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REVIEW

Municipal solid waste management in Ethiopia; the gaps and ways for improvement

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Abstract

This study aimed at examining solid waste management systems in Ethiopia, identifying the gaps, and exploring ways for improvement. Expansive literature surveys of journal articles, official reports, state-issued pamphlets, critical review of laws and policies were used to elicit information. Case studies provided insight into challenges while investigations into the waste management system of countries with a better system were made to draw comparisons and pinpoint areas of improvement. The average waste generation (0.32 kg/capita/day) was found to be within the limit of waste generation for low-income countries: however, there is an annual increase in waste generation by 5%. The waste is dominated by organic biodegradables which accounted for 67.4%. Crude open dumping without pre-treatment and traditional open burning of wastes are common practices. only 5% of waste is recycled in an unsafe informal way. The current waste management system can be described by 3 I's (Irregular, inadequate, and inefficient) which denote sporadic and inconsistent collection, low coverage, technical frailties, and lack of enforcement of laws, respectively. Hence, implementing the new system proposed in this study should be a priority. Political will, institutional reform, finance, and most importantly change in behavior are necessary to ensure sustainable waste management.

Keywords Municipal solid waste · Waste management · Challenges · Recommendations

Introduction

Relevance and state of knowledge

Solid waste in developing nations is referred to as the everyday items used and discarded as garbage [8]. In the Ethiopian context, we refer to solid waste as items used and thrown away by individuals, households, hotels, small businesses, and institutions. These include: garbage (paper, packaging plastic bottles, furniture) food scraps, clothing, manure, batteries, appliances and paints. Economic development, urbanization and population growth have led to an increase in the quantity and complexity of generated waste, especially in developing countries [41, 29]. Regardless of the rise in the volume of waste generated, the performance of the solid waste management system is very poor in Ethiopia. Ngoc and Schnitzer [35] anticipated that, in an attempt to speed up the pace of development, emerging nations may not pay adequate emphasis to solid waste management. This is exactly what happened in Ethiopia, while everybody is busy preaching about industrial development, solid waste management issue has not been given adequate attention. The entire solid waste management system comprises: waste generation, segregation, storage, collection, transport, disposal, processing, and recovery [5]. However, waste management in Ethiopia has focused mainly on the collection and disposal of solid waste, and implementing the entire functional elements of solid waste management remains a dream. The recommendations in the past by organizations as well as scholars have been far from significance because of failure to assimilate local situations and they are disconnected from ground reality and lack implementation brief [10, 29, 37, 39, 41]. Furthermore, the recommendations need to establish an implementation brief in which they could be applied to solve problems. Thus, this study examined a solid waste management system, identified the challenges, and forwarded realistic recommendations with the implementation brief.

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Conceptual framework

The conceptual framework for this study (Fig. 1) is formulated considering the UNDP theoretical view towards effective solid waste management. Solid waste management is a complex task that incorporates technical, political, institutional, social, and financial aspects [42]. Previous studies in Ethiopia investigated the problems in a scattered manner and dissipated the solution from problems and also failed to mainstream the role of stakeholders. This study believes solid waste management is a complex issue, the problems in waste management are a cumulative sum of factors from each component (technical, political, institutional, social, and financial) and the solution is integrated solid waste management that connects factors to each stakeholder and seeks a coordinated effort. The stakeholders are part of the constraints in waste management. Hence, each stakeholder has a role to play to rectify its challenge and most challenges are to be addressed by the collaboration of stakeholders. The municipality coordinates the joint effort of stakeholders including waste producers, public and private, Environmental Protection Authority. Council of Environmental affairs in the legislature who frame environmental laws are part of stakeholders responsible for political issues relevant to waste management. The political will, behavioral change, finance, and institutional reform can ensure sustainable integrated waste management in Ethiopia.

Materials and methods

Description of the study area

The Federal Democratic Republic of Ethiopia is situated in northeast Africa. The country covers an area of 1.1 million km^2 and its location extends 3–15° North latitude a–nd 33–48° East longitude. The government is a federal parliamentary with 9 regions and two city administrations. The population is estimated at 102.4 million with an annual population growth rate of 2.5% [38]. According to the World Banks's report [46], there is a high urbanization rate in Ethiopia diversifying the economy and it has created havoc that resulted in unemployment, crime, and most of all grubbiness. In most of the country's urban areas, there is a

