Assessment of Integrated Solid Waste Management Practices in Addis Ababa City: The case of Akaki Sub City, Ethiopia

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Abstract: Solid waste management is a significant public health and environmental issue in numerous cities across the world. The city of Addis Ababa (the capital city of Ethiopia) encounters pressing issues concerning the management of solid waste, the rapid rise in population, rapid development of city, and the economic endeavors that accompanying with shifts in lifestyle. This study aimed at assessment of Municipal Solid Waste Management (MSWM) practices in Addis Ababa, specifically in the chosen woreda of Akaki sub city. Consequently, to achieve the goals of the research, various methods were utilized in the study are which included questionnaire, interview, field observation/on-site monitoring, data analysis, and descriptive statistics. Both primary and secondary data sources were applied for the current study. Secondary data were gathered from various published and unpublished documents. The study used a total of 399 respondents. The study revealed that the average waste generation per capita in Akaki City was 0.49 kg/day/person in 2023 which is beyond the national average level of 0.33 kg/day/person. In total, about 76,996.24 tons of wastes were generated in the sub city annually. The study shows, the door-to-door collection service providers could collect about 145.43 t/d wastes from waste generators with service fees and 18.8 t/d wastes could be collected from street ditches and transported to waste transfer stations. Then, the municipality conducts the secondary waste collection service. From the total of 139.65 t/d wastes which is disposed to the final disposal site, 136.5 t/d of wastes are handled by the municipality and the industry owners or their delegates and the rest (3.15 t/d) will go to the disposal site. According to the study, in the meantime, around 1.63 t/d of decomposable wastes go to the compost preparation site and 3.62 t/d of recyclable wastes are collected by formal (2.69 t/d) and informal (0.94 t/d) waste recyclers. Periodically, these recyclable wastes are sold to waste recycling factories. Therefore, a sustainable transition of the current SWM practices is surely needed to overcome the environmental, economic, and social challenges caused by ineffective and inefficient SWM in the city.

Key Words: Integrated Solid Waste Management; Akaki Sub city; Waste Generation; transportation; Waste Storage and Disposal.

1. Introduction

Waste is a major and growing challenge for humans. By 2050, studies show that the expectation of waste generation will be increased by 70% globally [1, 2]. The waste administration in a given country is influenced by the economic, social, and political drivers of that country [3, 4]. Integrated Solid Waste Management (ISWM) is a holistic framework focused on reprocessing, composting, and dumping programs for a waste managing system [5, 6]. It includes the assessment of environmental conditions and needs, and then the selection and combination of the most suitable activities for waste management under those conditions. ISWM is becoming increasingly important for urban administration in developing countries [7, 8]. This is mostly due to the rapid expansion of cities and rapid population growth, which accelerates the generation rate of municipal solid waste (MSW) [9]. Developing countries spend about $ 46 billion per year on municipal solid waste [10, 11]. By 2025, the investment may exceed 150 billion U.S. dollars. Nevertheless, due to lack of proper planning, inadequate governance, limited technology, weak enforcement of current regulations and lack of economic incentives, ISWM including Ethiopia is often weak [12]. Solid waste management is a major public health and environmental concern in cities of many developing countries [13].

In most developing countries, waste is either spread in urban areas or improperly disposed of and dumped along slopes and gorges. Infrastructure, facilities, and skills for solid waste collection, transportation, treatment, and disposal are obsolete. The public's attitude towards proper collection and sorting frameworks is negative; as a result, environmental and health issues are becoming more prevalent in developing-country cities [14]. More than just waste collection is involved in waste management process which includes waste collection, transportation, processing, recycling, disposal, and monitoring. Environmental, economic, technical, legislative, institutional, and political challenges must all be considered [15]. In most African countries, due to population growth, the quantity and kinds of solid waste from households, public, and manufacturing activities are increasing [12, 16]. Due to the rapid increase in population, movement of people to metropolitan areas and expansion in industries, much pressure has been placed on solid waste management and the task has become difficult [16]. Solid waste management is a major public health and environmental concern in many African cities [17]. The generation and discharge of waste will have harmful effects on animals, plants, ecosystems, and the environment [13]. This waste management is needed to limit the damage to the surrounding environment and to recover scarce resources [18, 19].

ISWM services in Ethiopia were mainly a duty to municipalities. The service provision is threatened by a lack of collection and sanitary facilities and improper planning and coordination [14]. Until recently, waste remained a low priority issue in most municipalities and government agencies [14].To make waste management sustainable and environmentally friendly, an integrated approach is needed to coordinate the social, cultural, economic, and ecological impacts [20]. Urbanization with insufficient waste management practices, specifically widespread waste disposal in water bodies, dumping on the road, and uncontrolled dumpsites, exacerbates the problems of generally low sanitation levels across African countries, including Ethiopia [21]. The African continent's population growth and urbanization rates are alarmingly high, but the technology, technical know-how, financial capacity, community culture, and understanding required to properly manage solid wastes are insufficient [22, 23].

Effective waste management methods have been regarded as critical for economic development, particularly in low-income nations [22, 23]. The lack of knowledge, financial and technological deficiencies has also contributed to the poor management of solid wastes [23, 24]. In Ethiopia large amount of solid waste remains unmanaged and it affected the public health and the environment significantly [23, 25]. This is particularly true in Ethiopian higher institutions where SWM has become one of the priority issues in the institutional sustainability. MSW management is in a critical phase due to a lack of adequate infrastructure for the collection, transportation, treatment, and disposal of the increasing volume of the waste generated every day in metropolitan areas [25, 26]. MSWM is one of the critical services that Ethiopian municipalities are focusing on. This is primarily due to the fact that most Ethiopian towns do not properly handle and maintain solid wastes [26]. Addis Ababa City is known for its rapid population growth and urbanization. Because of the rapid increase in population and the rapid development of the city, the rate of solid waste generation has increased. The previous studies conducted in Addis Ababa Akaki sub-city shown that poor solid waste management. Considering these and other studies, the study tries to fills the gap by assessing the state of solid waste generation, collection, flow, and management in Akaki sub-city. As a result, the focus of this research was on the Assessment of Solid Waste Management Practices in Addis Ababa City Administration: the case of Akaki sub-city on a selected woredas.

