collecting vehicles are not enough to the amount requested in Addis Ababa. The department uses about 79 vehicles to collect and transfer the refuse to the final dump site from the point of origin. The output of the vehicle work was intended to be less than 40% of working vehicle days. A larger proportion of working days are lost due to maintenance problems, negligence of drivers, and frequent accidents during traffic concentration. At disposal time, all vehicles hold only one single container with the highest volume of 8 m³ or 2160 kg. Most vehicles have no material removal cover, so they discard garbage in the city on their way to the disposal facility [35]. Each sub-city is accountable for conveying to the final dump site “Repi” using vehicles from garbage containers. The municipality characterizes the uppermost level in the transport scheme. The role of the private sector in the transportation of garbage is minimal [36].

Waste disposal practices in Addis Ababa

Disposal is the final destination of all solid wastes, whether they are domestic, commercial wastes collected and transferred to landfill sites, incinerator, compost, or other materials from the several solid wastes treating plants that are of no more use to society. However, all the produced solid wastes have not been collected and disposed of appropriately. Most poor nations make use of open disposal as their form of land dumping [37]. Similarly, Addis Ababa also has only one open disposal site located 15 km from the metropolitan city center named “Koshe”, which was founded in the 1960s in the then boundaries of the metropolitan with an area of 37 hectares. This site is currently located in the middle of the city because of the horizontal enlargement of the city. It significantly affects the inhabitants and institutions. It has also reached its maximum full level. Yet, the city still uses this site as the only open disposal site. The dumpsite lacks an appropriate gas or leachate collection system. The dumpsite borders are not accurately known, as it does not even have a proper fence. The trash is not covered with soil, nor is there anything on top to cover it [38]. The dumpsite causes substantial environmental harm and is a thoughtful risk to the health and lives of many people living around the city [39].

The disposal system is unsanitary, having a negative influence on the welfare of the nearby people and the environment [40]. All kinds of trashes are disposed of on this site [41]. This shows the essence of incorporating solid waste management resolutions on managing waste to consider the environmentally friendly, economical, and social dimensions [42]. The lesson to be learned from this is that instead of putting all the solid waste together, they can be used separately. For example, with appropriate handling, composting is a sustainable, environmentally friendly, and feasible method for recycling and reducing

organic waste volume in developing countries [43]. Thus, converting organic solid wastes into compost, can be a source of income, and in addition to this, be used as a fertilizer to increase the production and efficiency of the soil.

Concerning hazardous waste, the Addis Ababa health office took some measures before dumping it at the landfill, including using a particular truck to transport and secure this type of waste by the police force, burying and digging hazardous waste, and reminding Repi scavengers of the hazardous nature of the waste. Whatever steps are taken, the scavengers will never entirely stop digging through the waste, searching for something they can eat or sell.

Therefore, the overall scenario is now pressing the metropolitan administration to think about its garbage handling system. They should upgrade the existing dumping site to control the adverse effects of the situation and propose an environmentally-safe sanitary landfill by local conditions and technological and financial capabilities.

Incineration of dry waste

Regardless of waste, municipal waste, industrial waste, electronic waste, biomass, or medical waste, our deal with them represents an intersection between the environmental, economic, and social aspects of our society. Waste is now at the heart of our several environmental problems. Nevertheless, environmentally sustainable practices can dramatically decrease resource utilization, energy usage, and carbon emission while turn wastes into a valued economic and agricultural resource [44]. Waste-to-energy plants are often used to bridge the gap between energy supply and a sustainable climate.

The plants serve the double objectives of dropping the garbage volume sent to landfills and creating useful energy [41]. Waste-to-energy technologies comprise any waste handling process that produces energy in the form of heat or transportation fuels and electricity from a waste source. These technologies can be applied to numerous kinds of waste: liquid, gaseous, and solid waste. The most common use, however, is MSW treatment [45]. The recent most recognized waste to energy technology for municipal solid waste treating is burning in a combined heat and power plant [46].

The city administration, in collaboration with a foreign firm, is building a facility to transform the solid waste dumped at Reppie/Koshe location to produce energy from methane. The Koshe- Reppie incineration plant is going to be built in the area of 7 hectares from a total of

37 hectares of discarding site, and the power has established a 50 MW/day according to the project agreement. Nevertheless, after the project, the net power produced will be 25 MW/day. The significant problem with this incineration plant in the city is the urban garbage discarding method. All the waste from the city is disposed of unsorted (including incombustible and organic wastes) and not available for the incinerator [47] (Figure 4). If solid waste changes to energy with economical and environmentally friendly methods, it has an active role in waste minimization and conversion to steam and electricity. Thus, regarding Addis Ababa, separation at the source should be given priority to maximize the efficiency of the incineration plant.