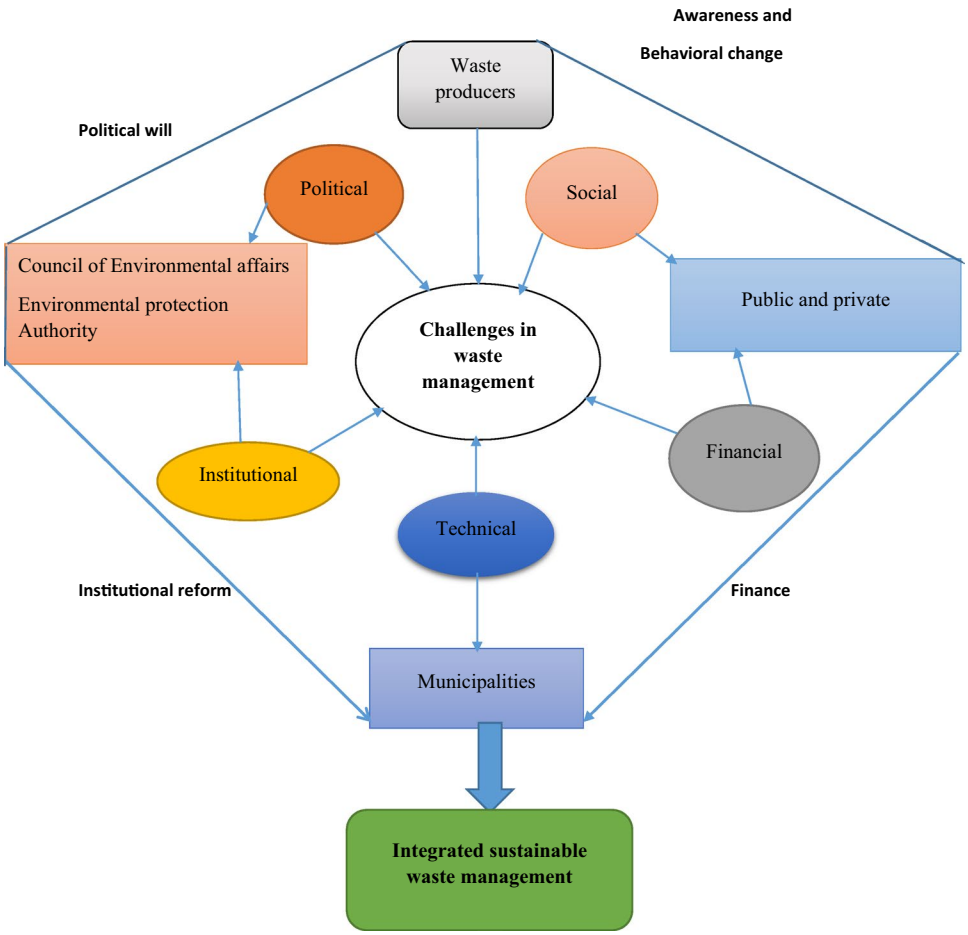

Fig. 1 Conceptual framework of the study

huge hole between the demand and supply of utility services particularly waste management.

Data sources and collection

An expansive literature survey of research articles, official reports, state-issued pamphlets, international, national, and local laws provided necessary data. Previous literature on waste management of Ethiopia was investigated to identify gaps. Policy option prospects and recommendations by academicians and organizations, such as the World Bank, African Development Bank, World Health Organization (WHO), and UNEP, were critically examined in relevance to local suitability and implementation brief. Recorded documents were reviewed to explore approaches to waste management. The review of unpublished written documents also supplemented the data. Investigation to get experience from waste management in selected countries believed to have a better waste management system was also executed.

Data analysis

The tips for gathering, reviewing, and analyzing data by M. Katherine McCaston, HLS Advisor [31] were followed to make sense of the data. Determination of quality of the data or information that has been gathered was carried out by identifying the purpose of information, detecting the potential level of bias, attempt to ascertain the credentials of the data source, and pinpoint the intended audience. Moreover, the temporal and spatial extent of data was also considered to determine its relevance to the purpose of the current study. A systematic summary and comparison analysis methods were employed to elicit meaningful and relevant information from the data (Fig. 2).

Results and discussion

Waste generation and composition

The current global waste generation figure is about 2.01 billion tonnes per year and it is expected to rise to 3.4 billion in 2050 [46]. The total waste generation in Ethiopia is estimated from 0.6 to 1.8 million tons/year in rural areas and 2.2–7 million tons/year in urban areas [12]. According to EPA [12], the per capita waste generation in Ethiopia ranges from 0.17 to 0.48 kg/person/day for urban areas and from 0.11 to 0.35 kg/capita/day for rural areas. The study conducted by Molla et al. [33] in SNNPR, Amhara, Oromia, and Tigray revealed that the overall household generation rate was 0.32 kg/capita/day. According to Ali and Eyasu [4], there is an annual increase in waste generation by 5% in Ethiopia. The waste generation rate in Ethiopia (Fig. 3) is among the lowest (Germany 325–350 million tons/year, [19]; Nigeria 43.2 million tons/ year [40]. Out of the total waste generated in different cities of Ethiopia, 67.4% is organic biodegradable waste (Table 1). This complements the investigation by Hoornweg et al. [24], who stated that 50% of waste comprises organic material in developing countries. The composition of solid waste in Ethiopia has increased its proportion of plastics and packaging materials due to a change in lifestyle [37].