2. Research Methodology

2.1 Description of the study area

2.1.1 Location

Addis Ababa is the capital city of Ethiopia. It lies between latitudes of 8°49'55.929" and 9°5'53.853" north and longitudes of 38°38'16.555" and 38o54'19.547" east. At the base of Mount Entoto, the city is located. The city rises to almost 3,000 meters in the Entoto Mountains to the North from its lowest position 2,114 meters above sea level in the Eastern fringe. It is situated at a typical elevation of 7,546 feet (2,500 meters). Its geography varies from gently undulating plains to hilly regions with comparatively greater gradients and a great number of rivers and stream valleys. There are 11 sub-cities in the City Administration of Addis Ababa, which covers a total area of 118.1 Km2 (ESS, 2022). One of Addis Ababa's largest sub-cities, Are Akaki subsites

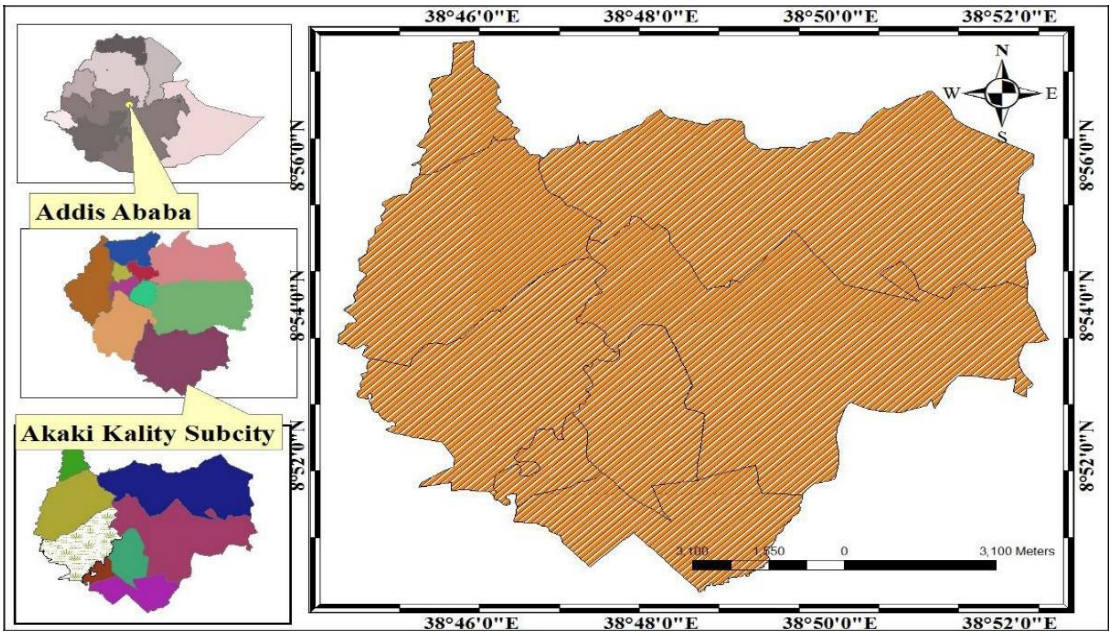

Figure 1. Maps of the study area of Akaki sub city

2.1.2 Population

The capital City of Ethiopia, Addis Ababa, has a total population of about 5,228,000 people and is expected to continue to expand at a 3.8% yearly pace, according to the 2014 demographic forecast (ESS, 2022). The same data states that males make up 47.4% of the city's population while females make up the remaining 52.6%. The overall
population is made up of 120,013 males and 135,335 females

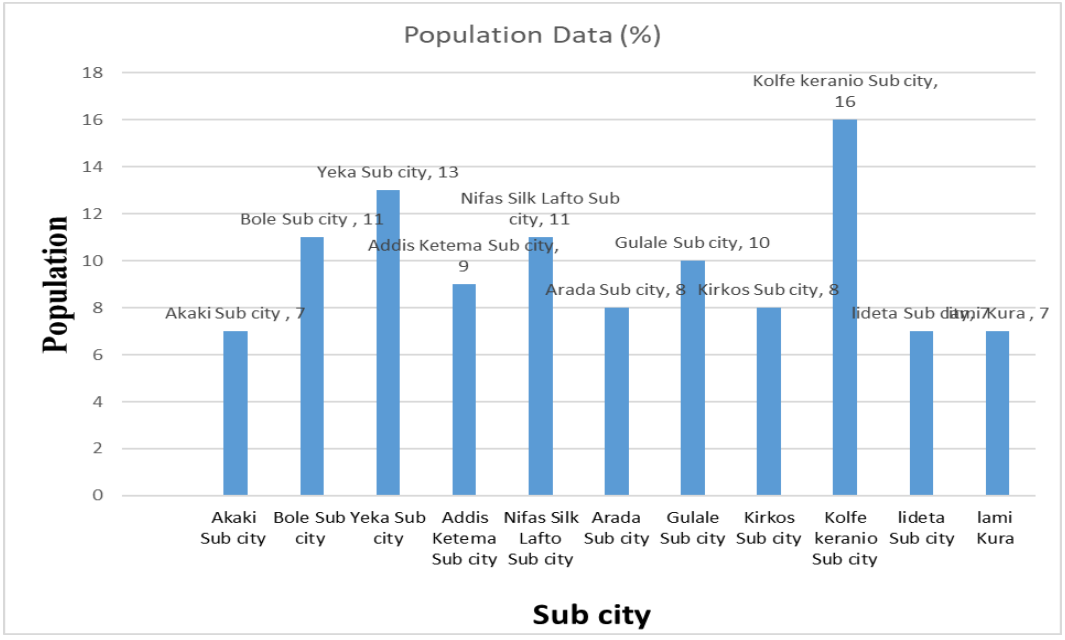

Figure 2. Population size in sub cities (Sources: ESS 2022)

According to the 2007 census and population progress of 2022, the total population of Akaki Sub city is 255,348 which is 8% of the entire population of the city.

