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Solid Waste Management in Adama, Ethiopia: Aspects and Challenges

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***Abstract*—**The ever increasing amount of solid waste (SW) generated which is exacerbated by lack of proper waste management system is of growing concern worldwide and in major cities in developing countries due to its social, economic and environmental implications. This study attempts to describe the aspects of solid waste management (SWM) in Adama, one of the fast urbanizing cities in Ethiopia, and highlights the challenges thereof. Data were gathered through interview supplemented by field observation and self-administered questionnaire. Then, the data were analyzed using the Statistical Package for Social Science (SPSS) software. In addition, secondary data were gathered from documents. Findings revealed that the current SWM practice couldn't cope with the fast urbanizing needs and the rapid population growth exhibited by the city. Besides, major factors contributing to the inefficient system were identified. The study would provide practical insights to decision makers in developing a sustainable SWM system leading to minimized risk in the city.

***Keywords*—**Adama, Aspects and challenges, Ethiopia, Solid waste management.

I. Introduction

MUNICIPAL Solid Waste (SW) is composed of different wastes generated by households, commercial and industrial premises, institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks, and gardens [1]. Developing countries have undergone a rapid urbanization during the past many years and the number of residents is expected to double between 1987 and 2015 [2]. Most human activities certainly result in the generation of waste which tends to increase with rapid urbanization, improved living standards and changing consumption patterns [3], [4]. In addition, the diverse sources of SW generation and the complex nature of its composition make it difficult to manage. As a result, governments and municipalities are facing considerable difficulties to provide adequate solid waste management (SWM) services.

SWM is, therefore, a critical component within urban sanitation and it is also one of the most important and resource intensive services provided by municipalities [5]. Studies also show that municipalities in developing countries spend 20-50% of their available budget on SWM and serve less than average inhabitants [6]. They collect and manage only 30-50% of the waste generated while the rest is either burned or left to decompose in open space or is dumped in unregulated landfills-impacting the environment negatively [7]. This implies that SWM is of a growing concern facing the developing countries because of its social, economic and environmental implications [8].

It is the way the waste generated is handled, stored, collected and disposed of that can pose risks to the environment and to public health [9]. Reference [10] shows, if SW is properly used, it can be a valuable resource; but if it is not effectively managed, it instigates adverse impacts on environment, public health, aesthetic, land-use, resources and economic concerns.

This necessitates an effective management of SW at the various stages of its generation, storage, collection, transfer and transport, processing, and disposal and recycling in an environmentally sound manner in accordance with the best principles of public health, economics, engineering, conservation, and aesthetics.

Studies in waste management literature reported the drivers for efficient and effective waste management systems leading to sustainable development. The drivers identified in these studies include availability of sufficient finance; infrastructure and facilities such as roads, vehicles, containers, bins, etc.; stakeholders' knowledge and awareness; attitudes and involvement of stakeholders; proper route planning for transportation; information sharing among stakeholder; affordable fee for waste collection and disposal; and implementing regulations related to waste collection, disposal and recycling [11]-[17]. Besides, innovativeness, availability of skilled and flexible workforce and supply chain development among the stakeholders are critical from the city administration side in order to realize the potential contribution of SWM to sustainable development.

Therefore, it is required nowadays that sustainable SWM system aim at protecting and improving public health, the environment and energy gains through promotion of environmental quality and productivity.

In Ethiopia, rapid urbanization coupled with increased urban population in the last decade brought immense pressure on municipal services, mainly in the management of the ever increasing amounts of SW. Since the year 2001, most municipalities and city councils in developing countries and particularly in Ethiopia have become aware of the negative consequences of poor SWM. Contrary to the hierarchy proposed in Fig. 1, municipalities in the country have put a system in place with traditional practices to collect, dispose

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and reuse waste which is not aimed at promoting public health, environmental protection and energy gains.

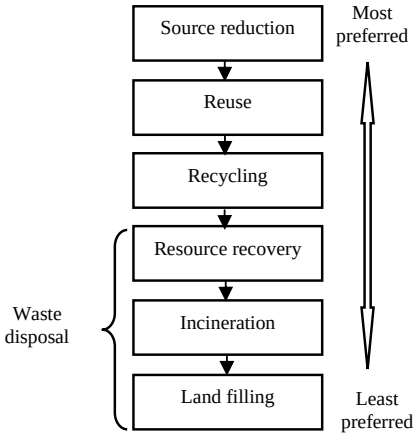

Fig. 1 The SWM hierarchy (Adapted from [18])

Following this, the Ethiopian government has passed a SWM Proclamation in 2007 [19]. Despite this, there are many challenges in the implementation of the proclamation and hence, an extremely low level of returns has been obtained from efforts put into dealing with SW.

