Waste Generation and Composition Analysis

Waste Stream Assessment

1

Quantity

Waste stream assessment determines the amount of waste generated in a community, both in terms of ***weight*** and ***volume***. This information is vital for making decisions about the SWM system, finance, and regulations.

2

Composition

The assessment ***identifies the different components*** of the waste stream, which helps in targeting waste management activities and setting goals for different elements of a waste management plan.

3

Sources

Identifying the sources of waste, such as ***residential***, ***commercial***, ***institutional***, and ***industrial***, allows for the development of tailored waste management strategies.

Rationale for Waste Stream Analysis

1. **Planning and Design**

   Waste stream analysis provides the basic data needed for planning, designing, and operating effective waste management systems.

2. **Monitoring Changes**

   Ongoing analysis helps detect changes in waste composition, characteristics, and quantities, facilitating the implementation of appropriate management systems.

3. **Recycling and Recovery**

   The analysis quantifies the amount and type of materials suitable for processing, recovery, and recycling.

4. **Technology Selection**

   The data helps in deciding appropriate technologies and equipment for waste management.

Waste Generation

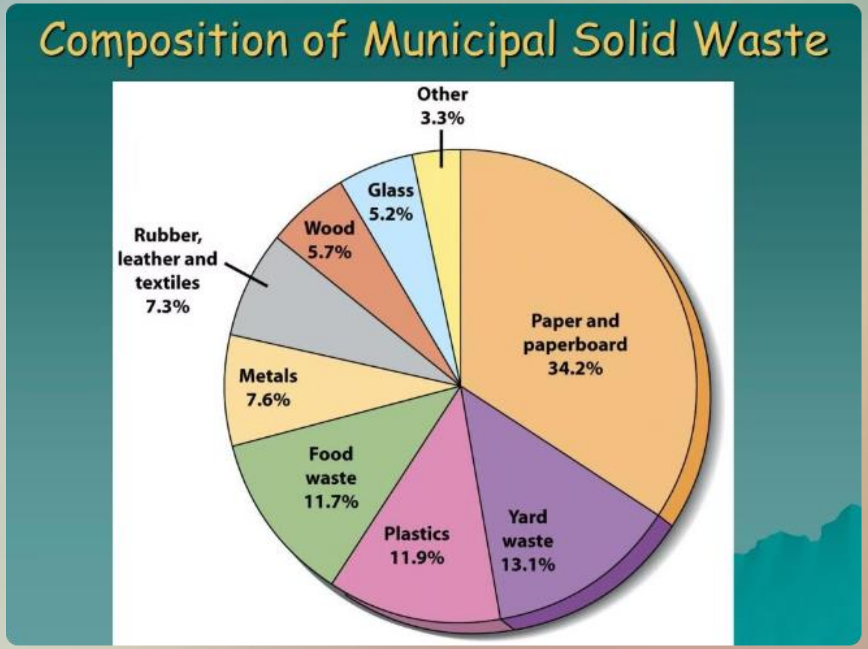
Definition

Waste generation encompasses the activities in which waste, be it **solid** or **semi-solid material**, ***no longer has sufficient economic value for its possessor to retain it***. It begins with the processing of raw materials and continues at every step in the process as raw materials are converted into final products for consumption.

Reduction Strategies

The amount of solid waste can be reduced by limiting the ***consumption of raw materials*** and ***increasing the rate of recovery and reuse***. This requires a societal change in the perception of wastes, which can be challenging to implement without appropriate management solutions.

Waste Composition



Major Components

The major constituents of ***municipal solid waste are paper and decomposable organic materials***. Other common components include metal, glass, ceramics, textile, dirt, and wood, with their relative proportions depending on local factors.

Physical Characteristics

Factors such as ***moisture content***, ***density***, and ***relative distribution*** of waste components are important for the characterization of solid waste and its management.

Socioeconomic Factors

Waste composition varies with the socioeconomic ***status within a community***, as ***income***, ***lifestyle***, and ***cultural behavior*** influence the types and quantities of waste generated.

Variability

Predicting changes in waste composition is as difficult as ***forecasting waste quantities***, as both are influenced by various factors ***over time***.

Factors Affecting Waste Generation and Composition

Geographic Location

Climate and ***growing seasons*** can influence the amount and types of waste generated, such as yard and garden waste.

Socioeconomic Status

Income, ***lifestyle***, and ***cultural behavior*** affect the composition of waste, with higher-income areas generating more paper, plastics, and other recyclables.

Seasonal Variations

Seasonal changes can influence the ***quantity*** and ***composition*** of waste, such as increased yard waste during the growing season.

Urbanization

The ***growth of urban areas*** can lead to changes in waste generation and composition, as lifestyles and consumption patterns evolve.

Impacts of Poor Waste Management

1

2

3

Public Health

Improper waste disposal can lead to the spread of diseases, contamination of water sources, and the breeding of disease vectors, posing serious risks to public health.

Environmental Degradation

Uncontrolled waste dumping can pollute air, water, and soil, harming ecosystems and biodiversity, and contributing to climate change.

Economic Impacts

The costs of poor waste management, including cleanup, healthcare, and environmental damage, can be a significant burden on communities and governments.

Waste Management in Addis Ababa

Waste Generation	2,900 metric tons per day
Waste Composition	Organic (61%), Recyclables (20%), Others (19%)
Collection Coverage	74% of the city
Disposal Method	Landfilling and incineration
Challenges	Inadequate infrastructure, informal waste picking, and public awareness

Waste Management Strategies

Waste Reduction

Promoting sustainable consumption, extended producer responsibility, and waste minimization at the source can significantly reduce the amount of waste generated.

Resource Recovery

Implementing effective recycling, composting, and other recovery programs can divert valuable materials from landfills and create economic opportunities.

Appropriate Technologies

Selecting waste management technologies that are suited to the local context, in terms of waste characteristics, infrastructure, and resources, is crucial for the success of the system.

Factors Influencing Solid Waste Generation

- Solid waste generation is influenced by a variety of factors, including seasonal changes, collection frequency, population diversity, salvaging and recycling efforts, public attitudes, and legislation. Understanding these key elements is crucial for effective solid waste management.

Seasonal Variations

1

Growing Season

The growing season of vegetables and fruits affects the quantities of food wastes generated.

2

Weather Patterns

Precipitation and temperature changes can impact the moisture content and density of solid waste, affecting collection and disposal.

3

Holiday Periods

Increased consumption and packaging during holidays leads to spikes in waste generation and composition.

Collection Frequency

Increased Collection

In areas with reliable collection services, more waste is collected, even if the total waste generated remains the same.

Limited Capacity

Homeowners with limited container capacity are more likely to store recyclables and other materials, rather than disposing of them.

Frequency Impact

The frequency of collection can significantly affect the quantity of waste collected, even if the total waste generated is unchanged.

Population Diversity

1

Income Levels

Low-income areas generate more waste compared to high-income areas, but the composition differs in terms of recyclables.

2

Age Distribution

The age distribution of the population can influence the types of waste generated, such as more diapers in areas with young families.

3

Cultural Factors

Differences in cultural practices and lifestyles can lead to variations in the quantity and composition of solid waste.

Salvaging and Recycling

Reduced Waste

The existence of active salvaging and recycling operations within a community can significantly reduce the quantity of waste collected for disposal.

Composition Changes

Recycling efforts can alter the composition of the waste stream, decreasing the proportion of recyclable materials like paper and plastics.

Economic Impact

Successful recycling programs can also have a positive economic impact by generating revenue and reducing disposal costs.

Public Attitudes

Reduce

Voluntary changes in habits and lifestyles can significantly reduce the quantity of solid waste generated.

Reuse

Encouraging the reuse of materials can divert waste from landfills and incinerators.

Recycle

Widespread adoption of recycling practices can dramatically decrease the amount of waste requiring disposal.

Legislation and Regulations

1

Material Restrictions

Laws and regulations can limit the use and disposal of specific materials, affecting the composition of the waste stream.

2

Recycling Mandates

Legislation that requires recycling of certain materials can increase the diversion of waste from landfills and incinerators.