Table 1. Population Density of Akaki Sub City by Woredas

(Source; Akaki Sub city Municipal Office)

Woreda	Area of the woreda/ha	Number of populations	Population Density (Pop/ha)
01	603.92	39,001	0.01
02	1323.61	22,379	24.46
03	235.96	20,710	172
04	1325.63	39,010	37
05	735.46	32,231	71
06	309.54	63,821	206
07	780.34	42,234	67
08	596.18	297,010	82
09	2847.61	11,863	4.2
10	1279.49	4,521	3.5
11	2,309.96	4,521	2
Total	**11810 ha**	**255,348**	41.67(average)

As indicated table1 above, Woreda 09 have the great share in terms of area which accounts 2847.61 hectare (24%), While Woreda 3 is the smallest area which accounts 235.96(2%). Woreda 11 have the highest population number which accounts 45,213(17.7%), While woreda 03 have the least population number which accounts 20,710(8%), Woreda)3 is the highest population density which is 172 persons is livening in 1 hectare.

2.1.3 Climate

Addis Ababa experiences a humid subtropical highland climate. The annual mean rainfall in Addis Ababa decreased by 36.45 mm in a decade, from 1025.06 mm, between 1992 and 2022. The year with the most rainfall, 1552.5", and the year with the least, "772.2"" June to the middle of September is the primary rainy season. The average maximum temperature in the study area fluctuates between 24.53°C in 2002 and 22.63°C in 1996, and the average minimum temperature fluctuates between 11.38°C in 2014 and 7.80°C in 1997.

2.2 Data collection methods

The data for this research were obtained from both primary and secondary sources. The primary source of data was collected through Questionnaires (both open and close ended) was held mainly for households to assess their disposal system, their attitude and awareness towards waste generation and proper management, to identify types of wastes they produce and to identify the causes of SWM problem that they are facing. A key informant interview has been made with sub-city administration officials, Cooperative

partnership association leaders, Sub-city and Woreda Cleansing Management leaders and experts. In addition, the researcher has directly observed the SWM operations taking place at stakeholders, institutions, groups and individuals in Akaki sub-city. Secondary sources of data were collected through reading and interpretation of documents, publications, annual performance reports and other related materials from city municipality and sub-city library.

2.3 Sampling procedure

To gather primary data, the researcher used both probability and non-probability sampling strategies. Non-probability sampling is the earliest sampling method. The initial woreda 1,4 and10 samples were deliberately selected. Geographical location, population density, and the availability of different infrastructures all play a role in making this possible. The second sampling method was the probability sampling method. A systematic selection technique was used to choose the respondents from Residences, Cooperative partnership associations, and sanitation administration staffs.

2.4. Sample size

To determine suitable sample size, a sample size formula provided by Taro Yamane (2001) was utilized. Assuming the city population size was around 255,348 and the number of households was estimated to be 66,529 based on the projection of Ethiopian Statistical Agency, 2007, and a confidence level of 95% and with a Margin of error (0.05), a sample size of 399 was calculated for household respondents. The sample sizes formula used to determine the sample size was described as follows:

$$\boldsymbol{n = \frac{N}{1 + N(e)^2}}$$

Where,

N: is the total population
n: is the required sample size
e: is the margin error

Table 2. Sampling distribution

Selected sub-city	Sampled woreda	Sample No of HHs	No of em-ployee	Sample MSEs Members	Sampled inter-viewed Kebeles team Leader	Total sample size
Akaki sub-city	1	68	20	36	2	126
	4	66	15	30	2	113
	10	83	35	40	2	160
Total	3	217	70	106	6	399

2.5 Data management and analysis

The presentation, analysis, and interpretation of data gathered from homes, the Akaki sub-city office, and field research are the topics of this part. Both qualitative and quantitative techniques were used to analyze the data. Open ended questions and interviews received qualitative responses, whereas closed-ended questions were given quantitative responses. Examples of percentages, tabular analysis, and frequency distribution quantitative methods. Among the qualitative methods employed were links between causes and effects and inductive and deductive reasoning. Using the computer program SPSS version 20, questionnaires were analyzed using quantitative techniques, i.e. tables, which were frequently utilized to illustrate the acquired data. Using descriptive data analysis approaches, frequency, percentage, mean, standard deviation, and graphic representation were produced.

3. Results and Discussion

3.1. Institutional Aspects of Solid Waste Management

According to the survey results (table 3), the respondents' level of agreement with the questions asked regarding institutional aspects of SWM. As a result, the majority of respondents agreed that there is integrated solid waste management practice between private and public agencies (M= 4.16 & SD= 1.185), the highest value, and there is proper institutional set-up for solid waste (M= 1.19 & SD=.394), which scores low mean and SD. We can conclude from the above findings that a lack of appropriate personal protective equipment for waste collection, such as gloves, eye and face protection, footwear, and so on, is one of the challenges raised by workers during an interview and confirmed by observing their situation while performing their day-to-day waste-collection activities. For example, the respondents asked that, there is proper institutional set-up for solid waste, have a mean value of 1.19 & SD=.394, this indicated that there is no proper institutional set-up for solid waste management in the study area. but regarding their contract period, the respondents weather agreed or not on the idea, they reply that they have no sufficient and consistent waste management contract period with the municipality which indicated by mean value of 1.15 and SD =.361. In accordance with this, the AKBPD staff head stated that "the municipality has only a few old cars used to collect waste throughout the sub city of the selected area, because the car, which municipality used to transport solid waste, was very old, it spent most of the time in a garage to be fixed," which resulted in an insufficient and inconsistent waste management contract period.

