Final Report

Diagnostic Assessment of Municipal Waste Management System at Birgunj Metropolitan City, Birgunj, Parsa, Nepal




Submitted to:

Birgunj Metropolitan City

Birgunj, Nepal

Submitted by:

Health Environment and Climate Action Foundation (HECAF 360)

Lazimpat, Kathmandu-3

2025

Acknowledgement

On behalf of HECAF 360, we express our sincere gratitude to Mr. Rajesh Man Singh, Mayor of Birgunj Metropolitan City, for his active leadership and encouragement in addressing the municipal waste issues.

We are equally thankful to Mr. Rakesh Sah, Senior Engineer, and Mr. Prakash Ayer, Environmental Officer of Birgunj Metropolitan City, whose technical guidance and coordination were crucial in successfully carrying out this assessment.

Our heartfelt appreciation goes to Mr. Rupesh Tiwari, Site Engineer, and the dedicated staff at the dumping site for their cooperation, provision of space, and valuable information during the assessment period.

We also extend our gratitude to Mr. Firoz, In-charge of the Healthcare Waste Management Center, Mr. Amodin Hawari, Autoclave Operator, and Mr. Lal Babu Thakuri, Contractor of the same center, along with the representatives of various health posts and hospitals, for their support and collaboration throughout the assessment.

Special thanks to the volunteers from Thakur Ram Campus and other campuses, whose commitment and participation contributed greatly to the success of this initiative.

Lastly, we acknowledge the essential support of all metropolitan staff, drivers, and waste separators involved in the waste assessment. Without their assistance and dedication, this assessment would not have been possible.

We also wish to express our deep appreciation to the dedicated members of the HECAF 360 project team for their unwavering commitment, hard work, and collaborative efforts and overcoming numerous challenges have been essential to our success.

To all those mentioned above, your outstanding contributions have not only left a lasting impact on this project but also stepped out as a gateway for Birgunj Metropolitan City in terms of waste management and environment protection. Your compassion, dedication, and unwavering commitment to creating a better world are truly commendable.

Sincerely,

Mochan Bhattarai
Executive Director
Health Environment Climate Action Foundation (HECAF360)

CONTENTS

Abbreviations and Acronym

MSW	: Municipal solid waste
HCW	: Healthcare Waste
MSL	: Mean Sea Level
CBS	: Central Bureau of Statistics
HECAF 360	: Health Environment and Climate Action Foundation
BRS	: Basel Rotterdam and Stockholm () Secretariat and Break
L/day	: Liter per day
ADB	: Asian Development Bank
JICA	: Japan International Cooperation Agency
Kg/day	: Kilogram per day
WHO	: World Health Organization
PET (1)	: Polyethylene
HDPE (2)	: High Density Polyethylene
PVC (3)	: Poly Vinyl Chloride
LDPE (4)	: Low Density Polyethylene
PP (5)	: Polypropylene
PS (6)	: Polystyrene
O (7)	: Other
UN	: United Nations
%	: Percentage
EIA	: Environmental Impact Assessment
IEE	: Initial Environmental Examination
BMC	: Birgunj Metropolitan City

List of Figures and Tables

Figures

Tables

Executive Summary

The solid waste assessment was conducted to determine the municipal waste generation and composition and identify the present scenario, practices and issues of Birgunj Metropolitan City. The municipal waste assessment was conducted from 11 February 2025 to 21 February 2025 including orientation to municipal wards and volunteers. Based on the assessment, key issues and challenges were identified and actionable recommendations were provided for improvement for waste management in the metropolitan city.

The main sources of municipal waste generation are household, commercial, institutional, religious, healthcare, etc. Based on the per capita waste generation calculated, the total MSW generation of the municipality was estimated at about 37 tons daily, equating 13510 tons annually. The total municipal waste generated by households is 28373 kg/day, institutional sectors 3818 kg/day, healthcare sectors is 3781.75 kg/day, commercial sectors is 843 kg/day and religious sectors is 198 kg/day.

Similarly, the average daily waste generated by each household is 0.60 kg/day, each institution contributes to 2.37 kg/day, the commercial center contributes to 0.57 kg/day whereas the religious area is 4.30 kg/day and the healthcare center is 9.09 kg/day. Household waste is estimated to contribute about 77 % of the total municipal waste generated, which was estimated at 0.138 kg/capita/day.

The assessment revealed a lack of waste segregation at the source. All the waste is mixed together and sent to the municipal vehicle and to the dumping site. The people in the rural areas are managing biodegradable waste through their traditional household composting technique and some are sending it to cattle feeding. A door-to-door collection system is in place across all wards; with each ward provided one tractor for collection and transport. The municipality lacks sufficient composting facilities for organic waste, and recycling infrastructure is underutilized. There is limited public awareness regarding proper waste separation. Moreover, the waste from healthcare sectors and waste from each of other sectors are

A plastic waste audit identified household sector were the largest contributors generating 67.59% of the plastic waste among health care, commercial, institutions and religious sectors. A plastic waste audit, "Other" plastic type is the highest contributor followed by LDPE, HDPE, PET, PP and minimal percent by PS and PVC. PET, HDPE, LDPE, and PP are recyclable; meaning a substantial portion of the plastic waste generated can be repurposed, offering potential opportunities to generate income through recycling initiatives.