With the increasing amount of SW in Adama, the city administration is unable to manage the SW generated from households and different organizations. During site observation, it was found that some households and organizations are more than 2kms far from nearby containers and some Kebeles (smallest local administrative units, having about 2000 households) do not have containers at all. As a result, the city administration currently collects and disposes 52% of the waste generated daily in the city. This observation is in line with [20]. A similar study implies that the collected SW is disposed in open dumping systems [21]. As a consequence, the waste generated from different sources which is not collected by the city administration is indiscriminately collected without being separated and is disposed of in low-lying areas, in the outskirts of the city, in drainage lines, in vacant spaces, and along side roads, or is informally burned.

Besides, there has not been improvement in SWM practices in Adama city in the last decade and the challenges continued. The challenges of SWM in Adama can be characterized by having few facilities to collect and dispose the waste, unavailability of enough number of centralized containers, lack of regular waste picking up schedule, absence of fee structure for waste collection and disposal service. Moreover landfill sites are also not scientifically designed leading to air, water and soil pollution. The ditches are filled with SW disposed by inhabitants causing flood in the city, and refuse often blocks drainage channels causing pounds often polluted with organic waste because of which domestic flies and mosquitoes are breeding. In addition, SW workers are not provided with appropriate clothing and usually complain about their health problems.

These problems are expected to become more evident as urbanization continues to expand in future. In general, the current SWM practice in Adama couldn't cope with the fast urbanizing needs of the city. There is a need to address the issues. Hence, by assessing the current SWM practice of Adama city, the present study attempts to describe the feature of the current system and identify major challenges as well as propose measures to be taken and suggest a framework for an improved SWM.

Having presented the above introduction, the next section of the paper discusses the materials and methods of the study followed by results & discussion. Then, the recommendations and improvement framework are presented. The last section gives the conclusion.

II. Materials and Methods

A. Site Description

Adama city is about 95kms south east of the Ethiopian capital, Addis Ababa. Reference [22] shows, the city is located in Ethiopian rift valley, 39.1^0N and 8.31^0E at an elevation from 1590-1770 meters above sea level. Its annual rainfall ranges from 400-800 mm and annual mean temperature is 22^0C. The city has a total area of 9,616,399.5m^2.

The city rose to the status of capital city in different times such as for East Shoa Zone, Oromia Regional State and now is a Special Zone. The changes in status brought about the increase in residents from about 100,000 in 1990 to about 213,995 in 2014 [23]. Adama city is divided in to 14 Kebeles and 4 nearby rural Kebeles.

B. Data Collection Methods

This study is descriptive in nature. In view of this, in order to understand and deal with the complex phenomena of SWM in the city, the research design of this study involved a hybrid approach Viz., qualitative and quantitative methodologies. Data were gathered through interviews supplemented by field observation and self-administered questionnaire. The analysis of the data employed SPSS software. In addition, secondary data were gathered from documents.

A total of 26 persons were interviewed from different stakeholders based on their experience and involvement in the SWM activities including households, city administration, Environmental Protection Bureau, Health Bureau and Micro and Small Enterprises (MSEs). Open-ended questions were used during the interviews to understand respondents' views about the extent of waste management activities such as waste composition, staffing, infrastructure, and fee.

The findings from the interviews and literature review provided a workable framework to develop a survey questionnaire. Self-administered questionnaire was used to describe the aspects, practices and challenges of SWM. The composition of respondents and the response rate by target Kebeles is illustrated in Table I. For the purpose of administering the questionnaire, 4 Kebeles which are most

prone to SW problems were purposively selected for having large number of industries, business places & population size.

TABLE I
SAMPLE COMPOSITION

Kebeles	Households			Organizations *(Industry/Business, Institutions & Hospital & Clinics)*		
	Sample size	No. of response	Sample proportion of response	Sample size	No. of response	Sample proportion of response
5	45	34	15.96	31	21	22.83
8	50	45	21.13	32	25	27.17
9	94	83	38.97	42	32	34.78
12	55	51	23.94	26	14	15.22
Total	*244*	213	100	*131*	92	100

Following [24], the sample size was taken to be 138. Considering compensation for non responses, for instance, the sample size for households is assumed to be 244. Accordingly, a total of 375 (244 + 131) questionnaires were distributed to the target categories (households and other organizations) and 305 questionnaires (213 + 92) were filled and returned (81.33% response rate). Prior to data gathering the questionnaire was pre-tested for ease of understanding and content validity.