Table 3. Institutional related factors of solid waste management in 2022/23

Item	N	*Mean	Std. Error	**SD
	Statistic	Statistic	Statistic	Statistic
There is proper institutional set-up for solid waste Management service.	399	1.19	.027	.394
Several institutions or agencies are involved in solid waste management	399	3.40	.087	1.274
We have sufficient and consistent waste management contract period with the municipality.	399	1.15	.025	.361

Item	N	*Mean	Std. Error	**SD
	Statistic	Statistic	Statistic	Statistic
There is integrated solid waste management practice between private and public agencies.	399	4.16	.081	1.185
Our company has faced frequent customer complaints about solid waste management in its assigned jurisdictions.	399	3.40	.078	1.139
The decentralization approach is common in your company.	399	3.13	.074	1.090

Note: * the average, which is found by adding up all the values in a set of data and dividing it by the total number of values you added together
**is a measure of how dispersed the data is in relation to the mean. Low standard deviation means data are clustered around the mean, and high standard deviation indicates data are more spread out.

3.2. Applying Technology on Solid Waste Management

Participants in the survey are requested to asked about applying technology on SWM, and then they stated that appropriate technologies are applied for monitoring trucks during the transportation of solid waste (which obtained the highest average score of 4.19 and standard deviation of 1.18), whereas appropriate technologies are frequently used for monitoring waste garbage in the field which received a lower average score and standard deviation (3.94 M and .90 SD), respectively as depicted in (Table 4). On the other hand, survey respondents confirmed that generated solid wastes are appropriately recycled before disposed of in sub-city which have a Mean value of 3.38 and SD of 1.03, this implies that Solid waste information from the field is usually gathered using technologically based instruments. Conversely, the remaining survey participants indicated that our company possesses sufficient and modern waste management equipment, with an average score of 3.87 and a standard deviation of 1.07. This indicates that the transportation of solid waste is carried out using appropriate technology-based equipment

Table 4. Applying Technology on SWM

Items	N	Mean		SD
	Statistic	Statistic	SE	Statistic
Transportation of solid waste is done using appropriate technological based equipment.	399	2.79	.084	1.227

Solid waste information from the field is usually gathered using technologically based instruments.	399	3.53	.061	.895
Appropriate technologies are frequently used for monitoring waste garbage in the field.	399	3.94	.061	.900
Appropriate technologies are applied for monitoring trucks during the transportation of solid waste.	399	4.19	.081	1.181
Our company has adequate and modern waste management equipment.	399	3.87	.073	1.071
Generated Solid wastes are appropriately recycled before disposed of in sub-city	399	3.38	.070	1.033
Transportation of solid waste is done using appropriate technological based equipment.	399	2.79	.084	1.227
Solid waste information from the field is usually gathered using technologically based instruments.	399	3.53	.061	.895
Appropriate technologies are frequently used for monitoring waste garbage in the field.	399	3.94	.061	.900
Appropriate technologies are applied for monitoring trucks during the transportation of solid waste.	399	4.19	.081	1.181
Our company has adequate and modern waste management equipment.	399	3.87	.073	1.071
Generated Solid wastes are appropriately recycled before disposed of in sub-city	399	3.38	.070	1.033
Grand mean		**3.62**	**0.072**	**1.0512**

3.3 Respondents Knowledge on Solid Waste Management

In terms of respondents' knowledge of solid waste management, the majority 156 (39.1%) disagreed on the entire process of an integrated SWM system, while 114 (28.8%) strongly disagreed and only 128 (32.1 %) agreed. On the other hand, 161(40.5%) and 122(30.7%) disagree and strongly disagree, 92 (23.3%) and 24(5.6%) agree and strongly agree, and in the same table, 187 (47%) and 141 (35.3%) also disagree and agree on solid waste management knowledge respectively (Table 5). As a result of the above findings, one can conclude that the reasons for the lack of solid waste management knowledge were improper solid waste disposal,

a lack of door-to-door solid waste collection services, and a lack of communal solid waste containers. The key informant interviews support this point of view; a 35-year-old female street sweeper stated that "the Akaki sub-city neighborhood has a bad attitude towards waste collectors and solid waste management." As a result, they simply dump domestic waste along the road and in drainage.

Table 5. Knowledge on solid waste management (SWM)

Variables	Responses	Frequency	Percent	Cumulative Percent
I know the whole process of integrated SWM system	Strongly disagree	114	28.8	28.8
	Dis-Agree	156	39.1	67.9
	Agree	128	32.1	100.0
	Total	399	100.0	
I know public health problems are associated with a poor SWM system.	Strongly disagree	122	30.7	30.7
	Dis-Agree	161	40.5	71.2
	Agree	92	23.3	94.4
	Strongly agree	24	5.6	100.0
	Total	399	100.0	
I know well the rule and regulation of solid waste management in the municipality	Strongly disagree	45	11.2	11.2
	Dis-Agree	187	47.0	58.1
	Agree	141	35.3	93.5
	Strongly agree	26	6.5	100.0
	Total	399	100.0	

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The survey results also show how little knowledge of integrated solid waste management the city's municipal government has raised. According to (Table 6) 299 respondents (74.9%) said they had no knowledge of integrated solid waste management, whereas 100 respondents (23.3%) said they had. In addition, those sample participants who indicated "Yes or agree" (those who received instruction, training, or knowledge about solid waste management) were asked about their source. In the same table, the majority of 128 respondents (59.5%) disagree, while 162 (38.6%) said they obtained their information independently, from the kebele, but regarding a solid waste small and micro-enterprise is well educated and informed on SWM in their respective area.

230 (57.7%) disagree, 92(23.3%) strongly agree and 44(11.2%) agree on the question. However, according to the survey results, lack of public awareness and attitudes creation priority was another challenge for the sub city towards integrated solid waste management. The majority of the households were not well informed about the consequences of poor solid waste handling and disposal methods.