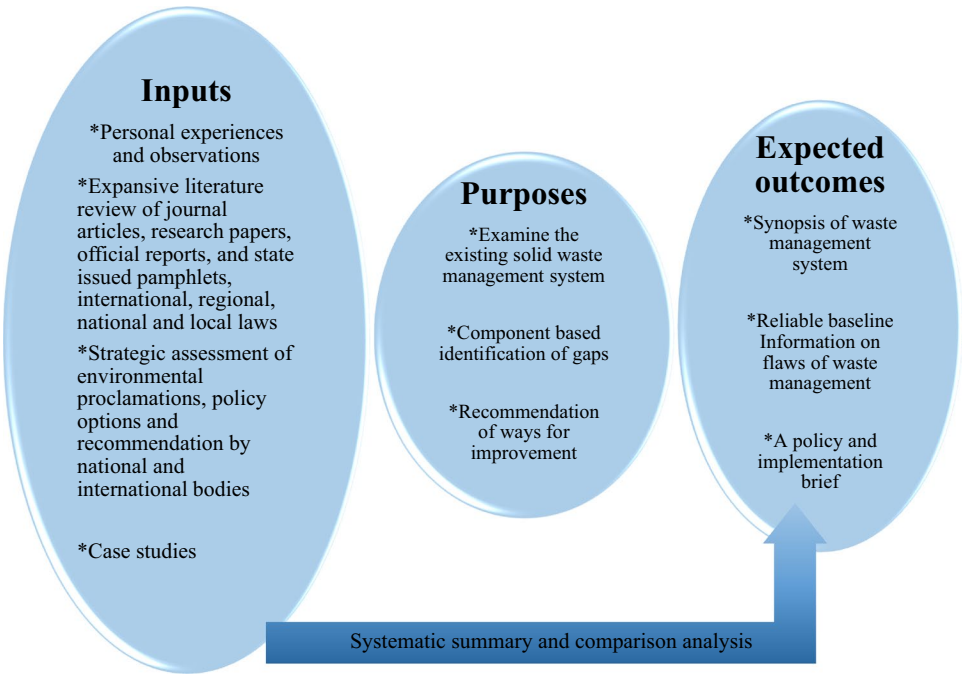

Fig. 2 Methodological framework of the study

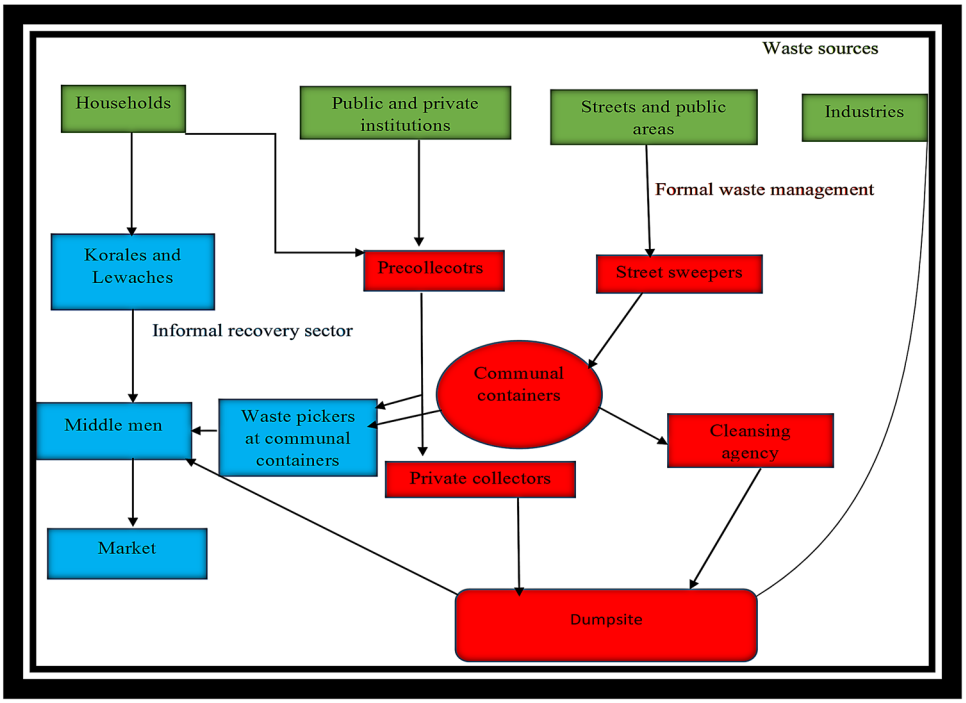

Fig. 3 Diagramatic description of the current waste management system in Ethiopia [36]

Table 1 Composition of waste in different cities of Ethiopia

City	Organic waste	Paper/cardboard	Plastics	Glass	Metal	Others	References
Addis Ababa	64.8	5.3	5.2	2.1	1.2	21.4	Meaza [27]
Bahirdar	86.6	3.3	2.2	0.6	0.3	7	Fenta [13]
Adama	58	12	20	1	1	8	Mengist and Assegid [28]
Hosaina	51.4	3.3	2.6	0.4	0.3	42	Abiot et al. [3]
Lagatafo	76	4.75	9.5	1.69	0.37	7.69	Mesfin and Muktar [29]
Average	67.4	5.7	7.9	1.15	0.63	17.2	

Table 2 Waste collection in major cities of Ethiopia, 2010 [17, 20]

Major city	population	Municipal solid waste generation tons/day	Solid waste collected (%)
Addis Ababa	2,979,100	1,132	70
Bahirdar	170,300	98.8	58
Mekele	261,200	78	82
Adama	260,600	59	48
Hawassa	200,400	46	44
Diredawa	256,800	77	48
Harar	108,200	32	45
Jimma	120,960	87	30

Waste collection and disposal

A study by UNDP [41] in four major cities of Ethiopia (Table 2) revealed that only 46, 48, 54, and 50% of the wastes generated are properly collected and disposed of, hence, half of the generated waste is left uncollected or disposed of in unauthorized areas. The performance of solid waste handling, recycling, and disposal systems remains very much poor in Ethiopia [11, 39]. A very small tiny proportion of waste is recycled through informal, unregulated, and unsafe ways [4]. Waste is often burned by households in open and uncontrolled ways to get rid of the waste. African development bank group reported that the open burning of waste is widely practiced by more than 50% of the population in Ethiopia. Recycling is not well-practiced and it is at a primitive level in Ethiopia due to the absence of formal structure and regulation. Kofoworola [25] reported a similar case in Nigeria.

Ethiopia and the ambitious targets

The African Union Commission has called on African cities to grow waste recycling industries and commit to recycling 50% of the waste they generate by 2023 [6]. However, Ethiopia is far away from achieving the target as its cities including the capital recycles only 5% and there is no sign of industrial development in waste recycling. Ethiopia is struggling to meet its objective of collecting over 80% of the overall generated waste and ensure saniatation by 2030.

Legal and Institutional framework

Environmental Policy provisions of Ethiopia by Environmental Protection Authority (EPA) address waste management in three different articles, namely article 3.7, 3.8 and 3.9 (Table 3). City's Waste Management Authority and Sanitation, Beautification, and Parks Development Authority (SBPDA) is responsible for street sweeping, waste collection, transport, disposal, and the overall system of waste management [14, 18]. The national policy on waste management released in February of 2007 is the Solid Waste Management Proclamation no. 513 (Table 4). The proclamation aims to tackle the adverse impacts and enhance benefits from solid wastes and implement solid waste management action plans [15]. It comprises 19 articles that address solid waste management system from collection to transport recycling and disposal.

Table 3 Federal laws and regulations relevant to waste management in Ethiopia [2]

Proc. no. 300/2002	Environmental Pollution Control Proclamation
Proc. no. 513/2007	Solid Waste Management Proclamation
Proc. no. 299/2002	Environmental Impact Assessment Proclamation
Proc. no. 200/2000	Public Health Protection Proclamation

Private involvement in waste management

Private involvement in waste management is crucial because municipalities are becoming unable and incapable to provide enough sewerage services due to the increasing amount of waste generation [11, 39]. Private involvement in Ethiopia is limited but in large cities, the private sector has a contract agreement with the municipality to collect and dispose of waste (Table 5). The largest private institutions collect waste from households, hotels, and institutions and dispose at the disposal site, however, small cooperatives collect waste from households (mostly in areas municipalities do not cover waste collection) and transport it to nearby transfer stations.