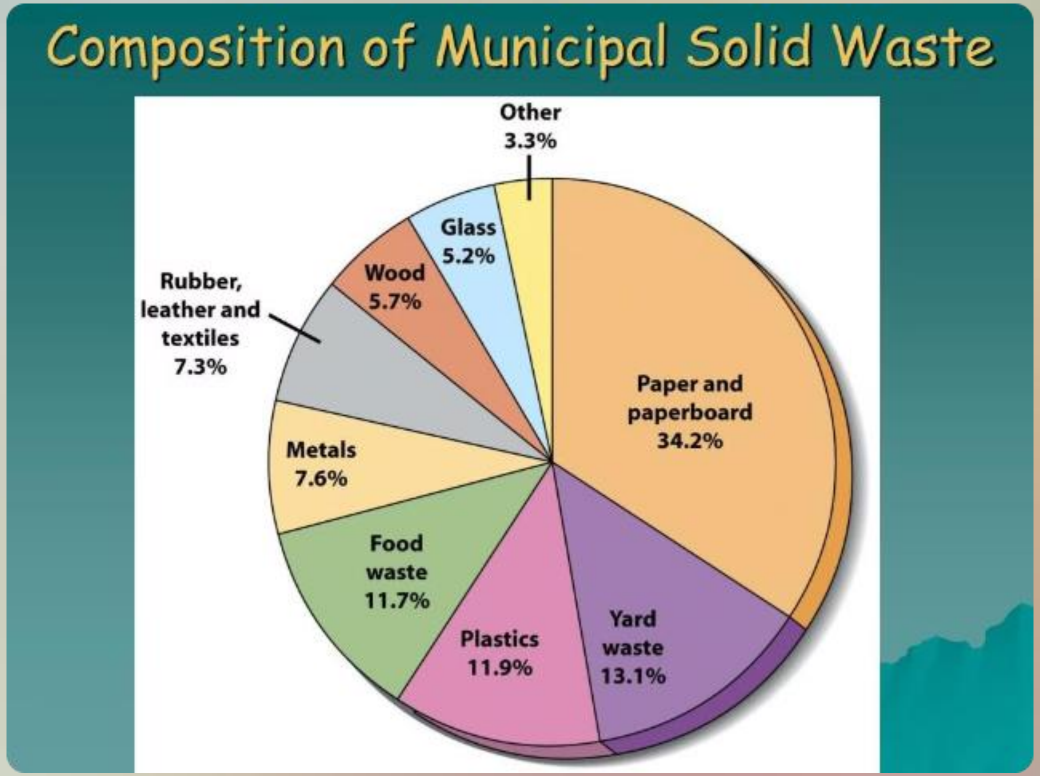
3

Disposal Policies

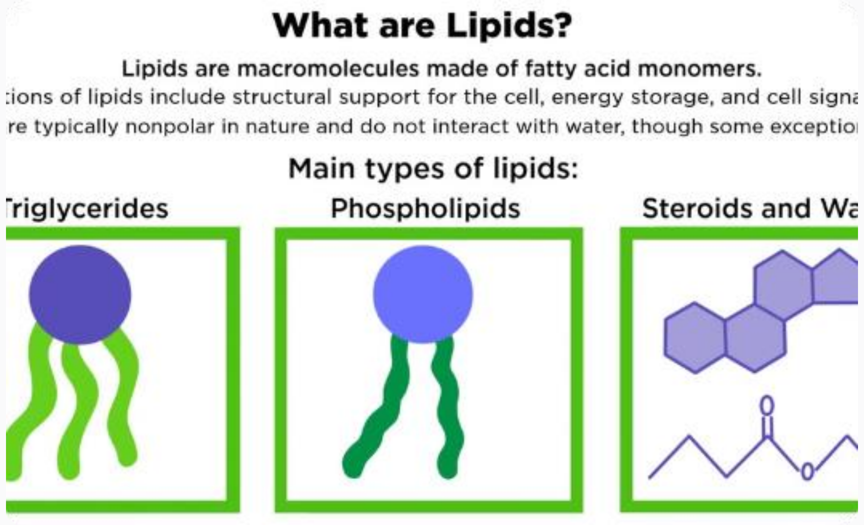
Policies governing the disposal of waste, such as landfill bans or taxes, can incentivize waste reduction and recycling efforts.

Physical Characteristics of Solid Waste

Characteristic	Importance
Density	Crucial for the design of collection, transport, and disposal systems.
Moisture Content	Impacts the cost of collection, transport, and treatment (e.g., incineration).
Particle Size	Determines the design of mechanical separation and shredding equipment.



Chemical Characteristics of Solid Waste



Lipids

Fats, oils, and grease have high heating values, making them suitable for energy recovery.

Carbohydrates

Found in food and yard waste, carbohydrates are readily biodegradable but can attract pests.

Plastics

Highly resistant to biodegradation, plastics have a high heating value but can release harmful emissions when burned.

Waste Composition and Heating Values

Organic Components

Organic materials like food waste, paper, and wood have varying heating values that are important for evaluating incineration as a disposal or energy recovery method.

Inorganic Components

Inorganic materials like glass, metals, and ash have lower heating values but can still impact the overall combustion characteristics of the waste.

Moisture and Ash Content

The moisture and ash content of the waste are critical factors that affect the efficiency and feasibility of thermal treatment processes.

Waste Composition

Component	Range (%)	Typical (%)
Moisture	15-40	20
Volatile matter	40-60	53
Fixed carbon	5-12	7
Glass, metal, ash	15-30	20

Chemical Characteristics of Waste

To evaluate alternative processing and recovery options, such as incineration, we need information on the chemical characteristics of wastes. Wastes can typically be a combination of combustible and non-combustible materials.

Combustible Waste

Combustible waste, such as plastics, consists of natural fibers and synthetic organic materials.

Garbage

Garbage, such as food waste, contains carbohydrates, lipids, and proteins.

Environmental Effects of Waste Mismanagement

Besides causing health disorders, inadequate and improper waste management causes adverse environmental effects.

1

Air Pollution

Burning solid wastes in open dumps or improperly designed incinerators emits pollutants (gaseous and particulate matters) to the atmosphere. Studies show that the environmental consequences of open burning are greater than incinerators, especially with respect to aldehydes and particulates.

2

Water and Land Pollution

Water pollution results from dumping in open areas and storm water drains, and improper design, construction, and/or operation of a sanitary landfill. Control of infiltration from rainfall and surface runoff is essential to minimize the production of leachate.

3

Visual Pollution

The aesthetic sensibility is offended by the unsightliness of piles of wastes on the roadside. The situation is made worse by the presence of scavengers rummaging in the waste.

4

Noise Pollution

Undesirable noise is a nuisance associated with operations at landfills, incinerators, transfer stations, and sites used for recycling. This is due to the movement of vehicles, the operation of large machines, and the diverse operations at an incinerator site.

WASTE GENERATION RATES

Generation rates of MSW

- The reason for measuring generation rates is to obtain data that can be used to **determine the total amount of wastes to be managed.**

- Due to different methods of measurement, the solid waste generation rate has caused considerable confusion.

WASTE GENERATION RATES

Measure of quantities

***Quantities of volume**

Both volume and weight are used for the measurement of solid waste quantities, unfortunately the use of volume can be extremely misleading.

- A cubic meter of loose wastes,
- A cubic meter of Compacted in a packer truck,
- A cubic meter of further compacted in a landfill

WASTE GENERATION RATES

***Quantities of weight**

To avoid confusion, solid waste quantities should be expressed in terms of weight. **Weight can be measured directly regardless of compaction.**

The use of weight records is also important in the transport of solid waste because the quantity which can be hauled usually is restricted by highway weight limits rather than by volume.

WASTE GENERATION RATES

Statistical analysis of generation rates

- In developing solid waste management system, it is necessary to determine the statistical characteristics of solid waste generation

- For many large industrial activities, the container capacity to be provided must be based on a statistical analysis of the generation rates and characteristics of the collection system.

WASTE GENERATION RATES

- The statistical measures should consider the mean, mode, median, standard deviation and coefficient of variation.

Expression unit for generation rates

*Residential kg/c/d --------kilogram per capita per day

Typical per capita solid waste generation rates in.

WASTE GENERATION RATES

	Unit Rate (kg/capita.d)	
Source	Range	Typical
Municipal*	0.75-2.50	1.6
Industrial	0.4-1.6	0.9
Demolition	0.05-0.4	0.3
Other Municipal	0.05-0.3	0.2.
		3.0

*Includes residential and commercial

*Commercial kg/c/d ------ kg per automobile for assembly plant or per case for a packaging plant

WASTE GENERATION RATES

Repeatable measure of production

Typical commercial and industrial unit waste generation rates

Source	Unit	Range
Office building	kg/employee.d	0.5-1.1
Restaurants	kg/customer.d	0.2-0.8
Canned and frozen foods	Tonnes/tonne of raw product	0.04-0.06
Printing and publishing	Tonnes/tonne of raw paper	0.08-0.10
Automotive	Tonnes/per vehicle	0.6-0.8
Petroleum refining	Tonnes/employee.d	0.04-0.05
Robber	Tonnes/tonne of raw rubber	0.01-0.3

WASTE GENERATION RATES

MSW predicting Methods

In case of predicting residential waste generation rates, the measured rates seldom reflect the true rate because there are so many confounding factors such as:

- on-site storage
- the use of alternative disposal locations

WASTE GENERATION RATES

Therefore, the true rate is difficult to assess.