Table 6. Knowledge on solid waste management

Variables	Responses	Frequency	Percent	Cumulative
	Strongly	8	1.9	1.9

	disagree			
I develop my knowledge of the SWM system by frequently sharing experiences with others.	Disagree	299	74.9	76.7
	Strongly agree	92	23.3	100.0
	Total	399	100.0	
I obtain sufficient job short-term training about integrated SWM systems.	Strongly disagree	4	1.9	1.9
	Dis-Agree	237	59.5	61.4
	Agree	162	38.6	100.0
	Total	399	100.0	
A solid waste small and micro-enterprise is well educated and informed on SWM in their respective area.	Strongly disagree	8	1.9	1.9
	Disagree	230	57.7	59.5
	Not sure	24	6.0	65.6
	Agree	44	11.2	76.7
	Strongly agree	93	23.3	100.0
	Total	399	100.0	

The majority of respondents 310 (77.7%) had not received any information about how frequently their sub city picks up garbage. Aside from that, the majority of 191 (47.9%) of respondents stated that there was no full and continuous training on solid waste collection by sub-city. In terms of whether the sub city has provided enough collection points near all beneficiaries, respondents 180(45.1%) disagreed, 74(34.4%) strongly agreed, and 296 (74.4%) disagreed, while only 54(13.5%) strongly agreed (table7)

According to the study, communities were unaware of the performance of solid waste management practices in the study area. Based on the major findings of the current study, the study recommend that the sub-city administration install trash bins near the communities' residences. Municipalities should educate residents about environmental and human health issues, as well as the effects of solid waste.

Table 7. The performance of solid waste management practice in the study area

Variables	**Responses**	**Frequency**	**Percent**
Frequency of waste pick–up is strictly followed by our sub city	Strongly disagree	45	11.2
	Disagree	310	77.7
	Not sure	8	1.9
	Agree	26	6.5
	Strongly agree	10	2.8
	Total	399	100.0
There is full and continuous training on solid waste collection in our company.	Strongly disagree	78	19.5
	Disagree	191	47.9
	Not sure	28	7.0
	Agree	76	19.1
	Strongly agree	26	6.5

	Total	399	100.0
The sub city has facilitated enough collection points near to all beneficiaries.	Strongly disagree	13	3.3
	Disagree	180	45.1
	Not sure	48	12.1
	Agree	135	34.4
	Strongly agree	23	5.1
	Total	399	100.0
Our sub city maintains waste spillover to the ground at collection is cleaned	Disagree	296	74.4
	Not sure	17	4.2
	Agree	32	7.9
	Strongly agree	54	13.5
	Total	399	100.0

As per the data in (table 8) about 302 (75.8%) of the respondents revealed that they know that solid waste has economic impact, while the rest 97 (24.2%) of the selected households stated that they did not knew that the solid waste has economic impact and 319(80%) agreed that they know how much solid waste have health impact but 80(20%) they did not know. Regarding solid waste have environmental impacts or not 358(88.4%) and only 41 (11.6%) disagree that solid waste has no an environmental impact, and 98(24%) agreed that solid waste used as a resource, but majority of the respondents 301(76%) were disagreed that solid waste not used as a resource.

According to in-depth interviews with cooperative partnership association leaders, households' knowledge of the value of such discarded wastes for "kuraleos" and "Liwach" and their poor economic performance prompted them to segregate store such wastes in order to generate income and purchase new household items. The responsibility for this domestic activity is heavily distributed across cooperative partnership associations. In other words, the information should give an assurance about whether the public (generators) are aware of the negative aspect of inappropriate solid waste management.

Item	Response	Frequency	Valid per-cent	Cumulative percent
Do you think solid waste have economic impact?	Yes	302	75.8	75.8
	No	97	24.2	100
	Total	399	100	
Do you think solid waste have health impact?	Yes	319	80	80
	No	80	20	100
	Total	399	100	
Do you think solid waste have an environmental impact?	Yes	354	88.6	88.4
	No	45	11.4	100
	Total	399	215	

Do you think solid waste have health impact?	Yes	319	80	8
	No	80	20	100
	Total	399		
Do you agree solid waste used as a resource?	Yes	98	24	24
	No	301	76	100
	Total	399	100	

Table 8. Local community's perception towards solid waste management

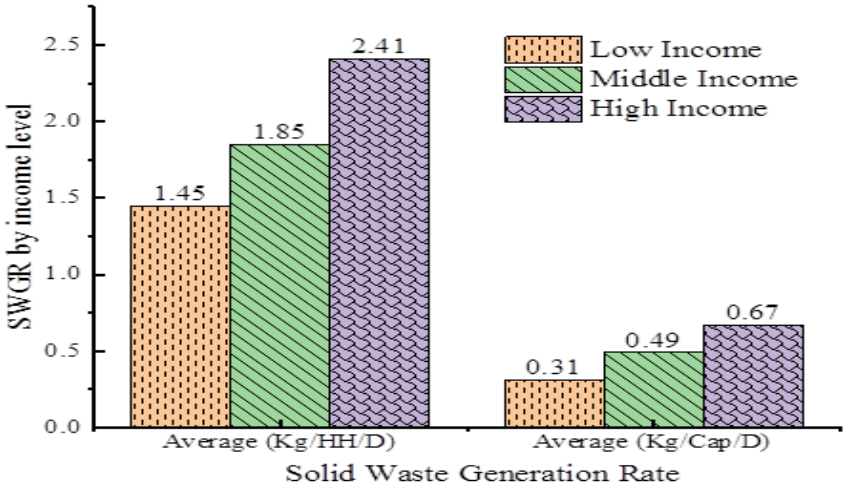
3.4. Current Solid Waste Management practice of Akaki Sub City

3.4.1 Solid Waste Generation Rate

MSW generation rates vary widely within and between countries. The generation rates depend upon income levels, socio-cultural patterns, and climatic factors.

Figure 3. Solid waste generation rate of Akaki sub-city

There is a strong positive correlation, with the median generation rates in high-income countries is about six-fold greater than in low-income countries. There is also considerable variation within countries. Waste generation per capita has risen markedly over the last 50 years and shows a strong correlation with income level [27]. The solid waste generation rate is the amount of solid waste produced form the given source at a given time. Per capita solid waste generation from different income levels household and different source was investigated during the study.