Currently, there is a formalization of the small informal enterprises but the policy changes at local government level and over-dependency of the microenterprises on public sector made the process difficult; hence, most of them continue to be informal, but they have some kind of collaboration with the municipality [30]. The collection coverage by municipalities covers only half of the population and in some towns even less than half [39, 44]. The small informal collectors play a crucial role in covering those residents not covered by the municipality collection, However, they showed bias by ignoring the very poor households [30]. Hence, formalization should have helped to make these enterprises more responsible. The informal small enterprises communicate with the municipality to identify areas not covered by the collection program they transport it to the place where the municipalities can pick and transport easily to the disposal site. This collaboration is important as it increases waste

Table 4 Solid waste management proclamation no. 513 [16]

Waste management action	law	Description
Segregation	Solid Waste Management proclamation, Article 11.1	Households have to make sure that the recyclable materials are segregated from other waste destined for disposal site
Collection	Solid Waste Management proclamation, Article 11.2	Urban administration shall ensure that an adequate number of collection bins are in place
Transportation	Solid Waste Management proclamation, Article 13.2	Each urban administrations have to set standards to regulate the skills of drivers and avoid overload of wastes
Disposal	Solid Waste Management proclamation, Article 14.2 and 14.3	The urban administration shall ensure the disposal sites are constructed and used properly, the environmental impact assessment is carried for new disposal sites in case of a modification of the existing one
Audit	Solid Waste Management proclamation, Article 15.1	Urban administration is responsible to make sure environmental audit is carried out on existing disposal sites
Penalty	Solid Waste Management proclamation, Article 17.4	Each urban administration can prescribe and enforce fines in case of violation of the requirements under the proclamation

Table 5 Private collectors in major Ethiopian cities [32]

Major cities	Number Private companies in waste collection	Number of vehicles (private companies) for waste transport	A major source of finance for private
Addis Ababa	20	18	Own capital (45%)
Bahirdar	6	5	Social institutions/Ikub (40%)
Mekele	4	4	Development association (75%)
Adama	5	5	Social institutions/Ikub (60%)
Hawassa	6	6	Own capital (67%)

collection coverage, saves resources, and time the municipalities are supposed to spend on a house to house collection.

Enterprises in waste management are not a priority by the government as the large banks only permit credit for enterprises in export, construction, and other sectors [22]. The financial sources of the existing private companies are either own capitals, friends and families, social institutions, such as Ikub (A small social system of saving money in a group in which members collect their share in turn through a lottery system), and development associations (Table 5). Lack of finance and the absence of legal provisions are mentioned as the constraint of private involvement in the waste management sector of Ethiopia [32]. UNDP [41] blamed the absence of incentive systems and insufficient cost recovery for limited involvement of the private sector in waste management of the country.

Waste management in Ethiopia

The waste management system Ethiopia includes waste generation, collection, transport, recycling, and disposal (Fig. 4).

Challenges of solid waste management in Ethiopia

Technical constraints

Absence of waste segregation

If segregation exists in Ethiopia, it is only small-scale segregation of recyclable waste materials for informal recycling [13]. Only a few people separate saleable and exchangeable wastes for their advantage and most of the waste is not separated by households because of lack of awareness and in some cases negligence [12]**;** [45]. Ethiopian solid Waste Management proclamation, Article 11.1 says the households are responsible for the segregation of waste but due to lack of enforcement, the laws serve only paper values.

Constraints in waste collection and transportation

In Ethiopia, only 40–50% of the waste produced is collected [42]; [39]. The waste collection system does not cover all residences (does not cover poor communities). Only half of the waste producers are fully covered [39]. In some towns, the coverage is even less than half [44]. The collection is irregular, as sometimes the collection service is once a week, sometimes time twice a week, and to the worst might not even happen once in a week [23].The

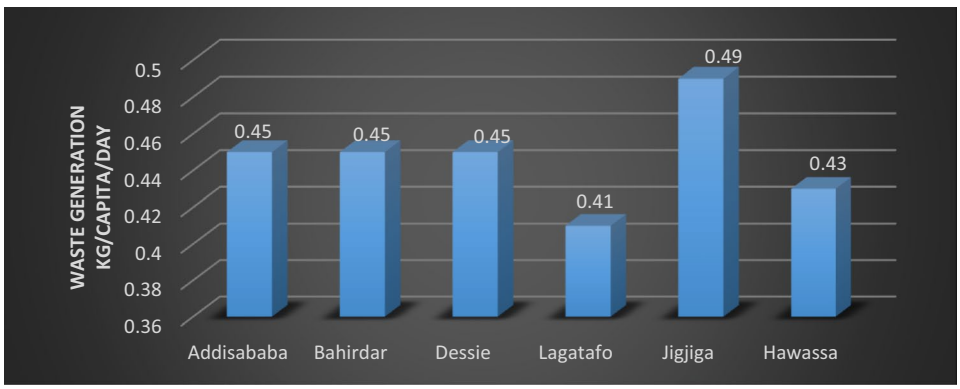

Fig. 4 Current waste generation in kg/capita/day of some cities in Ethiopia [4, 13, 10, 29]

problem of transportation is the lack of trucks to empty the central collection containers and transport the waste to disposal sites. In some cases, the vehicles for waste management are used for other purposes [44]. The Solid Waste Management proclamation, Article 13.2 of Ethiopia mandates the urban administrations to set the standards to determine the skills of drivers and equipment operators and prevent overloads of solid waste, however, the implementation of the proclamation is yet to be seen and felt.

Problems in the waste disposal and Management

The disposal sites are established without careful investigation and consideration of the impact. The waste generated in households is dumped together without any sort of segregation. Some of the hazardous wastes are also disposed of with the municipal solid wastes [23]. The dumpsites are not soil-covered and fenced to reduce health problems and environmental pollution [44]. Open burning of the wastes is done by households and the municipalities to just get rid of the waste under any conditions. Incineration is a waste management system used to generate energy and reduce the weight of the waste under-regulated and controlled atmosphere [45]. In Ethiopia, incineration is almost none-existent. The Repi waste to energy incineration plant project in Addis Ababa was built to generate 50 MW of electricity, but it has failed due to economic, material, and technological feasibility reasons. The project is located at an open dumpsite in Addis Ababa and inaugurated in 2018. Having received significant media coverage at the regional and international level, the project required about 2.6 billion Eth. Birr. It was applauded as an environmentally friendly investment which should be replicated by other countries in Africa. However, it proved to be a misguided investment with the initial decision-making process. There are basic prerequisites for the technology to be economically viable. The major prerequisite is the domestic waste produced has to consist of energy-rich combustible waste. There should also be efficient waste segregation and collection infrastructures. Ethiopia, particularly Addis Ababa where the Repi incineration plant located does not meet the basic prerequisite and does not fulfill operational requirements [9]. The waste produced in the city has less calorific value, the wastes are not segregated at the source to have suitable ones for incineration and there is no advanced technology. The project proved to be misguided and unsuccessful due to high technical, financial, and operational costs. Overall, the technical challenges of waste management in Ethiopia are very complicated and expose the distance that the country should strive towards the better achievement (Fig. 5).