Most solid waste generation rates reported in the literature are actually collection rates and not generation rates.

Direct measurement

* Load-count analysis

The number of individual loads and the corresponding vehicle characteristics are noted over a specified time period.

WASTE GENERATION RATES

Example: Estimation of Unit Solid Waste Generation

Rates for a Residential Area

From the following date estimate the unit waste generation rate for a residential area consisting of approximately 1,000 homes. The observation location is a local transfer station, and the observation period is 1 week.

WASTE GENERATION RATES

(1) Number of compactor truck loads = 10

(2) Average size of compactor truck = 15.3 m^3

(3) Number of flatbed loads = 10

(4) Average flatbed volume = 1.15m^3

(5) Number of loads from individual residents private cars & truck = 20

(6) Estimated volume per domestic vehicle = 0.23m^3

WASTE GENERATION RATES

<u>Solution</u>

1. Set up the computation table

Item	Number of loads	Average volume m^3	Unit weight kg/m^3	Total weight kg
Compactor truck	10	15.3	208	31820
Flatbed truck	10	1.15	89	1023
Individual private vehicle	20	0.23	59.3	273
Total (kg/wk)				33116

WASTE GENERATION RATES

2. Estimate the unit waste generation rate based on the assumption that each household is comprised of 3.5 people.

$$\text{Unit rate} = \frac{33116 \text{ kg/wk}}{(1000 \times 3.5)(7 \text{days/wk})} = 1.35 \text{ kg/capita/day}$$

WASTE GENERATION RATES

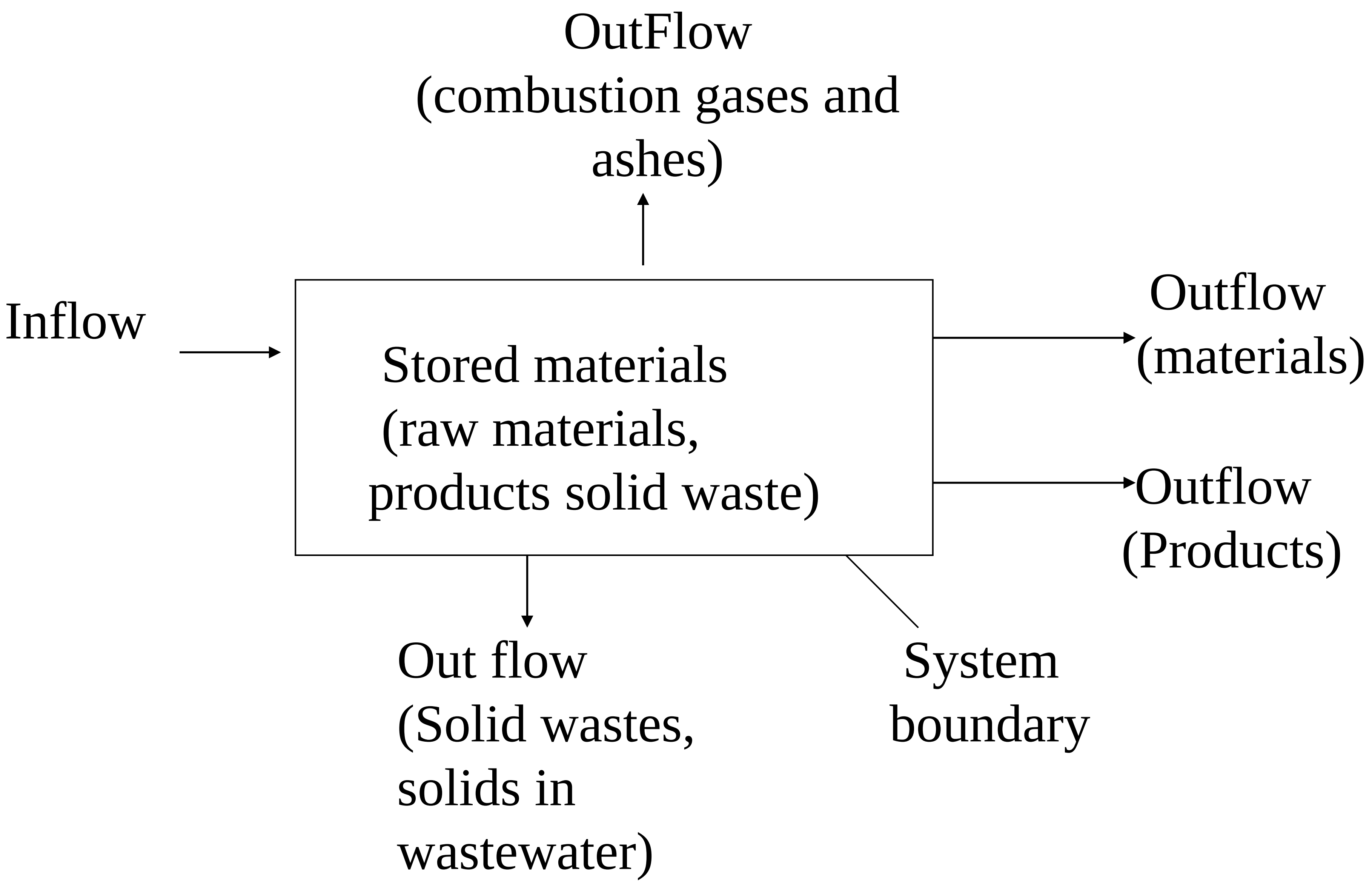
Materials Mass Balance Analysis:

$$dM/dt = \sum M_{in} - \sum M_{Out} + r_w$$

Rate of accumulation of material within the system boundary	=	Rate of flow of material into the system boundary	-	Rate of material out of the system boundary	+	Rate of generation of waste material within the system boundary

WASTE GENERATION RATES

Material Mass Balance Analysis

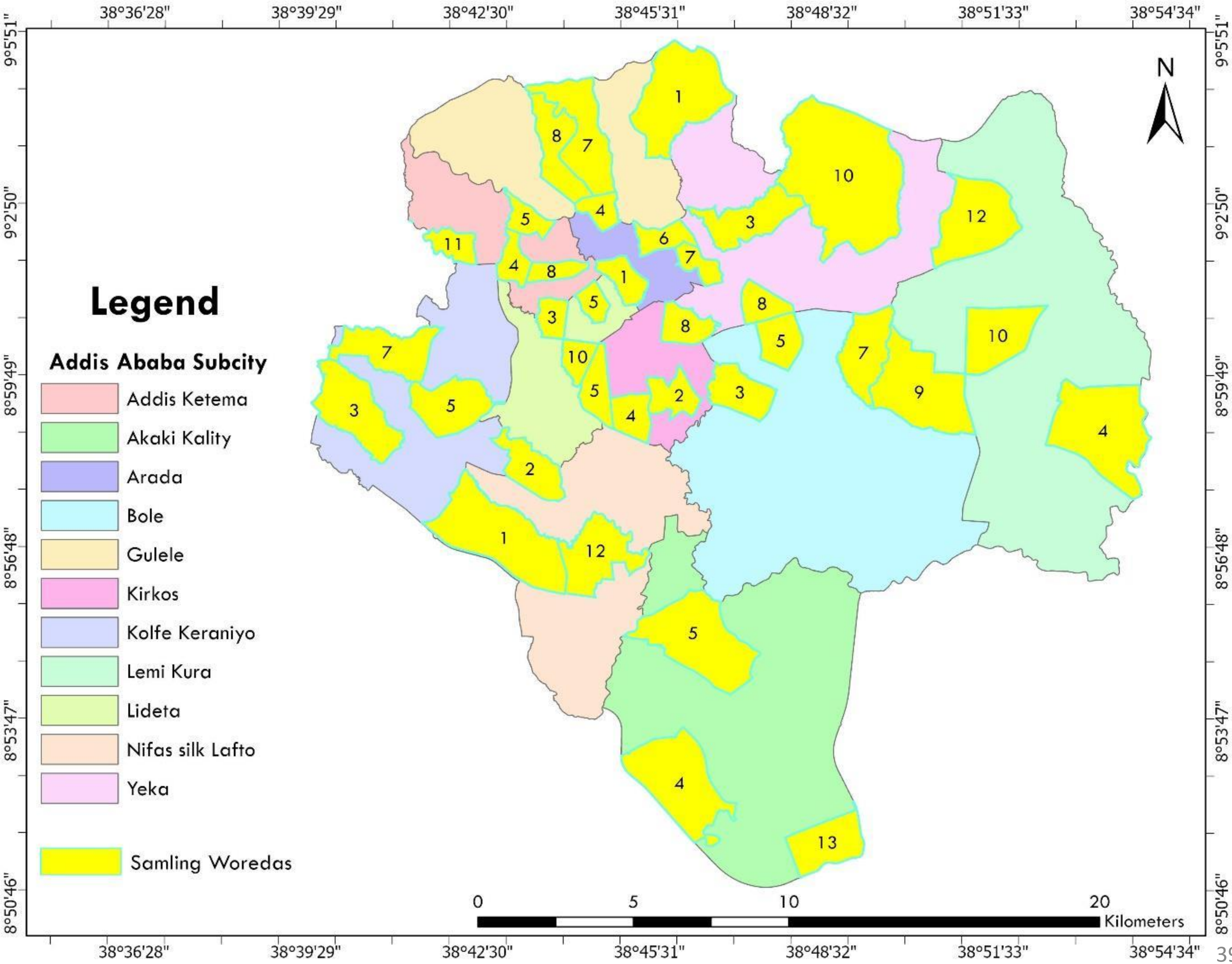


Selection of Sampling Sites

- A stratified random sampling method is mostly used to select residential households from study area

Stratified random sampling is a method of sampling that involves the division of a population into smaller subgroups known as strata. In stratified random sampling, or stratification, the strata are formed based on members' shared attributes or characteristics, such as income or educational attainment.