The factors driving changes in the solid waste management system of Addis Ababa city

Public health problems

Waste is an unavoidable consequence of the consumption and production activities of a society [48]. Many agents from human and animal waste contaminate water and food and cause diseases [33]. Suryawanshi et al. [49] stated that there is no access to sanitation for more than half of the population of low-income nations, and more than 80% of the polluted water generated is discharged directly into water bodies. The situation is similar in Addis Ababa City.

Garbage managing challenges in the city are the result of many contributing factors. These include unplanned construction of houses, uncontrolled location of industries and factories, migration of people from all areas of the country, and most importantly, the government's inability to find efficient ways to manage and finance the ecological needs of the people [50]. More than 200-300 garbage collectors actively work and live near the site to collect recoverable materials such as wood, scrap metals, and leftover food. The negative impact of inadequate waste management facilities on the city's competitiveness and economic growth is very important. Inadequate collection and inappropriate removal of household waste by transporters may have adverse health effects. Potential health risks from the accumulation of contaminated water provide mosquito breeding grounds and attract flies, and vermin [40].

According to Kassie [51], risks associated with inadequate garbage handling are human health, environmental and aesthetic risks. Human health risks involve diseases caused by pathogenic organisms, for example, a sickness triggered by insects, rodent vectors, and water and air

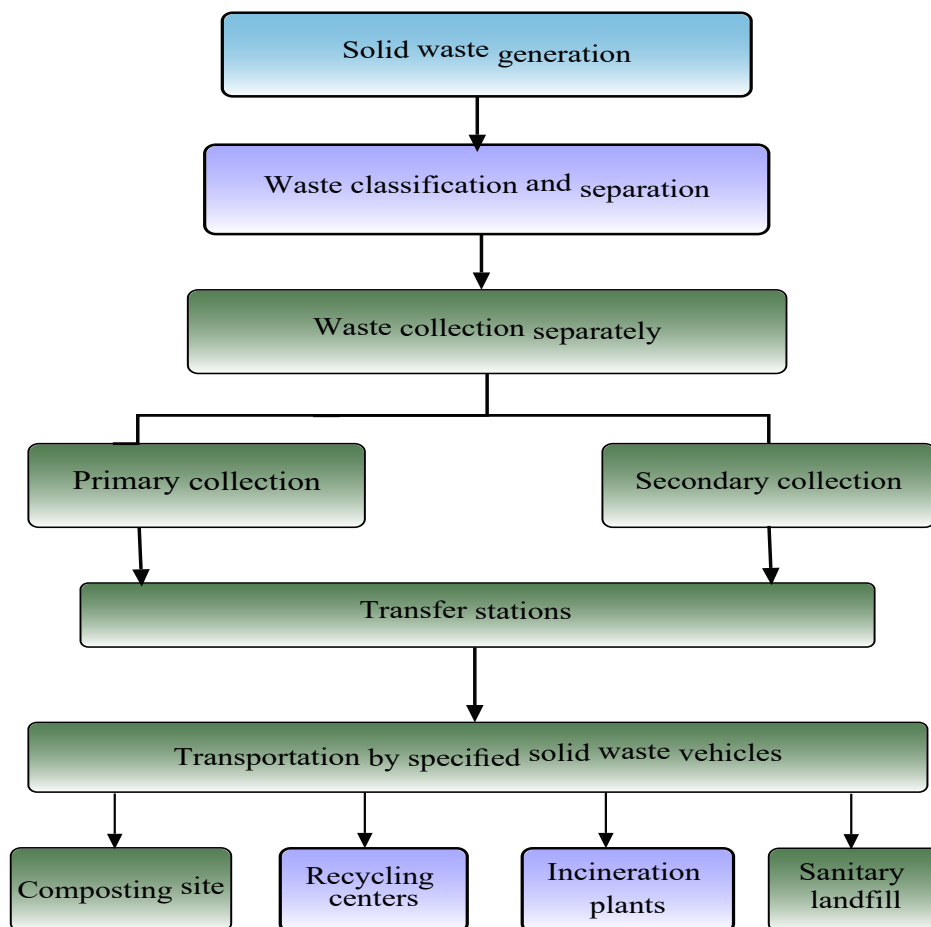


Figure 6. The Proposed Flow of the Solid Waste Organization Scheme in Addis Ababa

pollution-related diseases. Man's first line of protection against the disease is environmental health, i.e., proper administration of dry waste, the delivery of clean water, and proper disposal of human excreta. All these activities will block and prevent disease-causing organisms from entering the human body. However, many preventable diseases and deaths are occurring in the developing world. About 90% of the diseases happening in low-income nations result from sanitary problems [34]. The health risk from inadequate garbage handling has been recognized for a long time in Addis Ababa.