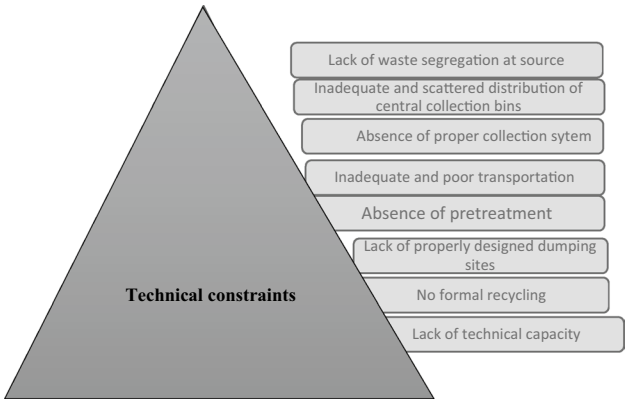

Fig. 5 Technical constraints of waste management in Ethiopia (own, figure)

The 3 I's that summon waste management in Ethiopia

Table 6 is adapted from what a waste global review of solid waste management originally by the World Bank Group and later updated by Daniel and Perinaz [7]. The report is acclimated to update the current situation in Ethiopia and analyze in a comparative way to developed countries to show the huge gap. In terms of the waste management system, the 3 I's (irregular, inadequate, and inefficient) can best explain the waste management system of Ethiopia. Irregular denotes the collection frequency and transportation which is sporadic and inconsistent, inadequate represents low coverage of waste collection, gaps in transportation and finance while inefficiency determines technical frailties and lack of enforcement mechanisms for waste management regulations.

Financial constraints

The financial constraint in the waste sector of Ethiopia emanates from a single root cause that is a low priority given to the waste management sector. Besides limited finance, the planning and management of financial resources are very poor which results in the halt of services and the disintegration of waste management [39]. According to Nigatu et al. [37], the waste sector is less attractive to the officials; hence, they do not allocate sufficient budget. The absence of service charges is another problem. For instance, in Germany, the households pay a waste service charge but in Ethiopia, there is no formal waste service charge. Little service charge exists in some cities but only if the waste collector is a private company. The service charge is not regulated by law and decided by the negotiation between the households and the collector hence, it is voluntary, so the service charge by private companies is not sufficient to cover service costs [26]. The major financial constraints of the waste sector in Ethiopia are described in Fig. 6.

Table 6 Ethiopian reality in relevance to high-income countries adapted and acclimated from what a waste, global review of solid waste management by World Bank group [7]

Activity	Ethiopia	High-income countries
Source Reduction	Low per capita waste generation rate but no organized program for waste reduction at the source. Even no clear proclamation on source reduction	Emphasis on producer responsibility and pro-active measures in product design. Organized and effective. Awareness programs in reduce, reuse, and recycle
Collection	Irregular, inadequate, and inefficient. The overall collection below 50%	Organized, effective, and mechanized collection and transport of waste. Collection rate greater than 90%
Recycling	Informal and unregulated recycling. Only 4% is recycled. The markets involve middlemen. Large price fluctuations	Regulated and high Standard technology sorting and processing. Approaches to long term marketing
Composting	Despite high potential because of large organic waste, composting is rarely practiced formally. Lack of segregation at the source makes composting difficult	A smaller percent of compostable. Anaerobic digestion well-practiced. Segregation makes compositing easier
Incineration	Unfamiliar and not successful due to high technical, financial, and operational costs. Traditional burning common to destroy the waste	Common and done for energy recovery and in the situation of low availability of land. Regulated and technology for environmental pollution control
Landfilling/dumping	Open dumping of wastes without any treatment. Significant environmental and health impacts. Often receive hazardous wastes	Sanitary landfills with lining, leak detection, leachate control systems, and gas monitoring
Finance	The waste collection represents about 90% of the budget and only 10% is allocated for disposal. Collection fee system inefficient, no implementation of regulations	The collection cost about 10%. Large budget for treatment, recycling, and disposal. High community participation, reduced cost

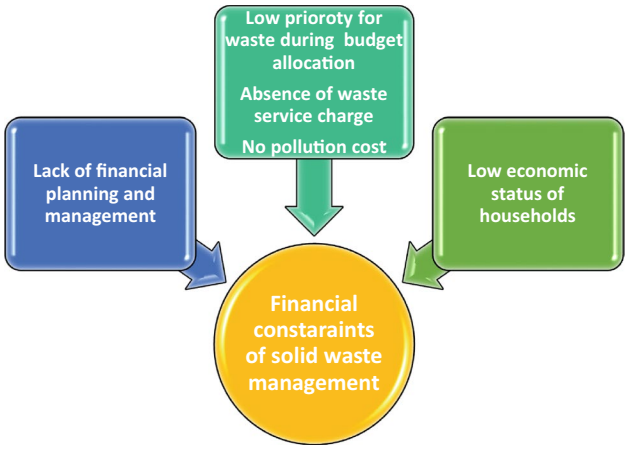

Fig. 6 Summary of financial constraints of solid waste management in Ethiopia (own, figure)

Social Constraints

According to Mesfin and Muktar [29], the low level of awareness is manifested in the community, officials, private, and decision-makers. On the contrary, Fenta [13] stated that public awareness of solid waste management has increased significantly. Awareness remains a problem, however, the major problem is attitude because people who are very much aware of waste issues are not managing their waste. Abel [1] and Demos [34] reported the same cases in Nigeria and India, respectively. Apathy or the feeling of not much emotion to waste management is a big constraint resulted in a low willingness to pay for waste services in Ethiopia (Fig. 7). Another social constraint related to awareness and attitude in Ethiopia is the low social status given to solid waste workers [37]. In the survey conducted by Getinet [21], 67% of waste workers in Addis Ababa noted that their salary is insufficient and beneficiaries have a negative attitude towards them.