III. Results and Discussion

A. The Current SWM System

Based on the data gathered through observation and from secondary sources, the SWM system setup, i.e., the solid waste collection and disposal operation in the city is shown in Fig. 2.

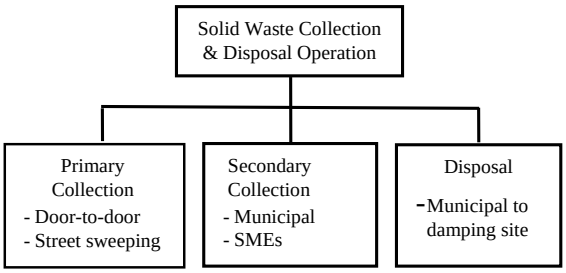

Fig. 2 A hierarchy of SWM in the city

Referring to Fig. 2, during primary operation, in door-to-door collection, households and other organizations have two options: either disposing waste into a nearby container or having contract agreement with MSEs to dispose it into the container using hand pushed carts. Each MSE serves more than 2000 households and other organizations. Most households and low income families prefer the first option as no cost is incurred on them. Some middle and high-income households prefer the second option. Besides, in primary operation though inadequate; the municipality provides street sweeping services twice in a day for a total of 58kms. The mode of the service is provided by:

(i) municipality sanitation workers and MSEs using facilities such as straw brooms, wheel barrow and shovel and
(ii) street side public garbage bins for street users and pedestrians drop some waste stuff in to the public garbage bins when they are out of their homes and business offices.

Data from Adama city administration revealed that the annual SW collection by the street sweepers is 2340m^3 comprising of 63% collected out of the 3750m^3 SW generated from the streets. The low performance is due to the inadequate number of dust bins in the locality and the lack of public awareness to drop SW, especially paper and plastic materials in the dust bins.

In the secondary operation, waste collection and transportation is carried out by municipality with two skip loaders and four vehicles from SMEs while in the third operation the transported waste is disposed by the municipality in an open controlled damping site 9Kms away from the city. This shows that the waste is not well managed.

Based on findings from the interview, the features of the current SWM practices and the challenges are summarized as follows:

(i) Almost all the interviewees stated that composition of the SW generated in the city are food and related waste, tree trimmings, paper, plastic, metals, glass, clothes/rags, vegetable and fruit flakes.
(ii) About 65% of the interviewees witnessed the SWM system of the city did not go hand in hand with the development of the city; and 62% of them stated that no effort has been made by the city administration to properly manage SW.
(iii) All the interviewees reported that the current SWM system of the city is very poor because of
- Lack of coordination among stakeholders;
- Insufficient communal containers (only 13 containers each 8m^3) were available in Kebeles 01, 05, 06 and 14 only and even those few containers were not picked when filled;
- Inadequate number of vehicles deployed; and
- Unavailability of performance measurement system in the entire SWM chain.

(iv) About 92% of the interviewees stated that SMEs and private collectors did not serve the community properly and regularly. Besides, there was lack of control by the city administration.
(v) 87% of the interviewees did not have any idea aboutthe amount of waste generated in the city.

In general, almost all the interviewees considered the SWM practice being not up to the mark and the services were not provided to the desired level. SWM has now been a problem not only to the city but also to rural areas causing impact on the environment and the inhabitants.

The data gathered through self-administered questionnaire are summarized as follows:

B. Profile of Respondents

The survey revealed that about 40% of the respondents were males and the rest 60% were females. 32% of participants were above 40 years of age while other 43% were

between the ages of 26 and 40. Most of the respondents' educational level was above high school (47%). About 75% of the respondents lived in Adama city for more than 10 years. So it was assumed that respondents could give reliable ideas about the issue under discussion.

The average monthly income of respondents was also considered as an important variable that could influence people's perception and attitude about SWM system in the city as SW generation rates have direct relationship with income level [25]. Accordingly, about 33% of the respondents had a high income level (>1200 Br), about 27% had middle income (600-1200 Br/Month) while 24% had low income (<600 Br). 15% of the respondents did not reveal their income level. 58% of the respondents were having a family size of 3-5 persons and 25% of them had 6-9 persons in their families.