1 BACKGROUND

1.1 Introduction

Birgunj Metropolitan City (BMC), located in the Parsa District of Madhesh Province in southern Nepal, was officially declared a Metropolitan City in 2017. Often referred to as the "Commercial Capital of Nepal," Birgunj is a major urban hub and the largest city in Madhesh Province. It ranks as the sixth most populated metropolitan city in the country. Between the 2011 and 2021 national censuses, Birgunj experienced a dramatic population increase from 140,000 in 2011 to 272,382 in 2021, effectively doubling in just a decade. This rapid urban growth has significantly increased the generation of solid waste, creating substantial challenges for effective waste management and raising concerns about environmental sustainability in the region.

The municipality generates all kinds of Municipal solid waste (MSW). MSW refers to the waste generated by households, commercial areas, businesses, institutions, religious and historical areas, industries, factories including healthcare waste (HCW). It includes a wide variety of materials including recyclable and non-recyclable materials including HCW. According to WHO, HCW should not be mixed with municipal waste without any treatment. It is because healthcare waste generated from healthcare sectors are both risk and non-risk waste because they are highly infectious and contaminate with the normal waste. So, after proper treatment of HCW, with great care and concern, it can be mixed with the municipal waste.

The management of MSW is a critical issue for metropolitan city like Birgunj due to its volume, composition, and environmental impact. As populations is growing rapidly leading to increase in generation of MSW, posing significant challenges for waste management systems. MSW is being disposed to the dumping site but haphazardly, which led to various environmental and public health concerns such as groundwater contamination, air, water pollution, and the attraction of pests. As awareness of these issues grew, there has been a shift towards more sustainable waste management practices, including recycling, composting, waste-to-energy technologies, and landfill diversion programs.

With a growing population and limited waste management resources, it is essential for Birgunj Metropolitan City to adopt sustainable waste management practices within the metropolitan city. By conducting this assessment, the metropolitan city aims to identify the waste management practices and generation, create a waste management plan that reduces environmental pollution, conserves resources, and improves the health and well-being of its residents. This report will serve as a foundation for future policy decisions and infrastructure investments in waste management.

1.2 Demographic information

Birgunj Metropolitan City lies in Parsa DIistrict in Madhesh Province of southern Nepal. Its area is 75.24 sq. km. and has 32 municipal wards. Birganj is located in the Terai plain

which is the northern part of the Indo-Gangetic plain. It lies 135 km (84 mi) south of the capital Kathmandu, attached in the north to Raxaul on the border of the Indian state of Bihar. According to CBS, 2021, the total population is 272,382 (male and female population coverage is 52.2% and 47.8% respectively), the total household is 47,114, the average household size is 5.78 persons per household, population density is 2,062 person/sq.km and annual population growth rate is 9.46%. The literacy rate of this municipality is 76% (male is 83.6% and female is 67.8%).[1]

1.3 About HECAF360

Health Environment and Climate Action Foundation (HECAF 360), formerly Health Care Waste Management Program of Health Care Foundation Nepal (HECAF), is a non- governmental and not-for-profit sharing organization committed to promoting a clean, green, climate resilient health care system in Nepal. HECAF 360 is a pioneer in environmentally safe health care waste management systems based on Zero Waste principles and non-burn technology.

HECAF 360 is committed to creating a toxic-free Nepal by designing and implementing clean, green climate-smart solutions via partnerships with health care facilities, schools, communities, and municipalities for development of healthy cities to reduce negative human health impacts.

Our work in health care settings also extends to: eliminating mercury-containing devices; instituting safe injection systems; planning and instituting renewable energy projects; promoting climate smart healthcare solutions; encouraging green building design; ensuring effective Water Sanitation, and Hygiene (WASH); building safe wastewater treatment systems; implementing safer chemical substitution; safely managing pharmaceutical waste; safely disposing of menstrual sanitary waste; and advocating for sustainable green procurement.

HECAF 360 has been working extensively in Nepal and other countries for a number of years to mitigate the health impacts caused by health care waste. It has played a pivotal role in transforming waste management practices in large and small hospitals of Nepal including small healthcare facilities such as health-post and primary health centers to establish their healthcare waste management system.

In addition, HECAF360 is also working on a zero waste model in schools and the municipalities of Nepal. Certain municipalities of Nepal are connected and concerned for maintaining a zero waste city in Nepal.