Political and institutional gaps

According to UNEP [43], prevention is arguably the best of all alternatives because, if waste is not generated, it does not need to be managed. However, the existing waste proclamations in Ethiopia neglected waste prevention. According to the Federal Negarit Gazeta [16], the waste management proclamation no. 513/2007 article 4.1 states that urban administrations have to create suitable conditions for investments in waste management, so far the lack of investments in waste management sector is evident due to incapability of the urban administrations to execute the proclamation [42, 11]. The solid waste management proclamation article 5.1 (Table 7) declares the responsibilities to be shared by lower administrative units [4]. Nevertheless, it is the municipalities

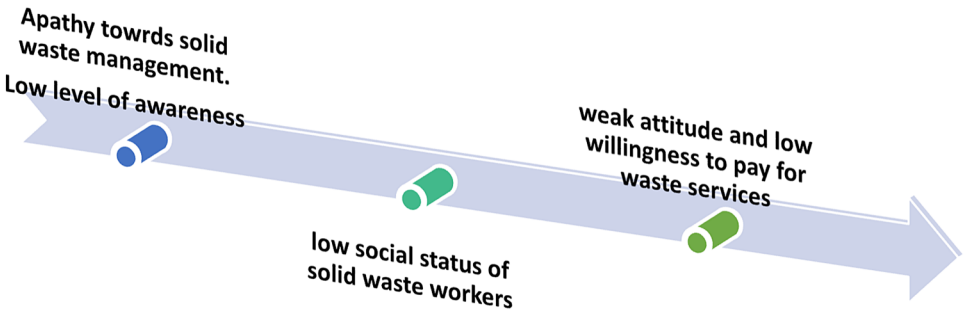

Fig. 7 Major social constraints of solid waste management in Ethiopia (own, figure)

Table 7 Institutional responsibilities of urban administrations and the lowest administrative structures [16]

Administrative level	Law	Legal responsibility
Urban administration	Solid Waste Management proclamation, Article 4.1	Create suitable conditions to promote investment in solid waste management services
Urban administration	Solid Waste Management proclamation, Article 4.2	urban administration shall permit any concerned body to engage in solid waste management
Urban administration	Solid Waste Management proclamation, Article 5.1	Urban administrations have to assure the participation of the lowest administrative units and the local community in designing and implementing waste management plans in their locality
Lowest administrative units (Kebeles)	Solid Waste Management proclamation, Article 5.4 a	Formulate and implement waste management action plan at the local level
Lowest administrative units (Kebeles)	Solid Waste Management proclamation, Article 5.4 b,c and d	Ensure installation of street waste bins, ensure frequent and sufficient collection of waste, carryout public awareness activities
Lowest administrative units (Kebeles)	Solid Waste Management proclamation, Article 5.4 e	Take necessary measures to prevent pollution arising from mismanagement of wastes

that are doing everything in waste and the lowest administrative units have not been able to bear on their responsibilities due to poor institutional setup. In article 4.2, the proclamation mandates the urban administration to permit any concerned body to engage in solid waste management activities, yet bureaucracy to get licenses and corruption mind set up of some officials restrain investors from participation.

Table 8 describes the overall waste management challenges in Ethiopia, concerning stakeholders, proposed solutions, and implementation brief.

Proposed waste management system

To propose this waste collection method, the experience from Germany particularly the city of Bonn is considered. In Bonn, every household has four bins black, green, blue, and yellow bins and the waste has to be sorted according to the material it contains. In Ethiopia, the wastes generated, the composition and treatment are different from Germany so, considering those situations and awareness of the people to waste segregation, the following management system is proposed for implementation (Fig. 8). The major justifications for proposing the new system are:

- Absence of waste segregation at the source of waste
- Inadequate, irregular and inefficient collection service
- Indiscriminate waste disposal and its adverse environmental consequences
- The increasing waste generation and non-progressive waste management service
- Environmental pollution control and waste management proclamations of Ethiopia.

Implementation brief

The proposed system will have the following scenarios and implementation brief (Fig. 9).

- Reduced waste generation
- Awareness creation for households. The awareness creation activities should be continuous to help the households bear on their responsibilities.
- Regular pick and transfer of waste: municipalities transport system should be standardized considering the Solid Waste Management proclamation, Article 13.2.
- Composting: composting facilities should be updated and new technologies should be adopted.

Table 8 waste management activities, challenges, concerned stakeholders, proposed solutions and implementation brief (own, table)

Waste management activity	Identified challenge	Major stakeholder	Countering measures	Implementation brief
Reduction at the source/ waste prevention	Absence of legal proclamation	Council of Environmental affairs	Establish a relevant proclamation on waste reduction at the source following article 55(1) of the Federal Democratic Republic of Ethiopia	Strict enforcement of the proclamation, incentives for industries that have better waste prevention performance
Waste separation	Absence of waste segregation at the household level	The public, municipalities and Environmental protection Authority (Households do not segregate waste due to lack of awareness and motives. The municipalities do not provide enough support for waste segregation	Provision of waste segregation bins at least three for every household(biodegradable, nonbiodegradable, recyclable)	Awareness creation for households to segregate waste Insist on municipalities to enforce the Solid Waste Management proclamation, Article 11.1
Collection and Transport	Irregular, inefficient and inadequate collection and transport	Municipalities and Private companies in waste management	Build financial and technical capability of municipalities to provide an adequate and frequent collection	Introduce a standard waste collection service charge Allocate enough budget. Set standards to determine the skills of drivers and equipment operators
Recycling	Informal and unregulated recycling	Private, public, municipalities, city administrations, Council of Environmental affairs, Environmental protection Authority	Formalization of waste recovery and recycling	Institutionalize waste recycling
Disposal and incineration	Absence of sanitary landfills, Indiscriminate disposal, uncontrolled incineration	Municipalities, waste producers, Environmental protection authority	In-formed decision in site selection for disposal Institutional reform to update the waste disposal system Attempt to energy recovery through incineration	Implement Environmental Pollution Control Proclamation, Article 5.1 which states that the urban administration shall ensure appropriate treatment and disposal of wastes