The survey findings regarding the aspects of SWM is presented briefly in the following sections:

C. Characterization of Waste Generation & Composition

Respondents were requested to express their views about the characterization of waste composition and the amount generated. The result is illustrated in Figs. 3 and 4. As shown in Fig. 3, 42% of the household and 16% of the respondents from other organizations reported that food and food related wastes constituted larger portion of the SW generated followed by SW from plastics.

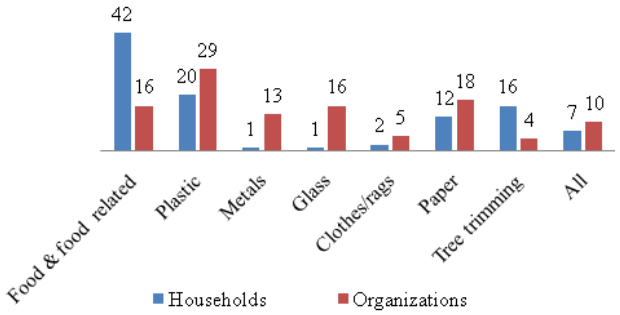

Fig. 3 Waste composition

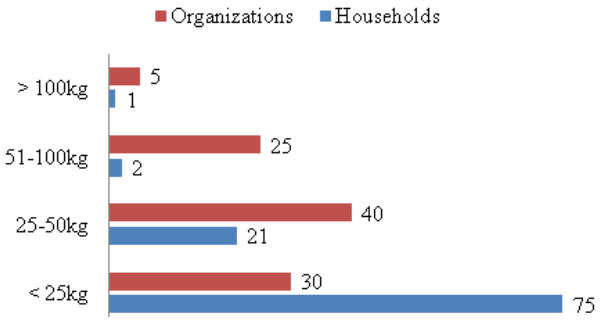

Fig. 4 Amount of waste generated

This is in line with [7], stating that largest stream of municipal SW in developing countries is from food wastes. Regarding the amount of waste generated (Fig. 4), majority of the households (75%) and 30% from organizations generated less than 25Kg/week while 21% of households and 40% others generated 25-50Kg/week.

Regarding the method/s respondents used to dispose the waste at their source, 44% of all the respondents stated that they damped food and food related waste, glass/ceramics and vegetable and fruit flake in containers while they mostly burned tree trimmings, papers and plastics. Another 17% stated that they recycled cloths/rags wastes. It was also found that the use of waste as fertilizer and the concept of disposing waste from the source were minimal.

D. Waste Storage and Sorting

When requested about the use temporary storage for SW and sorting at the source, almost all respondents stated that they have temporary storage. 66% of respondents from organizations implied that they stored SW separately while 58% of households stored indiscriminately. The detailed information is shown in Table II.

TABLE II
WASTE STORAGE AND SORTING

Items & Responses		Households (%)	Organizations (%)
Use of temporary storage	Yes	99	100
	No	1	0
Store separately	Yes	42	66
	No	58	34

In terms of the type of temporary storage used (Fig. 5), majority (85%) of households and 50% of organizations used sacks.

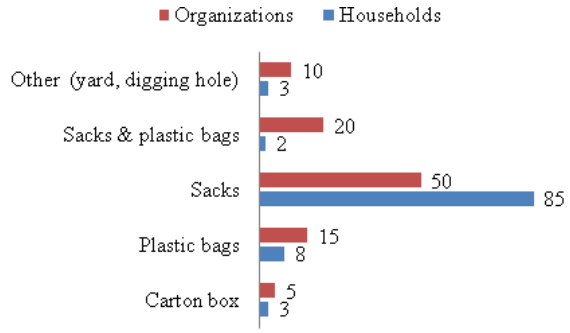

Fig. 5 Type of storage used

E. Frequency of Service

The information regarding the responsible body for collecting and disposing waste and the frequency of service is summarized in Table III.

TABLE III
FREQUENCY OF WASTE COLLECTION AND DISPOSAL

Items & Responses		Households (%)	Organizations (%)
Collection and disposal of SW	Private collectors	14	15
	SMEs	69	60
	City administration	3	5
	No response	14	20
Frequency of service/month	Once	19	35
	Twice	17	20
	Thrice	11	15
	> three times	40	25
	No response	13	5

Regarding the waste collection and disposal services, most of the respondents from the households (69%) as well as the respondents from organizations 60% stated that their waste was disposed by SMEs while the city administration gave the service sometimes. Regarding the frequency of disposal services, most of the time households reported they got the service more than three times in a month and organizations only once in a month.