Waste amount and composition

Henry et al. [21] has identified waste amount and composition as another critical driver of the dry waste handling system of Addis Ababa. In urban areas, the dry waste composition is more complex and heterogeneous [52]. In several developing nations, wastes contain an enormous volume of inerts such as sand, ash, dust, stones, and high moistness levels because of the significant usage of vegetables and fresh fruits. Such variables make the waste very thick (increase the wetness of the

garbage). So, means of transportation and systems that function well with low-density wastes in industrialized countries are not reliable or suitable when the wastes are heavy [53]. The combination of the extra weight, the roughness of the sand, and the corrosiveness caused by the water content can quickly impair the equipment. If the waste contains a high quantity of wetness or primarily inert solid, it is not appropriate for burning, and so this treatment option is ruled out. The majority of the garbage composition of Addis Ababa city is organic waste, paper, and plastic. Sometimes, recycling or recovery efforts minimize the proportion of combustible paper and plastic in waste until it enters the stage of treatment. However, there are no sufficient treatment plants for that huge amount of garbage. Likewise, the urban problem is directly or indirectly associated with many issues, such as urban lifestyles, patterns of resource usage, levels of employment and income, and other cultural and socio-economic issues. Given this condition, there is a need to encourage another course of action, such as community initiatives to manage garbage sustainability and be a potential basis of income for the poor [38].

Access to waste for collection

Another main factor in Addis Ababa's sanitation is the infrastructure of the city [32]. Roads or side streets might reach many sources of waste, but they are inaccessible by several means of transport because of their width, slope, overcrowding, or surface, and the inter-space from the transfer station. According to Desta [35], the existing distance of the transfer station or containers from households is 0.5 km to 1 km far away in the city, while the recommended standard is 150 m. This is especially a significant challenge in unintended settlements such as shanty towns or low-income zones and thus mostly affects the selection of equipment. Also, most of the households of Addis Ababa have no standardized waste storage or waste bins. A recent study has shown that 75.4% of the community used a sack, and others used plastic bags [34]. Only 24.6% of the residents were using standardized waste bins. In addition to this, the collection time interval of the garbage by the municipality workers to the final landfill is long, and as a result, the waste is more likely to contaminate during the stay. Therefore, the city government should improve the collection time interval for garbage. It also needs to make a change by thoroughly inspecting the infrastructures that are an obstacle to garbage collection in the city.

Awareness and attitudes

Public awareness and outlooks to waste can influence the whole solid waste handling system [54]. All steps in SWM from domestic waste storing to waste separation, reusing, collection frequency, the quantity of scattering, the readiness to pay for garbage handling facilities, the opposition to the siting of waste handling and dumping facilities, depend on public awareness and participation [55]. Thus, this is also a critical issue that determines the achievement or letdown of a solid waste handling system. Regarding Addis Ababa, the main problem in the garbage handling system is that the knowledge about the importance of the environment and the expertise on how to handle waste is missing. The awareness level of the community is very low in Addis Ababa regarding solid waste management. Only 28.6% of households separate dry wastes at the source. About 71.4% of the population do not separate wastes according to their nature. Thus, the waste cannot be incinerated effectively at the incineration plant [12]. Therefore, the core work of improving the solid waste situation in Addis Ababa would be to raise awareness about the environment and waste handling through education. The government should invest in importing the needed education and make this knowledge available to all civilians.

Institutions and legislation

Institutional issues include the current and intended legislation and how much it is enforced. Implementing regulations in the Federal Democratic Republic of Ethiopia (FDRE) goes as follows: the president first passed a proclamation in 2007; according to the proclamation, the council of ministers issue regulations for effective implementation, and the authorities issue directives.

The declaration can be cited as Proclamation No. 513/2007 of solid waste management. The objective of the third article of the proclamation reads as follows: "This proclamation intends to increase capacity at all levels to avoid possible adverse effects while generating solid waste capital that is economically and socially beneficial" [5]. The proclamation has five parts. The first part of the proclamation defines the terms of use and declares the title and objective. Part 2 is mainly about the responsibilities of urban administrators. Responsibilities of actors in handling distinct forms of waste are declared in part three, and guidelines for transporting solid waste and managing garbage dumpsite are in part four. The last part of the proclamation declares penalties when these guidelines trespass.