Example


Legend
Addis Ababa Subcity
Addis Ketema
Akaki Kality
Arada
Bole
Gulele
Kirkos
Kolfe Keraniyo
Lemi Kura
Lideta
Nifas silk Lafto
Yeka
Samling Woredas
N
0 5 10 20
Kilometers
38°36'28"
38°39'29"
38°42'30"
38°45'31"
38°48'32"
38°51'33"
38°54'34"
9°5'51"
9°2'50"
8°59'49"
8°56'48"
8°53'47"
8°50'46"

Duration of Sampling

- Collect waste samples over seven consecutive days to capture variations due to different days of the week (e.g., weekdays vs. weekends).

- However, plan for eight consecutive days of waste collection to account for any unexpected events (e.g., holidays, disruptions).

Representativeness

- Ensure that the sampling period covers a representative cycle of waste generation.
- Consider seasonal variations (if applicable) to capture differences in waste composition.

Sample Size:

- The sample size depends on the desired level of confidence and precision.
- Cochran's single population proportion formula

$$\mathbf{n} = \frac{(\mathbf{DEFF})\mathbf{N}\mathbf{Z}^2\mathbf{PQ}}{\mathbf{d}^2(\mathbf{N}-\mathbf{1})+\mathbf{Z}^2\mathbf{PQ}}$$

- Where, n is required sample size, N is total housing unit, Z is standardized normal deviation at the 95% confidence interval = 1.96, P is HSW generation =50% for maximum variability, Q is non-residential HSW generation, Q = 100% – 50% = 50%, and d is statistically allowable margin of error.

Determination of Sample size for household solid waste characterization for Addis Ababa City

Projected population 5,461,000 for the year 2023
Estimated average household size 4.87 for the year 2019.
(United Nations-World Population Prospects)

- The total sample size determined 817 houses and the response rate is 20 % (164 units).
- 817+163=980 households.
- The sample size for the study will be 990 households, with ten added to make it uniform across all Ketena.

Household selection: multi-stage cluster sampling approach

11 sub-cities

3 Woreda/district purpose sampling

2 villages (ketenes) purpose sampling

15 households purposely

A total of 66 Ketenas which represent the city using each selected woredas' SWM office database as a sampling frame.

Determination of income status

- Household income stratification will be made based up on proxy indicators such as housing conditions pertaining to construction materials, ownership of the house, finish work, access to electricity, road infrastructure and other facilities that will be analyzed during the preliminary site visit activities.

income status

- come (2 households), middle come (5 households) and low-income households (8 households).

	Housing Class	Characteristics
	**Low Income**	Housing structure made of Wood & Mud, Wood Only Mud Brick, Reed/ Bamboo, Stone & Mud
	**Middle Income**	Housing structure made of Stone & Cement, Un-plastered Hollow Blocks
	**High Income**	Housing structure made of Plastered Hollow Block and Bricks

- After grouping (stratifying) households from low-income, middle income and high-income groups by randomly selecting the housing unit will be tagged by code.

Determination of sample size for commercial households

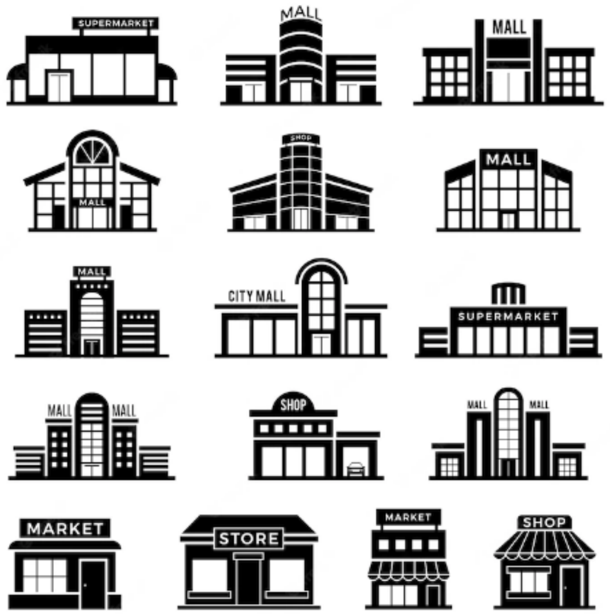
- Where n is required sample size, N is total commercial household unit and e is statistically allowable margin of error

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

For commercial establishment

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

According to the Addis Ababa Trade and Industry Bureau database (2020), there are nearly 825,549 establishments ranging from small to large scale enterprises in wholesale, retail trade, super market, hotel, restaurant, services etc.



- Sample size will be 400 commercial establishment.
- A total of 12 commercial establishment will be selected from each selected Woreda.
- This sample will be stratified as retail trade shops, wholesale trade shops, commercial centers, supermarkets, hotels, bar and restaurants, business centers, and repair services.

Determination of sample size for institutional households

- Since there is no up-to-date and exact institutional household data the Cochran Formula (Cochran, 1977) of a single proportion and infinite (unknown) population will be used to determine the sample size because the exact target population size is non-deterministic assuming that P is 50% (maximum variability), Z is the standardized normal distribution at the 95% confidence interval = 1.96, and margin of allowable error.

$$\mathbf{n} = \frac{\mathbf{Z}^2\mathbf{P}(1-\mathbf{P})}{\mathbf{d}^2}$$

Degree of Variability (p)

- Degree of Variability (p) indicates the response variance you expect to obtain from individuals in the population.

- Using p = . 50 would indicate the maximum amount of variability is likely to occur. Level of Precision (e) indicates the amount of sampling error that would be acceptable.