F. Willingness to Pay and Amount Paid

Table IV summarizes the responses about the willingness of respondents to pay for the waste collection and disposal services and amount they pay.

TABLE IV
FEE RELATED TO WASTE COLLECTION AND DISPOSAL

Items and Responses		Households (%)	Organizations (%)
Amount paid to private collectors and SMEs for the service/month (ETB)[a]	< 10	22	15
	10-30	63	45
	31-60	1	2
	> 60	0	0
	No response	15	20
Amount paid to city administration for the service/month	10-30	1	5
	31-50	0	5
	51-70	0	0
	> 70	2	0
	No response	97	90
The amount paid for the service is affordable and enough	Yes	64	60
	No	27	20
	No response	9	20

[a] Ethiopian currency, Ethiopian Birr

Referring to Table IV, 63% of the households and 45% of other respondents paid 10-30 Br/month for the service provided by SMEs and private collectors while no response was obtained about the payment to city administration. However, very few stated the payment to be 10-30 Br/month. The majority of the respondents believed that the amount they pay for the service wasaffordable and enough.

G.Stakeholders' Perception about Environmental Protection

Table V summarizes the perception of respondents about the challenges in the current SWM system and their willingness to participate in the environment protection activities. The results indicate that about 34% of the households and 10% of the respondents from organization had containers in their locality and 24% of households and 7% of respondents from organizations replied that the containers were found more than 1km away from their vicinity.

In addition, about 51% of the households and 35% of the other respondents claimed that the capacity of the containers did not carry all the waste generated by the locality and containers were not picked up by the municipality before the waste overflowed. This view was in line with the interview findings. In addition, about 65% of the respondents told that no training was given about methods of handling SW, while 31% replied that sometimes the city administration provided training.

TABLE V
CHALLENGES IN THE SWM SYSTEM

Items and Responses		Households (%)	Organizations (%)
The current SWM system in the city	Having container in their locality	34	10
	Containers located >1km away from their vicinity	24	7
	Unsatisfied with the capacity of the container (not carry all the waste generated by the locality)	51	35
	Containers aren't picked before getting overflow	49	38
	Waste transportation mostly is by hand push carts.	41	5
	No training is given so far by the city administration about handling solid waste.	65	15
	Either highly unsatisfied or unsatisfied by the service	60	50
Willingness to engage in environ-mental protection through appropriate SWM system	Waste separation & pickup of recycling materials, like plastic, paper, metals, etc.	59	35
	Willing to pay for pickup of recycling materials	76	14
	Participate in the program of composting solid waste.	84	65
	Willing to return plastic bottles for recycling program	88	55
	Need information about the method & types of waste and how to reduce waste	90	75

In general, in evaluating the current SWM system of the city, 60% of the respondents from the households and 50% from the organizations were either highly unsatisfied or unsatisfied with the current SWM activities and services.

Respondents also showed interest to participate in the SWM activities of the city and more than 75% of them revealed that they would like to have more information about the method and types of waste they could compost, reuse, and recycle in order to reduce the amount of SW.

In general, the factors contributing to lower performance of the city's SWM were identified as having institutional, financial, policy, socio-cultural, technical and environmental aspects.

V. RECOMMENDATIONS AND IMPROVEMENT FRAMEWORK

The current scenario of SWM in Adama city needs to be improved by integrating successful SWM strategies into all stages of the chain. The city administration should enforce

mandatory regulations and needs to provide more technical supports.

Besides, the study put forward the following measures for a sustainable SWM in the city including:

- Organizing continuous awareness campaign for the all the stakeholders on how to manage SW properly.
- Re-establishing/improving the organizational structure of the WM with capable human labour responsible for managing SW.
- Encouraging SMEs and other individuals and companies to engage in SW collection and disposal through payment. This measure will not only helps to create job opportunity to citizens but also motivates them towards a better system of waste management through different means.
- Taking measures on those who illegally dispose wastes at any open spaces such as ditches. In fact the ditches in the city should be covered.
- To have a sustainable SWM system the city administration should follow participatory approach in the entire SWM activities. Hence, initiating and facilitating collaboration with all stakeholders, research institutions and universities.
- Encourage industries working on the recycling, reusing and energy and compost generation.