There are two other proclamations relating to garbage handling and environmental policy. The proclamations are "Environmental Impact Assessment (EIA) Proclamation No. 299/2002" and "Environmental Pollution Control Proclamation No. 300/2002". The content of these proclamations is such that it sets the responsibilities of the authorities and actors concerned in the matter and declared penalties when the bodies fail to meet their responsibilities.

The environmental policy of Ethiopia consists of general attitudes to protect and preserve all-natural resources in the nation. The legislation and rules are well prepared; there is, however, a significant difference between what is written in the papers and what is done [13]. More than ten years have passed since all the proclamations were issued, but no major change has taken place. The regulations are also considerably non-practicing. The attempt needed to implement the regulations has somehow been missed. Despite all the regulations being good in theory, a few of them are adopted by the city administration and citizens, and very little is done to enforce them. In most cases, it is also difficult for the citizens to follow the regulation because they do not have access to a proper solid waste system that allows them to manage their waste according to the regulations. When the city administration has not developed any systematic organization for the

gathering of sorted waste, the argument that households should sort their waste seems meaningless.

Bjerkli [56] stated that it is meaningless to argue that every person is obliged to dispose of his or her waste in a sustainable way when someone has to walk 1 km to do so and even then, find that the container is already overloaded. Hence, there is a big gap between the requirements of the regulations and the reality on the ground, and this makes it difficult for the city administration and citizens to follow the regulations.

The regulations enacted by the government should, as stated above, be in line with the city's realities. A plan for the introduction of legislation, laws, and declarations and on how to embed principles in society also requires proper study. Moreover, each kind of dry waste should be transported by special vehicles to the destination of the disposal point. Awareness of the citizens about environmental protection and its risk should be increased. The government should inform citizens about their environmental rights and the impacts of its damage, as well as waste separation and its disposal system. Further, it is better if the city administration revises its solid waste management policy, strategy, and process. Finally, based on this study's finding, the solid waste organization method of Addis Ababa City might be revised and re-organized, as shown in Figure 6.

4. Conclusion

This study attempted to examine the spatial coverage and the status of Addis Ababa in managing the dry waste service provision. Also, the study examined the pace of dry waste generation in households, waste handling practices, and factors driving changes in the city's garbage managing system. These inquiries were addressed by reviewing different kinds of literature. Lastly, based on qualitative and quantitative data analysis, the findings of this analysis were summarized as follows. A significant amount of garbage in the city is produced by residential areas, and the highest percentage of its composition is organic. This revision also indicated that Addis Ababa city's sanitation service provision is very weak in terms of status, spatial coverage, and garbage handling facility. Currently, in the city, there are some public waste storage containers and roadside waste bins. Those places are situated at the curbside of main roads, and they are not well designed. Simply they are roadside exposed landfills deprived of any health, aesthetic, and environmental impact attentions. Also, the transfer stations are characterized by irregular spread both in terms of remoteness from beneficiaries and district exact loca-

tions. Moreover, the collected waste is also not separated according to its nature, transported by the same truck, and is not appropriate for effective incineration.

Dry waste handling in the city has several gaps regarding human health and environmental impacts, according to the evaluation of the current report. To prevent these impacts and promote garbage collection and delivery services, the following recommendations might be suggested. Rubbish dumpsites should be constructed based on scientific requirements suggested for such purposes. It should be built in a manner that could not pose a danger to the health of society and the environment as well. Apart from construction, a strong controlling, monitoring, and managing system should be employed to reduce the negative externalities of the rubbish dump site and transfer stations. Especially, reuse and recovery of solid waste should be given priority.

Ethical Considerations

Compliance with ethical guidelines

This article is a meta-analysis with no human or animal sample.

Funding

This research was supported by the Commerce Ministry Scholarship of the People's Republic of China as a scholarship for Diriba Dechasa Beka.

Authors' contributions

The manuscript was designed, prepared, and revised by both authors as well as the final manuscript was read and accepted.

Conflict of interest

The authors announced no conflicting interests.

Acknowledgments

The writers are very thankful for the useful comments and suggestions made by colleagues at Tongji University as well as for the encouragement and support of the Institute of Environment for Sustainable Development (IESD). The authors are also thankful to the Commerce Ministry Scholarship of the People's Republic of China for financially supporting.

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