1.4 Objectives

[1] https://censusnepal.cbs.gov.np/results

The general objective is to determine the municipal waste generation and composition of Birgunj Metropolitan City and identify the present scenario, practices and issues of the metropolitan city. The specific objectives are:

- To conduct assessment of the households, institutions, commercial, industrial, religious, healthcare sector etc. of Birgunj Metropolitan City and estimate their quantity and composition.
- To estimate the average per capita of MSW generation and its total quantity
- To assess the existing scenario of waste management practices within metropolitan city
- To conduct plastic audit of the types of plastics materials used in the metropolitan city

1.5 Scope of the Assessment

This waste assessment covers all major waste-generating sectors within Birgunj Metropolitan City, including residential, commercial, institutional, and public spaces. Data collection methods include waste audits, surveys, and interviews with key stakeholders such as municipal staff, waste collectors, and community members. The assessment focuses on both solid waste and organic waste, with particular attention to reducing landfill reliance and enhancing recycling efforts.

1.6 Limitations

This study covered waste assessment of municipal waste quality and quantity of households, markets, institutions, and commercial businesses, religious and healthcare sectors. However, waste generated from parks, roadside dumping, street sweeping, etc., which fall under municipal waste, were not accounted for. Moreover due to the inaccessibility of industrial area, this study excluded the industrial sector. This study was conducted only in one season so seasonal variation data were not collected.

1.8 Field Team

For conducting the assessment and survey in Birgunj Metropolitan City, the team of professionals from HECAF 360, local youths were mobilized as volunteers and waste separators from metropolitan city was allocated.

The team of HECAF 360 was coordinating and supervising the assessment team. Each assessment team includes professionals from HECAF 360, volunteers and waste separators from municipalities. A total of eight volunteers were mobilized to assess 16 wards, with each volunteer assigned to two wards. The assessment was conducted in two phases, covering eight wards in each phase. Details of the assessment team are provided in the accompanying table.

Table 1: Waste assessment field team for Birgunj Metropolitan City

S.N	Name	Designation	Organization
1.	Shrawasti Karmacharya	Program Manager	HECAF 360

2.	Sujata Singh	Project Supervisor	HECAF 360
3.	Ashmita Suwal	Intern	HECAF 360

2 Assessment Methodology

2.1 Assessment methodology

The waste assessment methodology is crucial for obtaining accurate data and insights. The waste assessment was conducted from 11th February, 2025 to 21st February, 2025. The following methodology was adopted for conducting waste assessment.

2.2 Orientation Training on waste assessment methodology

An orientation regarding waste handling, method of waste assessment, and occupational health safety had been provided to the allocated sanitation workers including drivers.

Photo 1: Orientation to volunteers on waste assessment methodology

In addition to this, local volunteers/youth interested for the waste assessment were selected and trained on the methodology for waste quantification, waste characterization, data recording, etc. Moreover they were mobilized for data collection of waste assessment.

2.3 Site visit and observation

The landfill site of the metropolitan city was visited and observed the existing status of waste management scenario of the metropolitan city. In addition, a preliminary visit has been conducted to the school, college, market areas, institutional areas, commercial areas, etc. of the municipal wards to understand the scenario, plan the activities and verify the theoretical mapping properly. The visit had provide an opportunity for a more in-depth assessment of the metropolitan city's solid waste management practices.

Photo 2: Visit to Landfill site

2.4 Sampling design and techniques

The stratified Random sampling technique was used to select the representative sites of the metropolitan city for the comprehensive representation of overall more than 50% of the city i.e., 19 wards in the metropolitan city where only household and healthcare samples were taken from the rural areas.

Sample sites include households of each municipal wards, institutions (school, college, offices and banks), commercial (shops, hotels, restaurants, etc.), health (hospital,

health post, polyclinics, labs, and pharmacy), religious sites, government offices and others.

2.5 Waste Assessment

A prime method of the diagnostic assessment process is the collection of waste generation data in the sampled areas. Waste from every sampled household, institution, commercial, industrial, health sector, etc. were recorded for 3 working days in a standard format designed by HECAF360. Similarly, the plastic audit was adapted from Basel Rotterdam and Stockholm (BRS) Secretariat and UN-Habitat and Break free from Plastic (BFFP).This will show the scenario of the waste categories from different households and non-households.

A team comprising volunteers, waste separators from the metropolitan city, and professionals from HECAF 360 conducted a diagnostic waste assessment. The assessment was carried out using the following methods:

- **Waste Collection and transportation:**

Photo 1: Waste collection

The wastes were collected on a daily basis for three days from households, institutions, commercial, industrial, health, religious, and religious and many other sectors. For the collection of day-wise waste from different sites, the sacks and polythene were distributed in different sample sites. The 24 hrs collected waste was collected and transported to the dumping site. The waste collection and transportation mechanism for the waste assessment was implemented by deploying three vehicles in the designated areas over two phases. Each phase covered eight wards, with operations conducted over a three-day period per phase (from February 14 to 16, 2025, and from February 18 to 20, 2025). The waste assessment of healthcare sector was conducted by transporting the waste using the infectious waste collection vehicle owned by metropolitan city to avoid contamination.