The level of industrialization, societal preferences, and regional climate all have an impact on MSW generation rates. In general, the amount of solid trash produced increases with economic growth and urbanization rates. Urbanization and income levels are closely related. Figure 3 shows that the average waste generation per capita per day is 0.49 kg while the average waste generation rate of households is 1.94 kg per day. The result of the study from different income level households in selected woredas of Akaki sub-city were 0.31, 0.49, and 0.67 (kg/c/d) LIHH, MIHH, and HIHH respectively. This in turn contributes to more than 213,878.44 kg or 213.878 tons per day waste generation in the sub city. This also in turns contributes more than 76,996,238.4kg or 76,996.238 tons per annual waste generation in the sub city.

3.4.2 Composition of municipal solid waste

Municipal solid waste is a word that is frequently used to describe a range of solid waste produced in urban areas, as described in the review of literature portions of this research. However, biodegradable and non-biodegradable waste are the two categories into which urban waste is typically divided.

Figure 4. The current Condition of wastes at the site of transfer station in Akaki Sub city

Organic waste such as food waste, garden waste, and agricultural waste undergo biological degradation under controlled conditions and can be turned into compost. However, the two categories into which urban garbage is commonly separated are biodegradable and non-biodegradable waste. As the information obtained from different bodies and direct observation of the study area, the sources of wastes generated in Akaki sub city is households, street, commercial institutes, industries, hotels, hospitals, construction and demolition wastes. As shown in Figure 5, the majority (52.84%) of the household waste was dominated by food waste including food leftover and other kitchen fruit and vegetables remains. About 10.33% of the household solid waste was leaves and grasses. Plastic waste (9.61%) is third most abundant composition followed by paper waste (4.99%). In addition, about 8.27% of the household solid waste has shown a hazardous solid waste composition such as diapers & sanitary napkins (7.07%) and other wastes with pharmaceutical in nature (1.2%). In general, about 74.29% by weight of the household solid waste in the sub city is microbially decomposable organic waste. Whereas, the remaining 17.41% of the solid waste is easily recyclable solid waste including plastics, textiles, glass, metals and aluminum waste. In general, the current practice has shortcomings in terms of solid waste separation and sorting at the point of generation. Aside from these, construction and demolition waste, which consists of broken pieces of ceramics, sands, soil, stone, nails, and cement concrete, is also visible in the city. This is due to the town's high construction activity, and such wastes are not stored by waste generators within their compound, but rather deposited just outside in streets and open areas; however, wastes from construction activities containing cement products have a high re-use value.

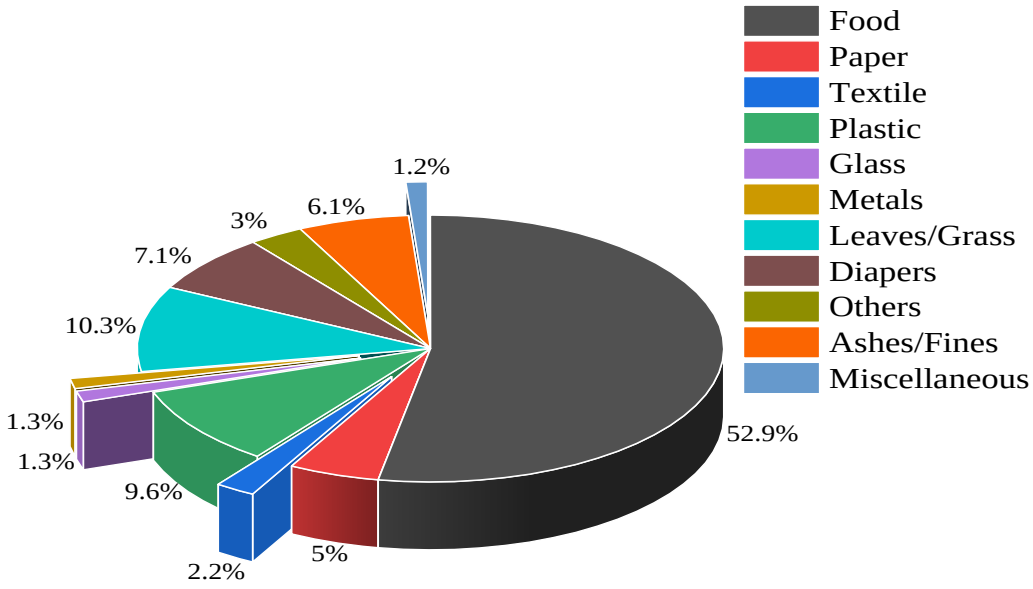


Figure 5. Akaki Sub city MSW Composition (Source: Survey Result, 2023)

3.4.3 MSW collection and transportation systems

The Akaki sub-city's current MSW collection system is a house-to-house collection system, and when the sign for solid waste collectors is heard, the waste generators take their rubbish. There are 286 places solid waste collectors collect and temporarily dumping solid wastes. Out of these 53 sites are solid waste plats. Solid waste from temporary duping site to solid waste plate transported by small track and hand pushcarts. Following collection, hauled container lifter and compressor trucks deliver solid garbage to the Reppi waste to energy recovery plant. According to the study, there are 53 locations for container lifer and compacter truck loading. Transport of solid waste currently in place as measured from the truck loading location to the Reppi waste-to-energy plant.

3.4.4 Solid Waste Disposal Practices in Akaki Sub city

3.4.4.1. Households' Solid Waste Disposal Practices

Sample households were asked about the availability of solid waste communal containers in their respective surroundings to check the provision of appropriate solid waste collection and transportation services. As shown below in (Table 9) 337 (84.4%) of sample respondents were stated that communal solid waste container is not available and the rest 62 (15.6 %) of sample respondents stated that public solid waste container is available. In addition to the availability of the communal solid waste container, the accessibility of solid waste storage container was asked to know the average distance between a residence and a communal container so, a container is located between 20 -50 meters radius for 49 (11.5%) of households; between 51 - 100 meters for 72 (18%) of households ; between 101-200 meters for 79 (19.7%) of households ; between 201 - 500 meters for 111 (27.9%) of households, and more than

500 meters for 92(23%) percent of households. Consequently, the same respondents were asked if they have participations in deciding the location or placement of the containers in their respective areas and most of the respondents, about 386 (96.7%) stated that they had no participation or say in choosing or deciding the location for the containers in their areas; whereas 13(3.3%) of the respondents acknowledged their participation in choosing and deciding for the containers.