Available software

For institutional establishment

$$\mathbf{n} = \frac{\mathbf{Z}^2\mathbf{P}(1-\mathbf{P})}{\mathbf{d}^2}$$

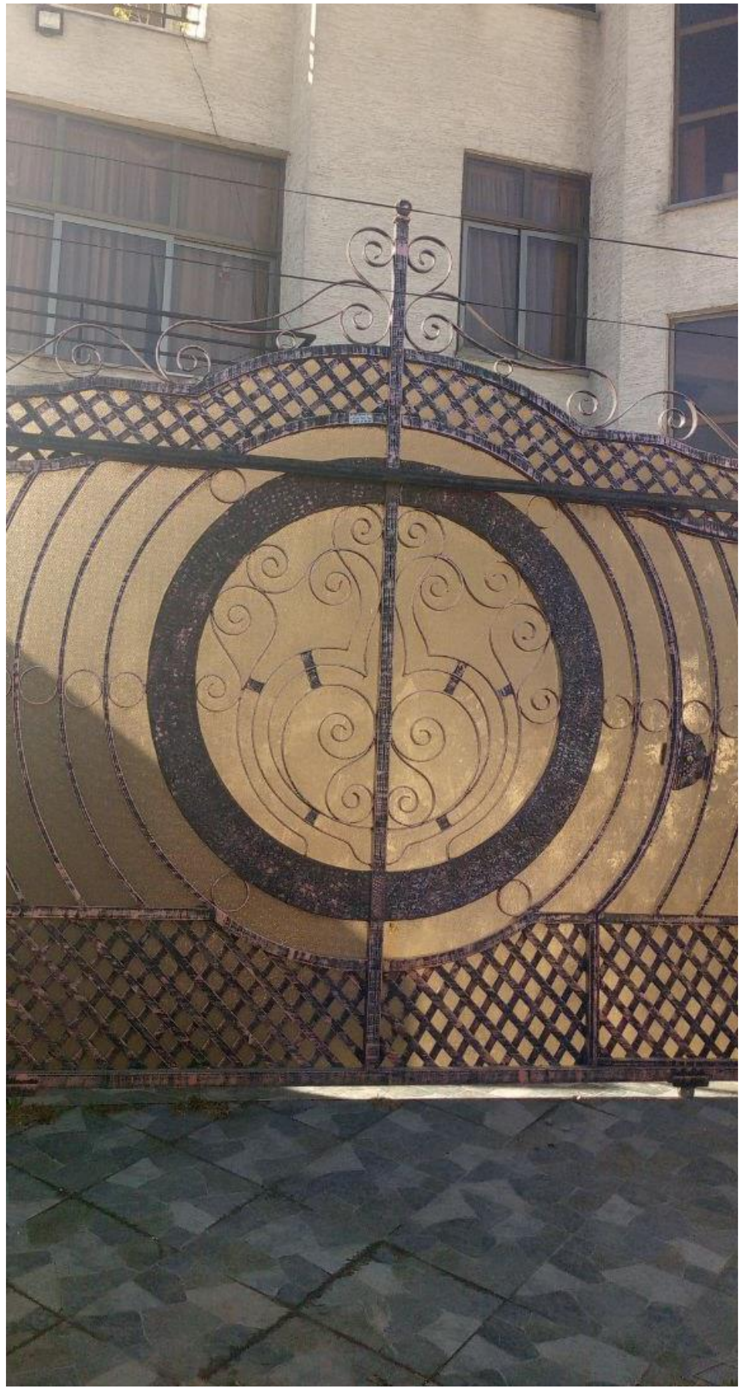
- The governmental institution ranges from federal to Addis Ababa city offices and Oromia Region State offices.
- The determined sample size is 196 institutional establishment.
- This sample was selected across the 11 sub cities and selected Woreda in the sub cities.
- The institution was stratified as governmental organization, educational establishments, religious institutions, and service providing institutions.

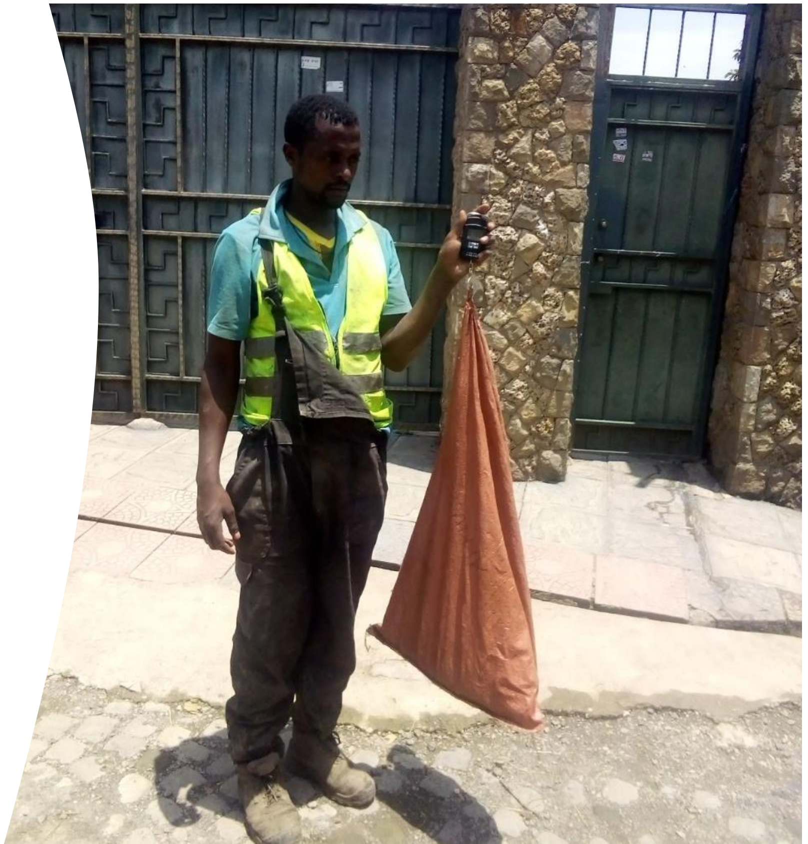
Total number of samples and number of samples from each type in the sub-city

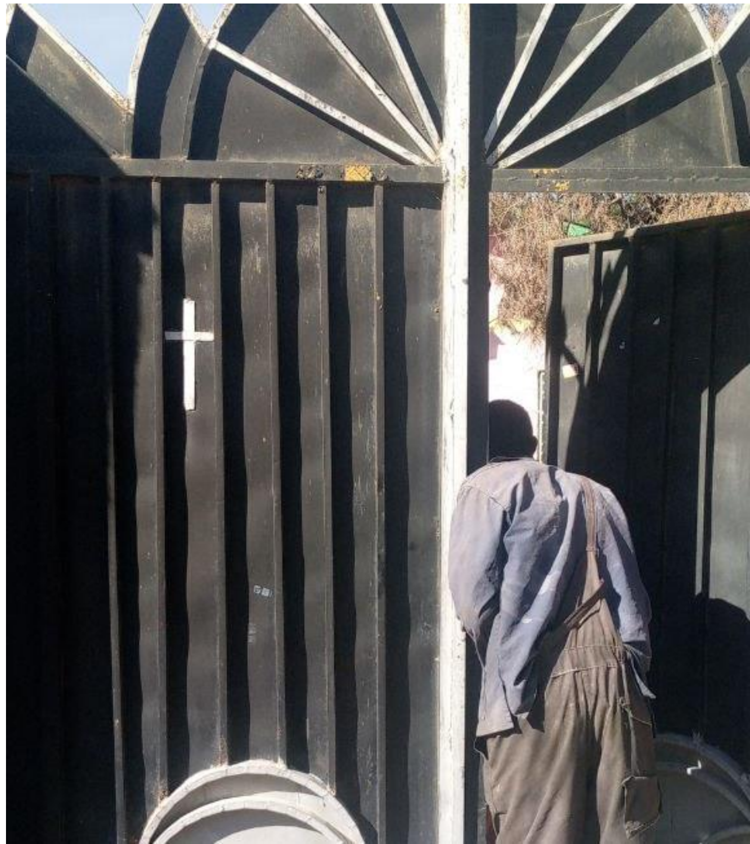
Name of Sub-city	Total No of Woreda	No. Sampled		No. Samples					
		Woreda	EA	HI	MI	LI	Commercial	Institution	Total
Addis Ketema	13	3	6	12	30	48	36	18	144
Akaki-Kaliti	12	3	6	12	30	48	36	18	144
Arada	8	3	6	12	30	48	36	18	144
Bole	15	3	6	12	30	48	36	18	144
Gulele	10	3	6	12	30	48	36	18	144
Kirkose	11	3	6	12	30	48	36	18	144
Kolfe	15	3	6	12	30	48	36	18	144
Lemi Kura	10	3	6	12	30	48	36	18	144
Lideta	10	3	6	12	30	48	36	18	144
Nefas Silk-Lafto	15	3	6	12	30	48	36	18	144
Yeka	14	3	6	12	30	48	36	18	144
Total number		**33**	**66**	**132**	**330**	**528**	**396**	**198**	**1584**