- **Waste Sorting and quantification**

The collected wastes were transported to the landfill site for sorting; during sorting, the team had ensured that the waste separators were well equipped with at least masks and gloves for their safety whereas forks were given for the separation of waste. The waste separators sorted the collected waste into categories such as organic, plastic, paper, metal, glass, textiles, leather, infectious, and other as per the category designed by HECAF360. Waste sorting process was continued for 6 days, 3 days for each wards of each day's waste collection. Before and after the sorting, the total waste was initially weighed and volume was also measured. The detailed records were carefully maintained.

Photo 2 Waste sorting

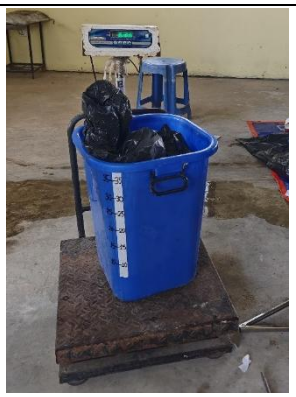

Photo 3 Waste Quantification

Further the plastic waste audit was further continued with the plastic waste collected during assessment. Plastic waste audit is a systematic process where various plastic waste sources are assessed and document the types and the amount of plastics, identify major sources of waste, and assess current waste management practices. It helps to identify the top contributors to plastic waste and encourage policy makers on how to reduce plastic waste, adopt sustainable solutions and implement Extended Producer Responsibility EPR programs.

The plastic waste audit categorized the plastic waste into 7 different types i.e., Polyethylene (PET), High Density Polythene (HDPE), Polyvinyl Chlorine (PVC), Low Density Polyethylene(LDPE), Polypropylene (PP), Polystyrene (PS) and Others.

2.6 Meetings, Surveys and Interviews

The meeting was conducted with different stakeholders such as municipal officials, representatives of different sectors such healthcare, commercial, institutions etc. These meetings informed the initiatives taken by metropolitan city on waste management sector. The survey was also conducted with representatives of the metropolitan city's officials who are involved in the waste management system to understand the managerial part of the waste management.

Moreover the formal and informal discussions and interviews are conducted for collecting the information on waste management.

Photo 4: Meeting with municipal officials

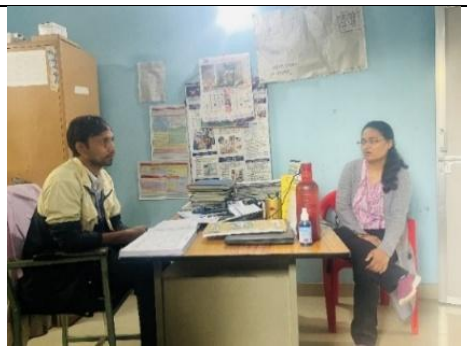

Photo 5: Meeting with health-post staff on waste assessment

Similarly, surveys were conducted with waste collectors and transporters on waste collection and transportation scenarios. Similarly, waste handlers working at landfill sites were also surveyed to gather information on the waste scenario of the landfill site. The survey was also performed in the community to better understand about the scenario around the dumping site.

Photo 6: Survey with local people around the dumping site

Photo 7: Survey with the representative at dumping site about the waste management

2.7 Documentation, reporting and dissemination

The audiovisual documentation of each of the process of assessment as well as on field information on current practices are conducted via photographs and videos. This documented information will be used for raising awareness among the community and involved stakeholders. Similarly, for the dissemination purpose the draft report of the waste assessment was prepared incorporating the current situation of waste of the metropolitan city, gap analysis, options for upgrading the system and recommendation for longer term system strengthening.

3 FINDINGS

3.1 Existing Scenario of Waste Management Practice

2.7.1 Waste segregation

The practice of waste segregation in the city remains unsatisfactory and inadequate. Although households and institutions have been instructed to separate biodegradable and non-biodegradable waste, observations during transportation show that all waste is mixed together without proper segregation. Furthermore, risk waste including infectious waste generated from healthcare sector is also not being separated from non- risk or general waste posing significant risks of contamination and serious public health impacts.

2.7.2 Waste Collection and Transportation

The municipality has contracted the waste management company that collects and transport the waste to the landfill site and manage the regular operation of the landfill site. The waste collection and transportation takes place daily for 8 hours in regular days and four hours in Saturdays. The metropolitan city is investing 12 crores per year equivalent to USD 865,177 for the management of general waste. In market areas, waste is collected twice or more daily to manage the high volume effectively.

Photo: Containers placed on roadside for the collection of waste

The metropolitan city has implemented a combination of waste management services, including roadside pick-up points and strategically placed 43 waste containers in few areas to temporarily store household waste between scheduled collection periods. In major urban zones, a door-to-door waste collection system is in operation to enhance service coverage and efficiency. Waste deposited in containers is transported to the dumping site once the containers reach full capacity. However, the lack of lids on these containers makes them easily accessible to animals, increasing the risk of waste being scattered onto roads and surrounding areas. This presents both environmental and public health concerns, highlighting the need for improved containment and management strategies.

The metropolitan city operates approximately 42 waste collection tractors daily, each assigned to a specific ward to ensure consistent and systematic waste collection and transportation f waste from households and market areas whereas 3 trucks are assigned for the collection of healthcare waste separately .