In addition,

- Appropriate facilities such as transporting vehicles, bins, other tools, and safety clothing must be provided as per the requirement of the waste to be disposed.
- Enough number of communal containers should be in place and SW needs to collect at optimum frequency so that waste should not be accumulated, overflowed or thrown in open spaces. To this end, World Health Organization (WHO) sets that one waste container should be used for 2000 inhabitants for developing cities in developing countries. This standard can be used to determine the required number of containers [5]. Hence, 137 containers are required for the city with the current population size.
- There should be a well-organized performance measurement system so that it could be possible to know how the SWM operation is being done and how to improve it.

If these measures are considered, the city administration can tackle the current SWM challenges and be able to deliver better services.

Besides, in order to improve the SWM of the city for sustainable public health and environment and to realize the benefit of this effort, there is a need to conceptualize a SWM improvement scenario. In view of this, a framework (Fig. 6) is proposed showing the four improvement initiatives for considerations, i.e. institutional capability, collaboration with stakeholders, availability of funding and facilities along with procedures for efficient SWM system setup.

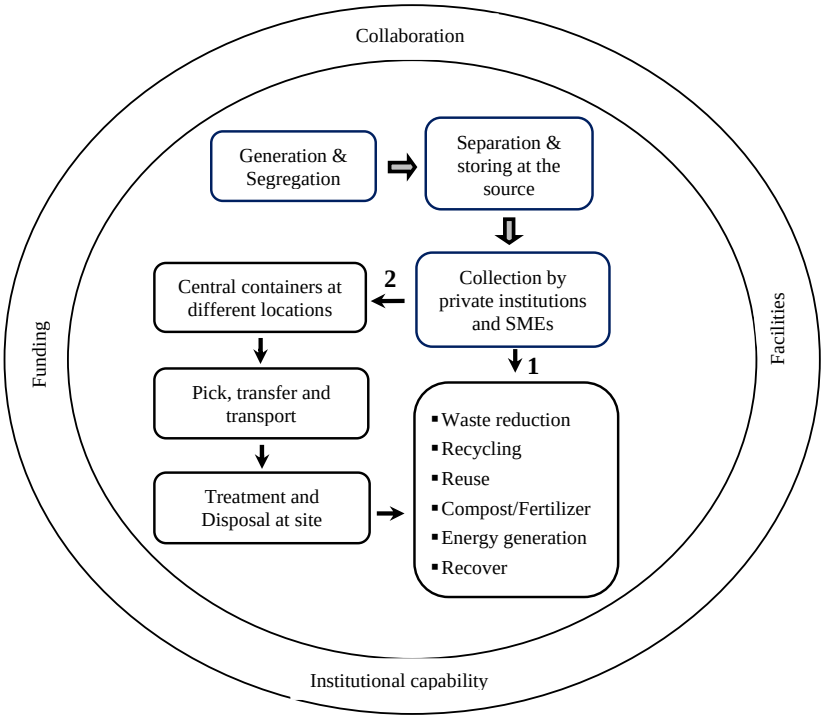

Fig. 6 Proposed SWM framework

As illustrated in the framework, the waste generated from different sources (households and organizations such as institutions, business and industry) is separated and stored temporarily at each source using card board boxes, sacks and

plastic bags. The SW is collected as separated by SMEs and other institutions. Depending up on the type of waste, there are two paths to consider for recycling or disposal: either directly (No. 1) to these programs or the waste is collected in containers placed at different locations of the city (No. 2). Then, the waste in containers is picked and transported by city administration and other private institution to dumping site and then to these programs.

VI. Conclusion

SWM is critical for sustainable development. Hence, municipalities and other stakeholders need to provide the SWM services to the public properly.

The study assessed the current SWM practices in Adama city and identified major challenges which need to be addressed. The qualitative and quantitative data analysis revealed that Adama, one of fast urbanizing cities in Ethiopia, has been unable to plan and implement sustainable SWM system in line with the city's development. This in turn can have its own negative impact on the public and the environment.

The study is hoped to contribute towards establishing a sustainable environment and public health initiatives in the city. It gives insight to decision makers in developing a reliable SW generation, separation, collection and transportation, treatment, disposal and recycling systems which will lead to establishing a relatively risk free city. It can also serve as base line for further studies. Future work focuses on conceptualizing and developing SWM improvement model for the country.

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