Table 9. Availability, Distance and participation on deciding container placement

Category	Variables	Frequency	Percentage (%)
Availability of Waste Disposal ContainerNear Home Location	Yes	62	15.6
	No	337	84.4
	Total	399	100
Distance of the Container from HomeLocation	20-50 meters	49	11.5
	51-100 meters	72	18.0
	101-200 meters	79	19.7
	01-500 meters	111	27.9
	>500 meters	92	23.0
	Total	399	100
Participation of Respondent in Deciding the Location/placement of Waste Container	Yes	13	3.3
	No	386	96.7
	Total	399	100

3.4.4.2. Existing Situation and Management of Solid Waste Disposal Site

Solid waste collection and transportation is not an end to solid waste management. There has been one open dumpsite, named "Reppi" or "Koshe", which has been giving service for all sub cities in Addis Ababa city since 1964.

Figure 6. Koshe solid waste open disposal site view

The site has served beyond its design period and has been a source of serious public and environmental health threats. It has a surface area of 25 hectares. The site is located in the southwestern part of the city in Kolfe Keraniyo sub-city, some 13 km away from the city center. Waste of all nature is indiscriminately disposed with no further treatment in the existing dumping site. The windblown waste is scattered all over the site and some light plastics and paper might travel back all the way to the city. Hauling of solid wastes and final dumping is not well scheduled & coordinated as refuses are observed to have been disposed of haphazardly, litters spatter everywhere before reaching the designated final dumping site and such practices are even worsen during the rainy seasons.

Figure 7. The internal condition of Koshe open disposal site.

As shown in (Figure 7), wastes on the disposal site are not properly managed. This site also has no proper fence which prevents

animals from entering and it is creating a rotten smell whenever passengers crossing the roads on both sides. Each day more than 213.878 tons of solid wastes are expected to be disposed of by the municipality However, concerning the expected waste generation capacity per day 65% of solid waste in the Sub city is properly disposed of. Due to the lack of waste disposal capacity, 35% of solid waste is not disposed of. As a result, the city's residents have become uncomfortable, resulting in environmental pollution.

3.4.5 Solid Waste storage facility and its handling

As can be seen from (Table 10) below selected sample respondents were asked first that they have temporary solid waste storage material and the result showed that 279(70%) of sample respondents had temporary solid waste storage material while the remaining 120(30%) of sample respondents do not have temporary solid waste storage material and with regard to the materials they use to store their solid waste at home by giving them alternatives in the form of multiple choices, the following results were obtained from the subject survey households. Residents of Akaki sub city used a different type of storage materials in their compound which is bamboo basket and sacks local name of "Madaberia" plastic containers local name "festal" and others. The result has indicated that 259 (65%) of the sample's respondents used "Madaberia" as their hometown name. Due to their frequent but low waste generation and financial ability to use replicable storage materials like plastic bags, this is highly related to the least expensive sack, easy market availability, suitability for holding large volumes of solid wastes, and ease of delivery by MSEs of the City. According to the study, of the 91(23%) plastic container and 21(5%) used other material for solid waste storage at home.

Table 10. Solid waste storage material used by sample households

Variables	Categories	Frequency	Percent
Possession of Temporary Solid Waste Storage Facility	Yes	279	70
	No	120	30
	Total	399	100
Type of storage material	Bamboo basket	28	7
	Sack	259	65
	Plastic container ('festal')	91	23
	Other	21	5
	Total	399	100
Do you use MSE to dispose-off your solid waste?	Yes	103	26.0
	No	296	74.0
	Total	399	100.0

3.4.6 Recycling and Reusing of Wastes Practices in the City.

The city has eight MSEs working on this subject who organize waste recycling activities. Five of them are involved in the free and paid collection of plastic waste from streets and waste transfer facilities. Waste that is recyclable and useable is collected by three Enterprise from the landfill. In the metropolis, there are also unofficial waste scavengers who work to manage urban waste sustainably in order to make money. Periodically, recyclable waste collectors will provide these wastes to the plastic and metal sectors in exchange for a fair payment. Even while the businesses tackling these problems are making a significant contribution to keeping the city free of unwanted waste, they are experiencing a variety of difficulties in their job. this work brought up were the lack of storage space until they sold to recycling industries because that requires a lot of land, the lack of funding, the high transportation costs associated with related collection and purchases from informal collectors, the lack of machinery for compacting to make transportation easier, etc. It can be encouraged to process the gathered wastes by changing their shapes and values to make it more profitable if great attention and support from all responsible bodies are in place.

Figure 8. Plastic Recycling Collection Activities Survey (Source: Field Result, 2023)

3.5. Current Solid Waste Management Service

Solid waste management is one of the services the Sub City administration provides for its residents. As service quality, environmental impacts, and operational costs. Regarding the survey results, majority of the respondents 290 (72.6%) were have no store waste separately at their home and only 109 (27.4%) of them were store waste separately and about 50 (12.6%) of the respondents practice solid waste re-use at their home while only 104 (26 %) of them were used MSSE to dispose-off wastes. According to one of the KII; we had also assessed the availability of waste storage containers in the town and all of the selected households stated as there is no container in all parts of the town and witnessed by our observation. According to one of a 30 years old male DBBPD staff members, "there were around 11 containers bought by the municipality in 2016, but they didn't place in the town and serve the community because the municipality had no lift truck to transport those containers from transfer station to final disposal site" (Table 11).