However, these services do not extend to rural areas, where the absence of waste management infrastructure and limited public awareness has led to the common practice of open burning or burial of waste. Collected waste from urban wards is transported directly to the designated landfill site. At the landfill, a workforce of 142 personnel including 85 labor staff, 15 machine operators and 42 drivers has been allocated by the city to carry out the segregation and categorization of waste, supporting more efficient waste management and potential resource recovery efforts.

The metropolitan city does not handle waste directly from the healthcare sector, recognizing that such waste is hazardous and must be managed separately to prevent contamination of general waste streams. In addition to healthcare waste, waste generated from other specialized sectors is also collected and transported separately to designated integrated healthcare waste management center but the ensuring compliance with proper waste management system. The municipality itself is managing the pharmaceutical waste and generating 50 lakhs per year equivalent to USD 36000.

2.7.3 Final Disposal

The collected waste from Birgunj Metropolitan City is disposed of at a crude landfill site located in Nagwa Ward 19, approximately 1 kilometers from the nearest residential area of Nagwa but as per the observation, the residential is very close to the landfill site. The landfill spans an area of 17 bigha and 5 Katha (116488 square meter) and is currently under a five-year contractual agreement. Geographically it lies 26^{0}59'47" N and 84^{0}53'20" E. The landfill site is designed for a life of at least 15 years and if properly managed it may extend to 20 years.

Photo: Present scenario of dumping site

Figure 1: Layout of Landfill Site at Birgunj Metropolitan City

As per the observation and exploration at site, waste is firstly dumped openly and without any form of treatment, contributing to environmental and health concerns due to unregulated disposal practices.

Despite this, the metropolitan city has implemented a basic waste management system that separates recyclable and non-recyclable materials. Recyclable waste is sorted and forwarded to appropriate facilities for processing, while non-recyclable waste is compacted daily into a 40 m² strip. Each strip is subsequently covered with a 5 cm layer of mud to minimize odor and vector infestation.

Based on informal discussions with the site engineer, the landfill receives an average of 65 tons of waste per day from Birgunj Metropolitan City, in addition to approximately 10 tons per day from Jitpur- Simara Sub Metropolitan City. Meanwhile, feedback from rural residents indicates that most households are managing biodegradable waste through traditional composting methods. The compost produced is commonly used as fertilizer in local farming, highlighting the effectiveness of decentralized biodegradable waste management in rural areas of the metropolitan city.

In contrast, households in urban areas, as well as other sectors, send their biodegradable waste to dumping sites. If proper segregation of biodegradable waste is implemented, the metropolitan city could establish a centralized composting or biogas plant. This would not only help manage waste but also create local job opportunities for waste workers and marginalized communities. Furthermore, the system would produce compost or residue that can be used for agricultural purposes, generating additional income and promoting organic farming, which enhances food security and reduces reliance on chemical fertilizers.

In addition to this, the metropolitan city has space for collecting the recyclable materials near the premises of landfill area.

Birgunj Metropolitan City occupies a significant economic and industrial hub with it being the second-largest city in Terai and the fifth-largest city in Nepal. As per the statistics available in the metropolitan city, almost 35 registered plastic industries are available who are manufacturing the plastic products but the plastic waste generated from the city and other parts of the country are exported to India for further processing and recycling by the scrap dealers.

In addition to this the waste collected and transported to landfill site are further separated and the contractor send approximately 22 tons of plastic waste per year. It seems that if the city could develop the system for collection of then this factory could use the local raw materials instead of the imported one. This will also promote the local recycling factory instead of relying on the Indian factories for recycling.

3.2 Municipal waste generation and composition

3.2.1 Sources of Waste Generation

The major sources of waste generation in Birgunj Metropolitan city are households, commercial (shops, markets, hotels, restaurants, banks, offices), industrial (industries and factories), healthcare (hospital, health posts, polyclinics, pharmacy, labs, etc.), institutions (schools, college), religious place (temples, cultural sites) etc.

Among them commercial sectors is the dominant source of waste as Birgunj is also considered as the "Commercial capital of Nepal". There are other sources of waste generation such as agricultural sites, roadside dumping, riverside dumping, etc., which are not considered under this study.