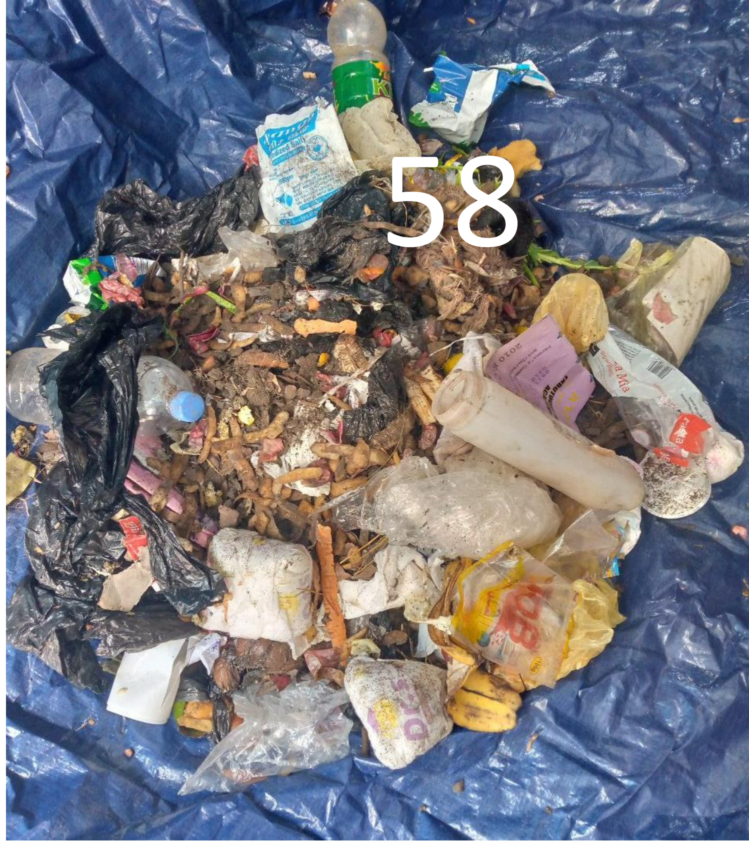
Low income

Middle income





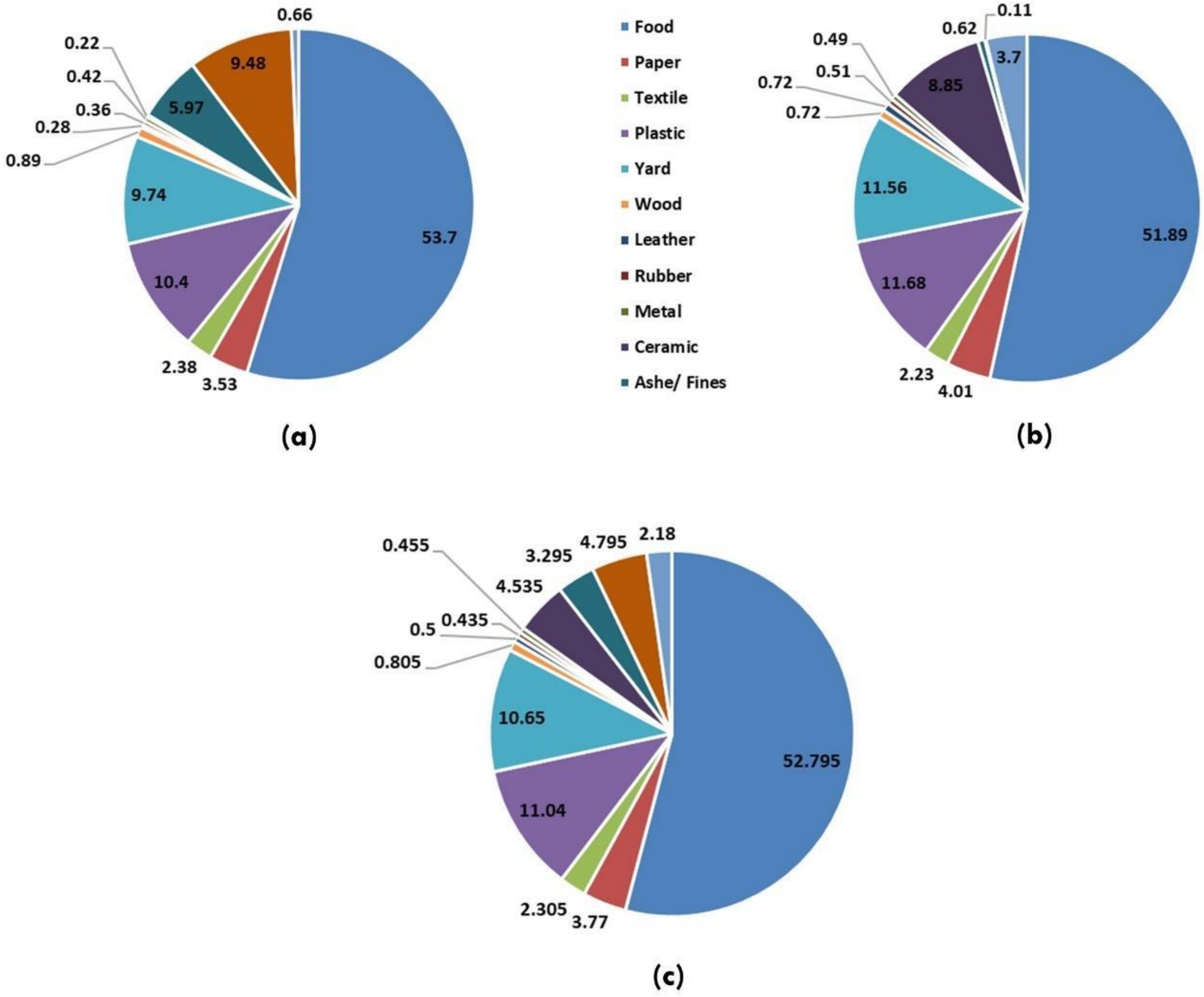




Result

Table E4: Daily variation of household waste generation rate

Sub City	Wet Season				Dry season				Annual Average SWG/Sub-city			
	HI	MI	LI	Mean SWG	HI	MI	LI	Mean SWG	HI	MI	LI	Mean SWG
Addis Ketema	0.464	0.352	0.354	0.39	0.41	0.33	0.2	0.41	0.43	0.34	0.25	**0.40**
Akaki Kality	0.177	0.531	0.248	0.32	0.34	0.3	0.4	0.34	0.29	0.38	0.35	**0.33**
Arada	0.401	0.483	0.236	0.37	0.61	0.31	0.28	0.34	0.54	0.37	0.26	**0.35**
Bole	0.423	0.42	0.197	0.35	0.5	0.4	0.28	0.35	0.47	0.41	0.25	**0.35**
Gulelle	0.658	0.298	0.45	0.47	0.54	0.38	0.27	0.35	0.58	0.35	0.33	**0.39**
Kirkos	0.799	0.413	0.387	0.53	0.51	0.43	0.32	0.39	0.61	0.42	0.34	**0.44**
Kolfe Keranyo	0.375	0.486	0.332	0.4	0.37	0.48	0.33	0.39	0.37	0.48	0.33	**0.39**
Lemi Kura	0.427	0.326	0.246	0.33	0.32	0.25	0.15	0.21	0.36	0.27	0.18	**0.25**
Lideta	0.292	0.241	0.208	0.25	0.4	0.27	0.17	0.24	0.36	0.26	0.18	**0.24**
Nifas Silk Lafto	0.486	0.347	0.44	0.42	0.64	0.42	0.34	0.41	0.59	0.4	0.38	**0.41**
Yeka	0.244	0.256	0.247	0.25	0.42	0.42	0.24	0.33	0.36	0.37	0.24	**0.30**



Food
Paper
Textile
Plastic
Yard
Wood
Leather
Rubber
Metal
Ceramic
Ashe/ Fines
53.7
10.4
9.74
9.48
5.97
3.53
2.38
0.89
0.28
0.36
0.42
0.22
0.66
(a)
51.89
11.68
11.56
8.85
3.7
4.01
2.23
0.72
0.72
0.51
0.49
0.62
0.11
(b)
52.795
11.04
10.65
4.795
4.535
3.295
2.18
3.77
2.305
0.805
0.5
0.435
0.455
(c)

Table E5: Daily Commercial sector waste generation rate

Business categories	Wet season (kg/day)		Dry season (kg/day)		Average (kg/day)	
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)
Food and beverage service						
Bar and restaurants	9.83±10.55	6.52	6.67±5.76	5.00	8.23±6.83	5.50
Cafeterias	5.11±5.88	3.13	5.89±7.59	3.25	5.52±6.83	3.18
Fruit and vegetable vendors	13.63±12.25	9.91	13.36±11.27	9.75	13.49±11.73	9.75
Hotel service						
Five-star hotels	807.44±187.87	819.07	876.98±30.96	884.43	842.21±134.29	874.58
Four-star hotels	166.38±48.41	178.82	180.52±18.79	176.46	173.45±36.03	177.64
Three-star hotels	41.54±45.06	32.02	28.10±10.53	25.65	34.82±32.83	25.65
One-star hotels	27.25±6.02	26.93	18.13±3.33	17.25	22.69±6.65	21.82
Uncategorized hotels	10.75±8.46	9.70	8.79±7.24	6.79	9.77±7.89	8.40
Pension and guesthouse	6.21±7.77	4.16	3.37±3.15	1.83	4.66±5.87	3.23
Wholesale and retail trade service						
Household goods	1.83±2.97	0.60	1.48±2.35	0.61	1.66±2.69	0.60
Boutiques	1.36±2.02	0.53	1.11±1.18	0.70	1.23±1.65	0.59
Supermarkets	1.14±1.54	0.54	2.33±5.28	0.80	1.85±4.23	0.73
Beauty salons	1.22±1.58	0.58	0.95±1.01	0.46)	1.07±1.30	0.49
Electronics	0.34±0.24	0.25	0.39±0.26	0.40	0.38±0.25	0.39