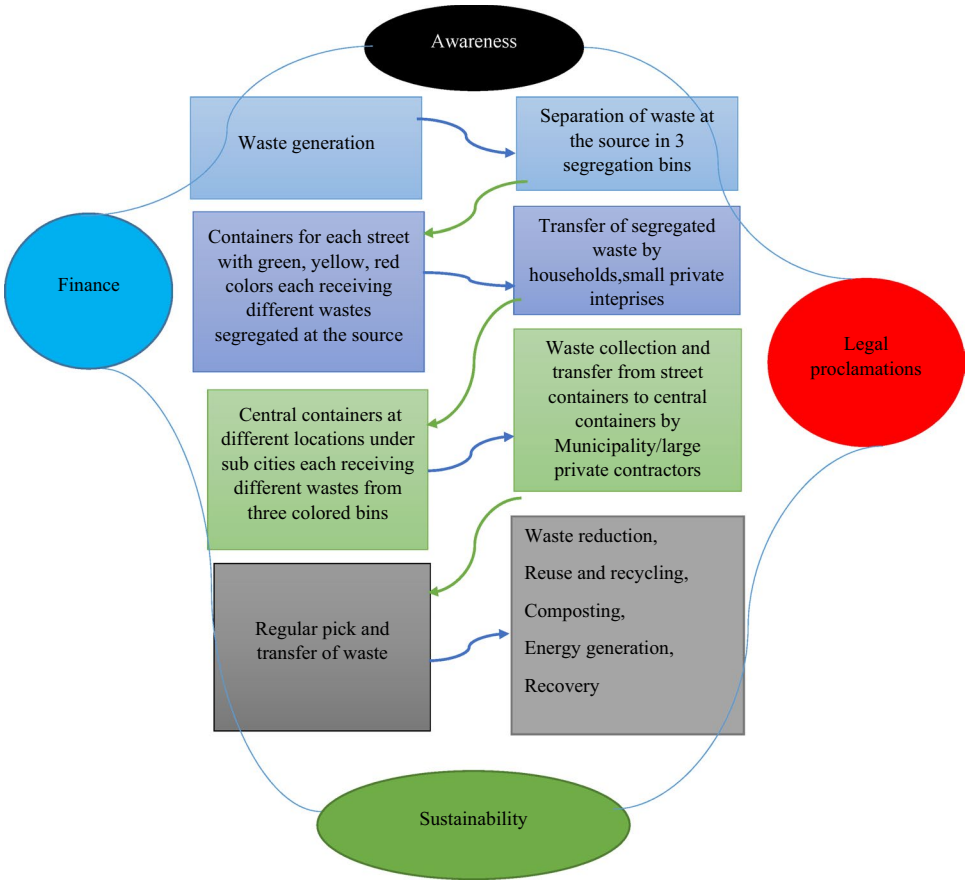

Fig. 8 The proposed new waste management system (own, figure)

- Ensure waste segregation at source: Provision of waste segregation bins at least three for every household with different colors that can be easily understood.
- Green: Biodegradable organic wastes
- Yellow: Non-biodegradable wastes (mixed wastes)
- Red: recyclable wastes
- Street bins for each street with green, yellow, red mark to store segregated wastes.
- Central containers at different locations under sub-cities with three colors each receiving different wastes. Urban administration should insist on the municipality for guaranteeing the collections of solid waste from bins with sufficient frequency. Formal collaboration with informal small enterprises to enhance the collection coverage is crucial here and the formalization of private small informal enterprises should be done. Increasing the involvement of large private companies is also important.
- Build sanitary landfills. Sanitary landfills with lining, leak detection, leachate control systems should be built.
- Regulations on service charges should be standardized**.** An average figure that takes in to account the income of the majority should be set for waste services.
- Waste recycling, treatment, recovery: Implement the Environmental Pollution Control Proclamation, Article 5.1 which states that the urban administration shall ensure appropriate recycling, treatment, and disposal of wastes.: The road map for implementation of the proposed waste management system is described in Fig. 10.

Conclusion and recommendations

Conclusion

Several constraints are hindering Ethiopia from achieving sustainable waste management. An informal and unregulated system of recycling means there is only 5% waste recycled. There is a low per capita waste generation rate but no organized program for waste reduction at the source. The overall waste collection is below 50%. Despite the high potential of compost with large organic waste, composting is practised informally and on a small scale. Open burning of waste is practiced by more than half of the population in uncontrolled ways to get rid of the waste. The common practice is crude open dumping of wastes without any treatment and disposal sites often receive a mixture of hazardous wastes. In addition to deficiencies in the budget due to the absence of service