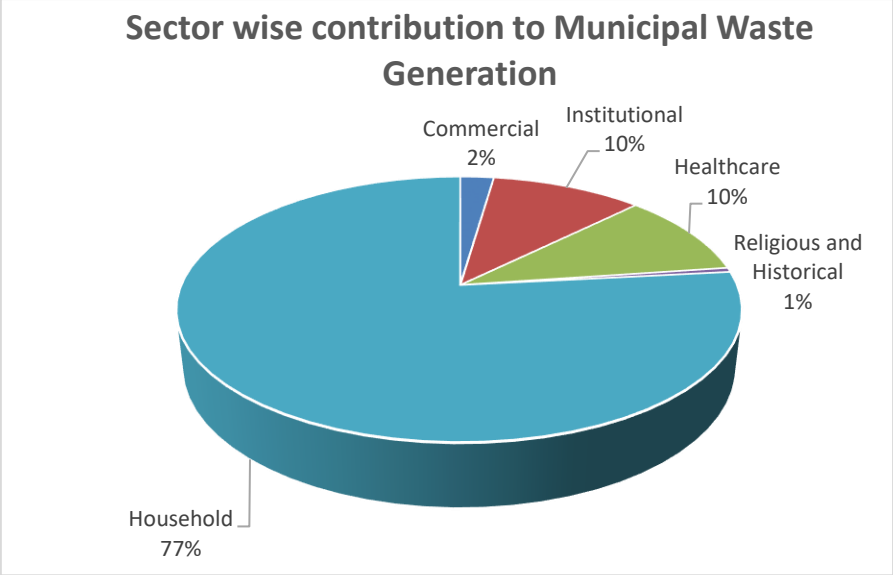

Figure 2: Sources of waste generation in Birgunj Metropolitan City

According to the assessment, households are identified as the primary source of waste, followed by the healthcare and institutional sector. Households generate a substantial 77% of the total waste, while the healthcare and institutional sector accounts for each 10%. Waste contributions from commercial and religious and historical sectors are relatively minor, contributing 2%. and 1% respectively. The data is illustrated in the figure 1.

3.2.2 Municipal Solid Waste Generation Scenario

The waste assessment data analysis shows that the total daily waste generation of the Birgunj Metropolitan City is 38 tons/day and 319.47 m3/day. The estimated annual waste generation of the municipality is 13510tons/year and 116668m3/year. The per capita waste generation rate was 0.138 kg/capita/day of the people residing in the municipality.

Waste composition analysis is the process of separating, weighing and categorizing waste into various waste categories such as biodegradable, plastics, paper, metals, glass, hazardous, etc. Some of the sample sectors are households, commercial, institutions, healthcare and religious places. Therefore, further analysis of municipal solid waste composition was analyzed into household, institution, commercial, industrial, religious and healthcare sectors as these sectors are responsible for waste contribution to the municipal stream. The waste composition is shown in the figure 2.

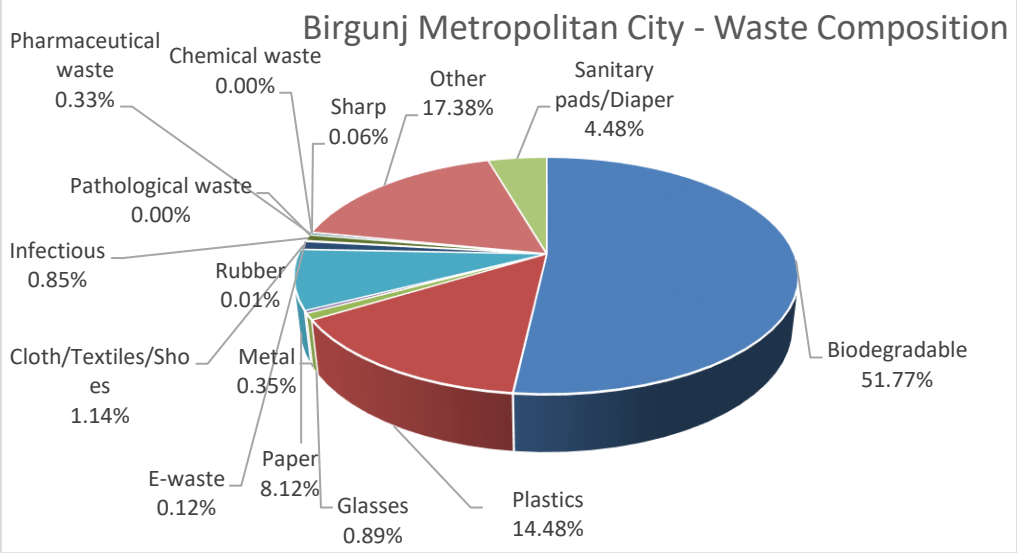

Figure 3: Waste composition of Birgunj Metropolitan City

The total waste generated by sectors (household, commercial, institution, religious and healthcare) in the metropolitan city was calculated. It was found that the highest waste contributor is biodegradable (51.77%) followed by other waste (17.38%) and plastic (14.48%) as major contributors of waste generation in the metropolitan city. Beside these, other waste is also generated such as paper (8.12%), infectious waste (0.85%), sanitary pads/diaper (4.48%), sharp waste (0.06%), cloth/textile/shoe (1.14%), rubber (0.01%), metal (0.35%), pharmaceutical (0.33%), e-waste (0.12%), glass (0.89%), and no chemical waste and pathological waste was observed during the time of waste assessment. The infectious waste, pharmaceutical, sharp, glasses etc. are mostly generated from the healthcare sector and minimal amount from household and other sectors.

3.2.3 Sector wise Waste generation scenario

The average daily waste generation by weight, volume, and sector wise contribution by households, commercial sector, institutional sector, religious sector and healthcare sector is presented in the table 3.