Table 11. SWM attitude assessment question and respond of households

Variables	Categories	Frequency	Percent
Do you have temporary solid waste storage at your home?	Yes	109	27.4
	No	290	72.6
	Total	399	100
Do you segregate waste at your home?	Yes	117	29.3
	No	282	70.7

	Total	399	100.0
Do you practice solid waste re-use at your home?	Yes	50	12.6
	No	348	87.4
	Total	399	100.0
Do you use MSSE to dispose-off your solid waste?	Yes	104	26.0
	No	295	74.0
	Total	399	100.0

3.6 Solid Waste Management Flow in the Sub City

The SWM process flow chart in the Akaki sub city diagram in (Figure 9) explains all the MSWM systems at one including the major waste generators, waste collection services, waste transfer stations, waste disposal site, main stakeholders, and their activities as follows. According to the study, the amount of waste generation in Akaki sub city. is estimated to be about 213.878 tons per day (t/d) of which 145.44 t/d, 34.22 t/d, 12.78 t/d, 3.2 t/d, and 18.18 t/d are generated from residential, commercial, institutional, industrial, and street sweepings respectively. About 145.43 t/d wastes could be collected by door-to-door collection service providers from waste generators with service fees and 13.48 t/d wastes could be collected from street ditches and transported to waste transfer stations. service. About 139.65 t/d wastes can be disposed to the final disposal site of about 136.5 t/d wastes are handled by the municipality and the industry owners or their delegates could transport about 3.15 t/d to the disposal site. In the meantime, around 1.6 t/d of decomposable wastes go to the compost preparation site and 3.63 t/d of recyclable wastes are collected by formal (2.69 t/d) and informal (0.94 t/d) waste recyclers. Periodically, these recyclable wastes are sold to waste recycling factories. Then, the municipality conducts the secondary waste collection.

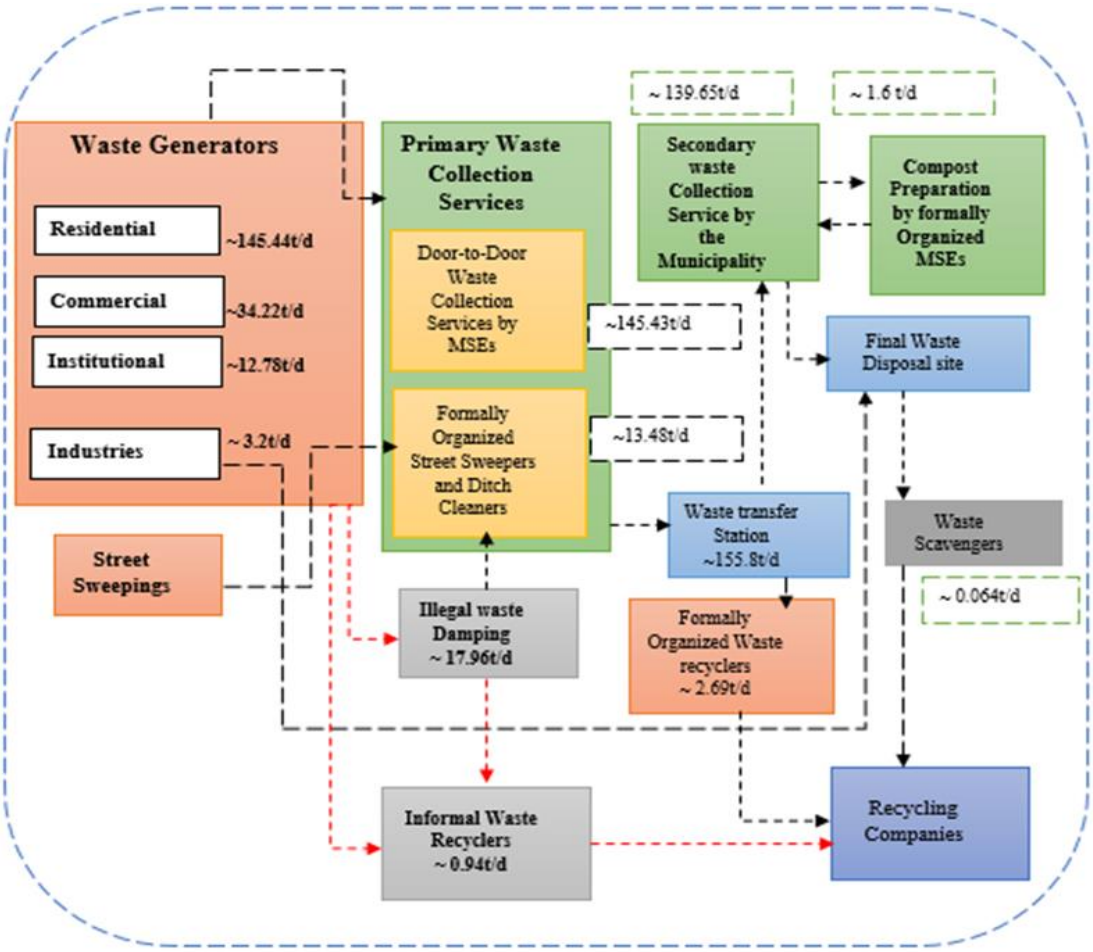


Figure 9. SWM Process Flow Chart in Akaki Sub City.

Source: Organized by the researcher from survey result, 2023.

4. Conclusion

The study found that the three main factors that worsen the city's current municipal solid waste management practices. These are institutional, technical, and sociocultural factors. The overall service systems are very poor. The coverage of the service is very limited, door-to-door waste collection coverage is only 68%. There is only 3.63 t/d waste recycled by formal and informal waste recyclers. The average waste generation rate capacity of a single person in the city is 0.49 kg/day/person, which is beyond the estimate at the national level, which is 0.33kg/day/person. Annually, about 76,996.24 tons of wastes are generated in the sub city. According to the study, the composition of this waste is 59% Food, 10% Plastic, 10% paper,9%Yard,4%Glass 2%Metal, 1% Wood,1%Hazardous and 4% others. This means that 147.889 tons of organic waste, 21.38 tons of plastic, 4.28 tons of metal, 8.6

tons of glass,19.5 tons of yard and 8.6 tons of other waste is generated per day. The treatment of quantities of waste will comprise landfilling approximately 70% since currently only 1.2% of organic waste will be composted. The study shows, about 30% of the waste will be recycled including metal, plastic, and glass. The study found that the waste management system of Akaki sub city city can be irregular, inadequate, and inefficient in waste collection, transportation, treatment, recycle, reuse and disposal of wastes. Therefore, the study underline that 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.

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