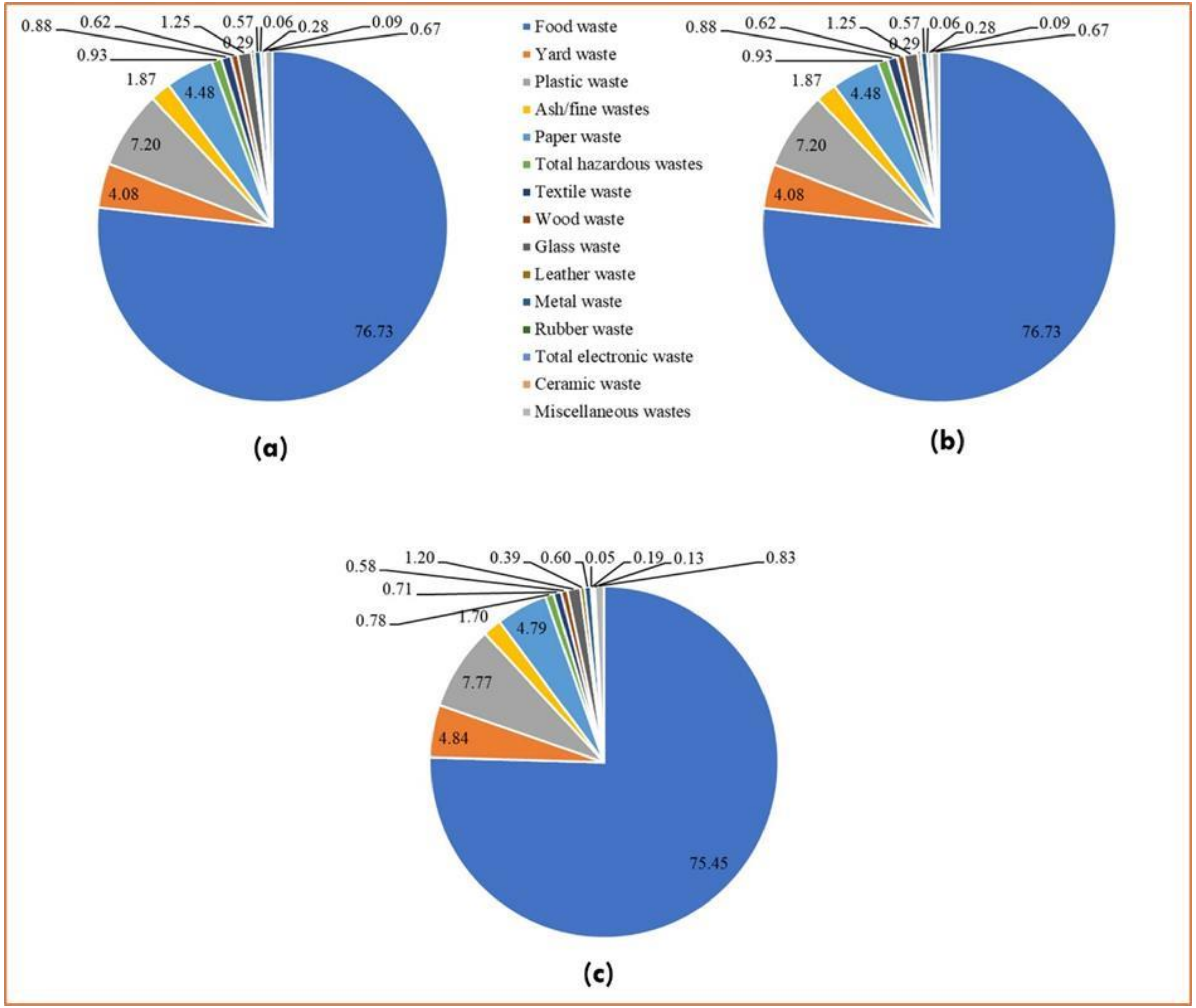
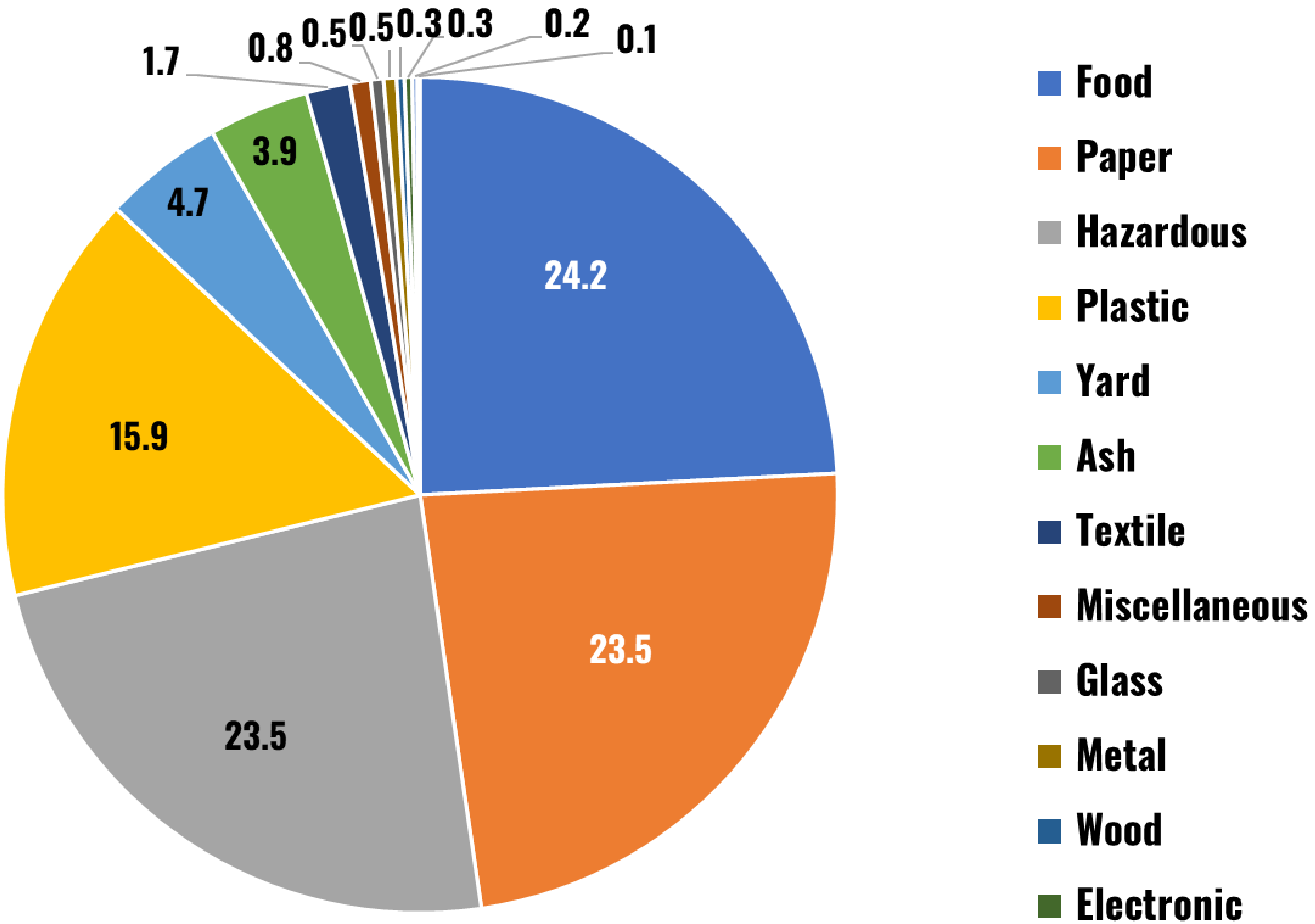

Food waste
Yard waste
Plastic waste
Ash/fine wastes
Paper waste
Total hazardous wastes
Textile waste
Wood waste
Glass waste
Leather waste
Metal waste
Rubber waste
Total electronic waste
Ceramic waste
Miscellaneous wastes
0.88
0.62
1.25
0.57
0.06
0.28
0.09
0.67
0.29
0.93
1.87
4.48
7.20
4.08
76.73
(a)
0.88
0.62
1.25
0.57
0.06
0.28
0.09
0.67
0.29
0.93
1.87
4.48
7.20
4.08
76.73
(b)
0.58
1.20
0.39
0.60
0.05
0.19
0.13
0.83
0.71
0.78
1.70
4.79
7.77
4.84
75.45
(c)