In addition, healthcare waste is found to be dominating with the waste of 9.09 kg/day followed by religious and historical places with the waste of 4.30kg/day. Even though Birgunj is known to be the commercial city but waste from commercial sector was found to be the last one with the waste of 0.57kg/day since it has excluded the industrial area where they manage their waste by their own.

Table 2: Municipal Solid Waste Generation Scenario

Sectors	Daily waste generation (Kg/day)	Daily waste generation (m3/day)	Sector wise contribution (sector/kg/day)
Commercial	843	11	0.57
Institutional	3818	20	2.37

Healthcare	3782	46	9.09
Religious and Historical	198	0.88	4.30
Household	28373	241	0.60

a. Household waste composition

Waste generated from the residents and households either owned or rented is categorized under this category. 188 households were under the assessment covering the 20 municipal wards. 28 tons of waste is generated from the household level amounting to 600gm per household in an average.

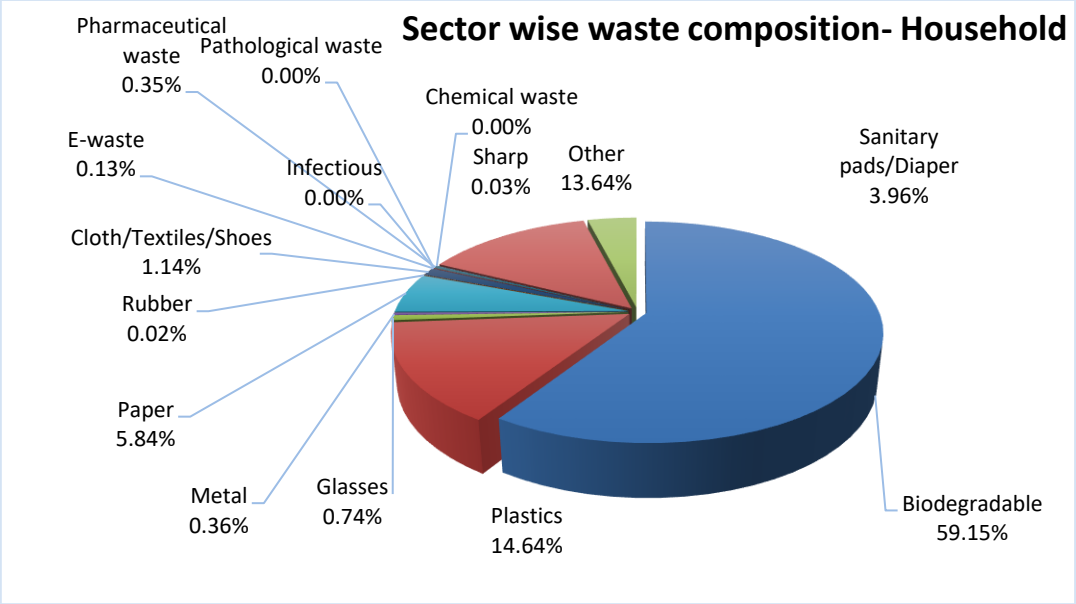

Figure 4: Household waste composition of Birgunj Metropolitan City

The household sector waste comprised the highest percentage of biodegradable waste i.e., i.e., 18 tons (59%) followed by 4.5 ton (15%) of plastics and plastic products, 14% other wastes, 6% paper, 4% sanitary pads/diapers and 1% cloth/textiles. The other waste such as glasses (0.74%), metals (0.36%), rubber (0.02%), e-waste (0.13%), pharmaceutical waste (0.35%) and sharp (0.03%) are found to be minimum i.e less than 1%. Whereas, pathological waste, infectious waste and chemical waste was found to be non- significant as its quantity is negligible i.e. 0.00%. The data is presented in the figure 3.

b. Institutional waste composition

The waste generated from schools, colleges, private and government offices, and other academic institution etc. is categorized as institutional waste. The institutional waste composition was presented in the figure 4.