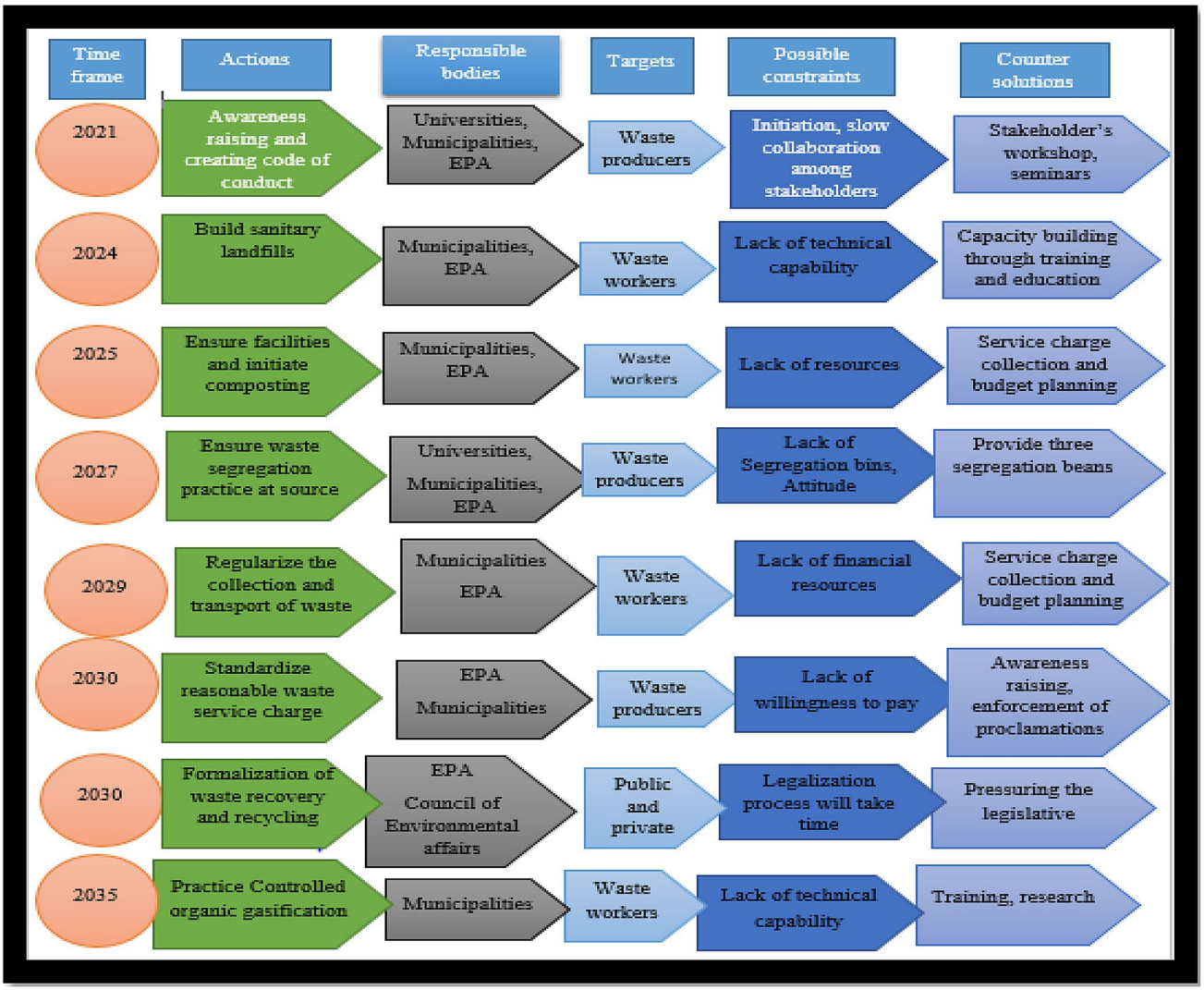

Fig. 9 Implementation brief for the new proposed waste management system (own, figure)

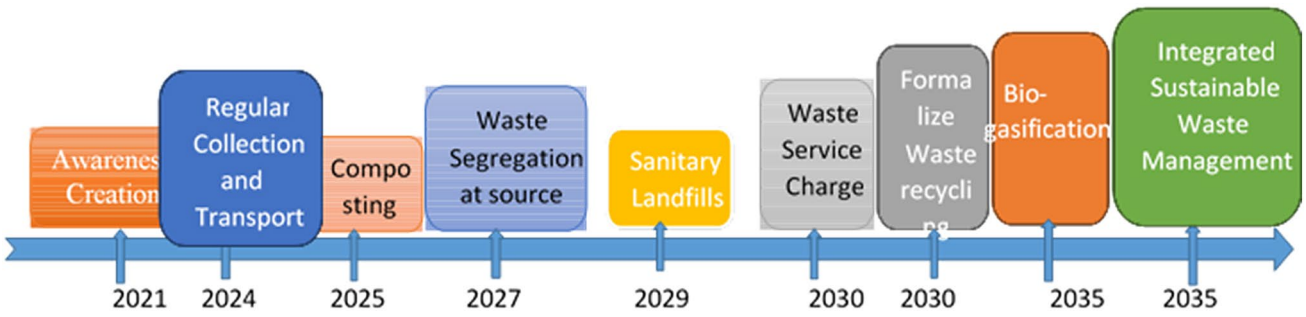

Fig. 10 Road map for implementation of the proposed waste management system (own, figure)

charge, the waste collection represents most of the available budget and only a small proportion is allotted for disposal.

The waste management system of Ethiopia can be elucidated by 3 I's (Irregular, inadequate, and inefficient) irregular signifies the sporadic and inconsistent collection and transportation while inadequate denotes low collection coverage. On the other hand, inefficient represents the technical flaws and lack of enforcement of waste management

proclamations. So far, waste prevention is not given adequate emphasis. Despite boasting one of the best possible laws and policies on paper, the country has no implementation mechanisms. Observed significant increase in public awareness towards solid waste management poses a question of attitude as a basic and important social constraint. From the absolute ineffectiveness of the existing waste management system, it will be a step forward to attempt and implement a new improved, realistic, and integrated waste management system.

Recommendations

The recommendations of previous investigations in Ethiopia regarding waste management are very hypocritical and unrealistic. Almost every recommendation suggested waste segregation but none of them demonstrated ways for implementing segregation at source. Wherefore, this study established an implementation brief of waste segregation based on legal provisions. Thus, the provision of at least three segregation bins to each household should make segregation practical. Besides, Article 11.1 which says the households are responsible for the segregation of waste should come to force after the provision of bins. Another usual recommendation is awareness creation activity. This study recognizes a lack of awareness in a small portion of the population but attitude and apathy towards waste management are major problems. Hence, awareness-raising and creating and enforcing the code of conduct should lead to better achievement. The municipality waste collection coverage covers half of the population hence, collaboration with small informal private enterprises to enhance collection coverage should be prioritized.

An increase in the municipality budget was suggested as a solution to financial constraints. However, this study found that the absence of service charge is a major problem in the waste finance sector of Ethiopia. Thus, a service charge figure that considers the average income of citizens should be standardized and enforced. Formalization of waste recovery and recycling should be a priority as the real situation shows that the recycling of waste is informal. The past investigations proposed sanitary landfills with leakage control and fences to reduce the socio-economic impacts of disposal sites. Yet, the disposal of wastes without treatment remains a major problem. Therefore, waste segregation at the disposal site, and treatment should better fix the disposal site problem. Previous studies proposed composting as an alternative to waste disposal and explained it as a simple option to be practised. This study agrees with compost as an option however, only large-scale composting would bring a sustainable solution. Municipal solid wastes in Ethiopia are heterogeneous in their composition, rapidly biodegradable, putrescible, mostly nonhazardous, and available in large quantity; hence, carefully controlled Organic gasification to manage leaching of harmful chemicals should be seriously considered as a viable option to take off pressure from dumpsites while contributing to energy recovery.

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