Table E6: Daily institutional sector waste generation rate

Types of institutions	Categories of institution	Dry season TWG in Addis Ababa (kg/day)	Wet season TWG in Addis Ababa (kg/day)	Average TWG in Addis Ababa (kg/day)
Educational*	Kindergarten	1902.32	-	-
	Primary School	899.1	2030	3104.64
	Secondary School	3286.8	810	910.2
	College/university	1,299.6	1440	9082.76
Healthcare	Clinic	1824	2020	1909.5
	Health center	257.74	250	251.86
	Private hospital	1558.96	1290	1492.4
	Government hospital	2043.47	9360	4737.2
Offices	Authority/bureau/commission	1750	3200	2700
	Bank/insurances	3973.2	6790	5297.6
	Ministry	203.7	690	366.66
	Police centers	495	680	580.5
	Woreda/sub-city	442	460	426.02
	SME/agencies/others	32605.2	52330.6	43473.6
Religious	Mosque	840	2660	1575
	Church	596.8	1044.4	820.6



24.2
23.5
23.5
15.9
4.7
3.9
1.7
0.8
0.5
0.5
0.3
0.3
0.2
0.1
Food
Paper
Hazardous
Plastic
Yard
Ash
Textile
Miscellaneous
Glass
Metal
Wood
Electronic

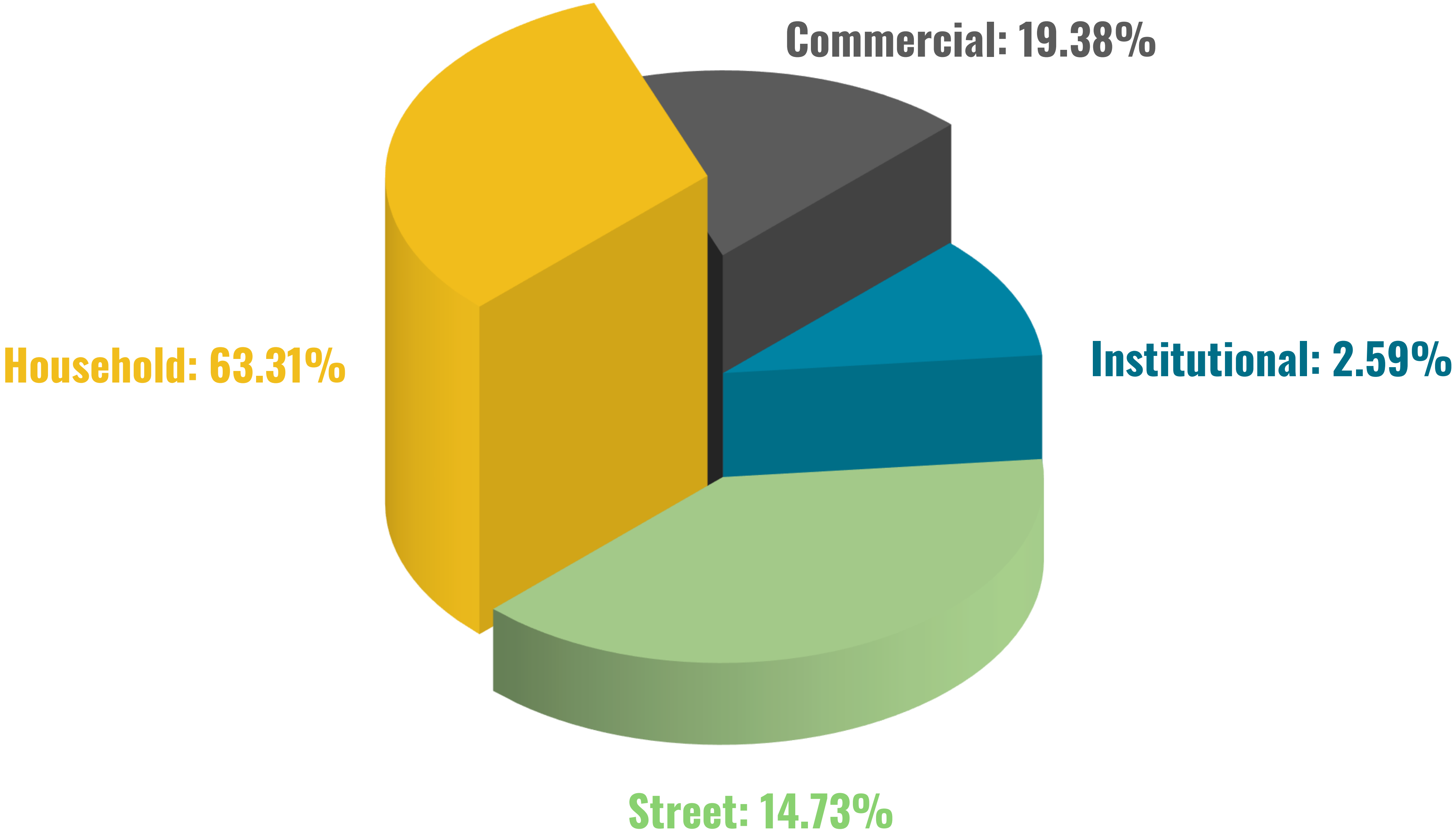
Municipal solid waste (MSW) generation

Source of waste (total) (tons/day)	Dry season	Wet season	Average
Household	1,802.13	2,020.57	1,878.58
Commercial	546.33	597.76	574.99
Institutional	53.98	85.06	76.73
Street waste	364.53	509.38	436.96
MSW	2,766.97	3,212.77	2,967.26
MSW (tons/year)	1,009,944	1,172,661	1,083,050
MSW (tons/day)	**2,767**	**3,213**	**2,967**
Total population	5,461,000	5,461,000	5,461,000
Per capita MSW kg/capita/day)	0.51	0.59	0.54

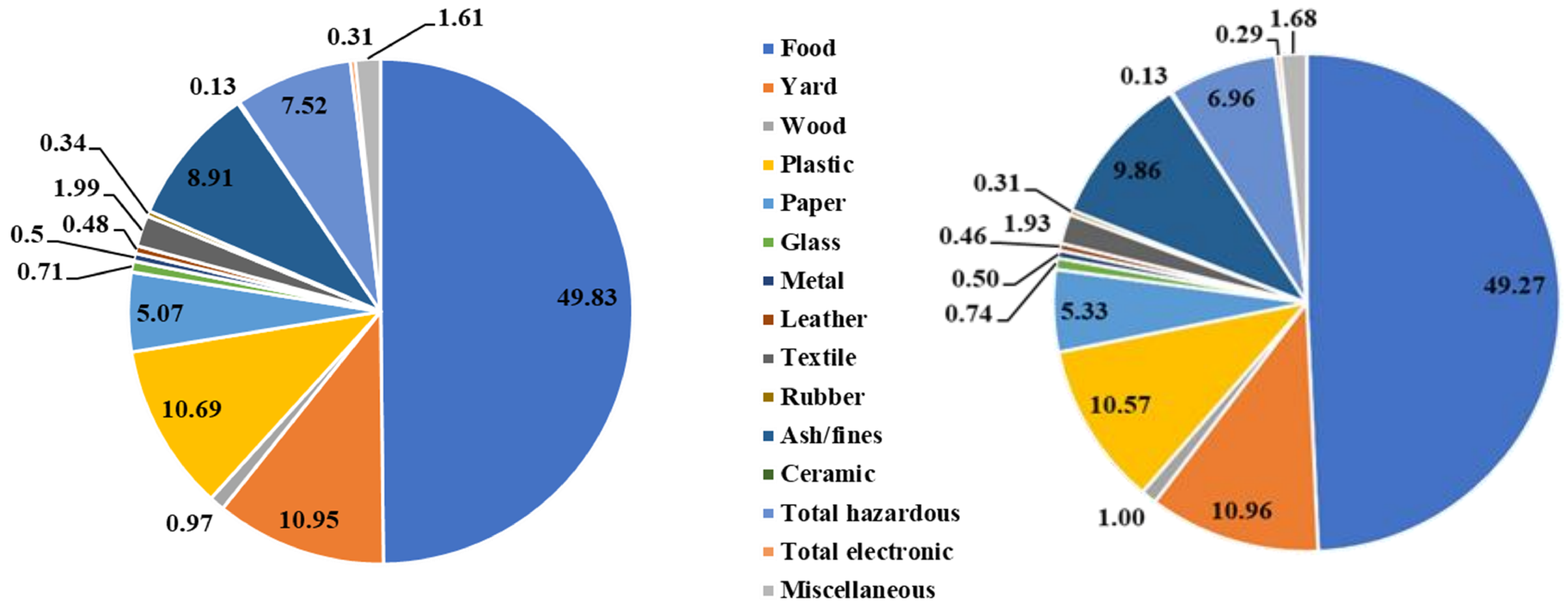
The average per capita Municipal solid waste generation rate was found about 0.54 kg/capita/day

The average per capita Municipal solid waste generation rate was found about 0.62 kg/capita/day

Municipal solid waste (MSW) generation sector contribution



Municipal solid waste (MSW) average composition



Average Municipal solid waste (MSW) composition (a) UN Projection, (b) CSA projection

Thank you!