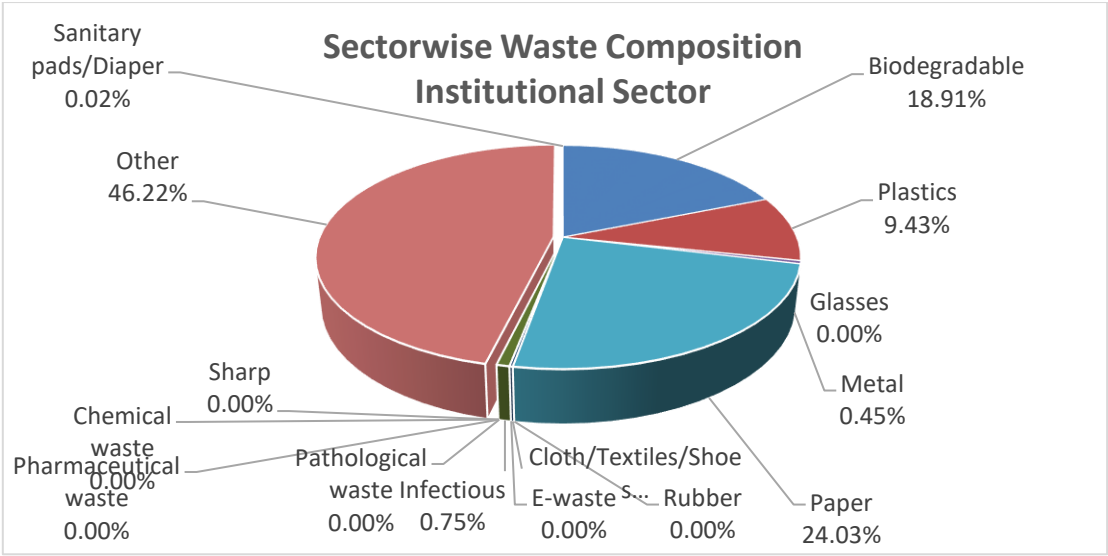

Figure 5: Institutional waste composition of Birgunj Metropolitan City

The composition of institutional waste reveals that the largest proportion consists of "other waste" (46%), followed by paper (24%) and biodegradable waste at 19%. In contrast, other waste categories contributed minimally to the overall composition: metals (0.45%), sanitary pads and diapers (0.02%), cloth/textiles/shoes (0.19%), and infectious waste (0.75%). No significant quantities were recorded for e-waste, pharmaceuticals, rubber, pathological waste, sharps, chemical waste, or glass, each accounting for 0.00% of the total waste.

c. Commercial waste composition

The waste generated from hotels, restaurants, shops, markets, etc. is categorized as commercial waste.

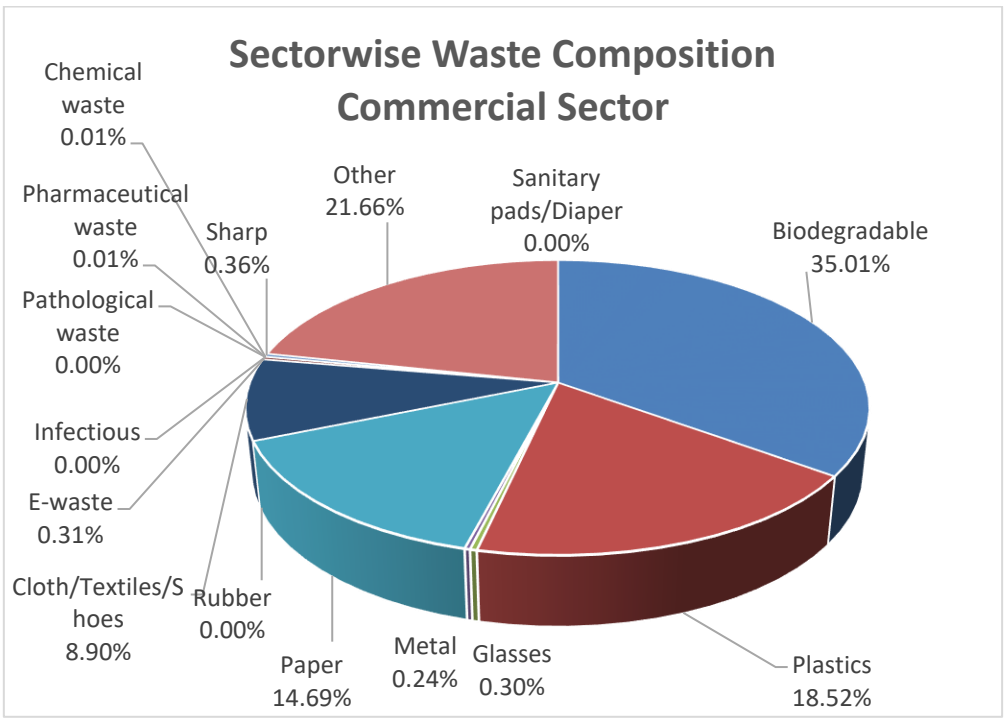

Figure 6: Commercial waste composition of Birgunj Metropolitan City

Similar to institutional waste, the largest component of commercial waste is biodegradable waste, accounting for 35.01% of the total. This is followed by plastics at 18.52% and paper at 14.69%. Other waste types contributed smaller proportions, including cloth/textiles/shoes (8.90%), other waste (21.66%), metals (0.24%), e-waste (0.31%), glass (0.30%), and sharps (0.36%). Minimal amounts were recorded for pharmaceuticals (0.01%), chemical waste (0.01%), and no measurable quantities were observed for sanitary pads and diapers, infectious waste, rubber, or pathological waste, each contributing 0.00%. The data indicates that a significant share of commercial waste is either compostable or recyclable like paper, plastics, metals, glass, textiles. With proper segregation and resource recovery strategies, only a small fraction would require landfill disposal, leading to reduced environmental impact and improved municipal waste management efficiency. The relatively high percentage of "other" waste implies poor sorting at the source.

d. Religious waste composition

The waste generated from religious, historical places and cultural areas is categorized as religious waste.

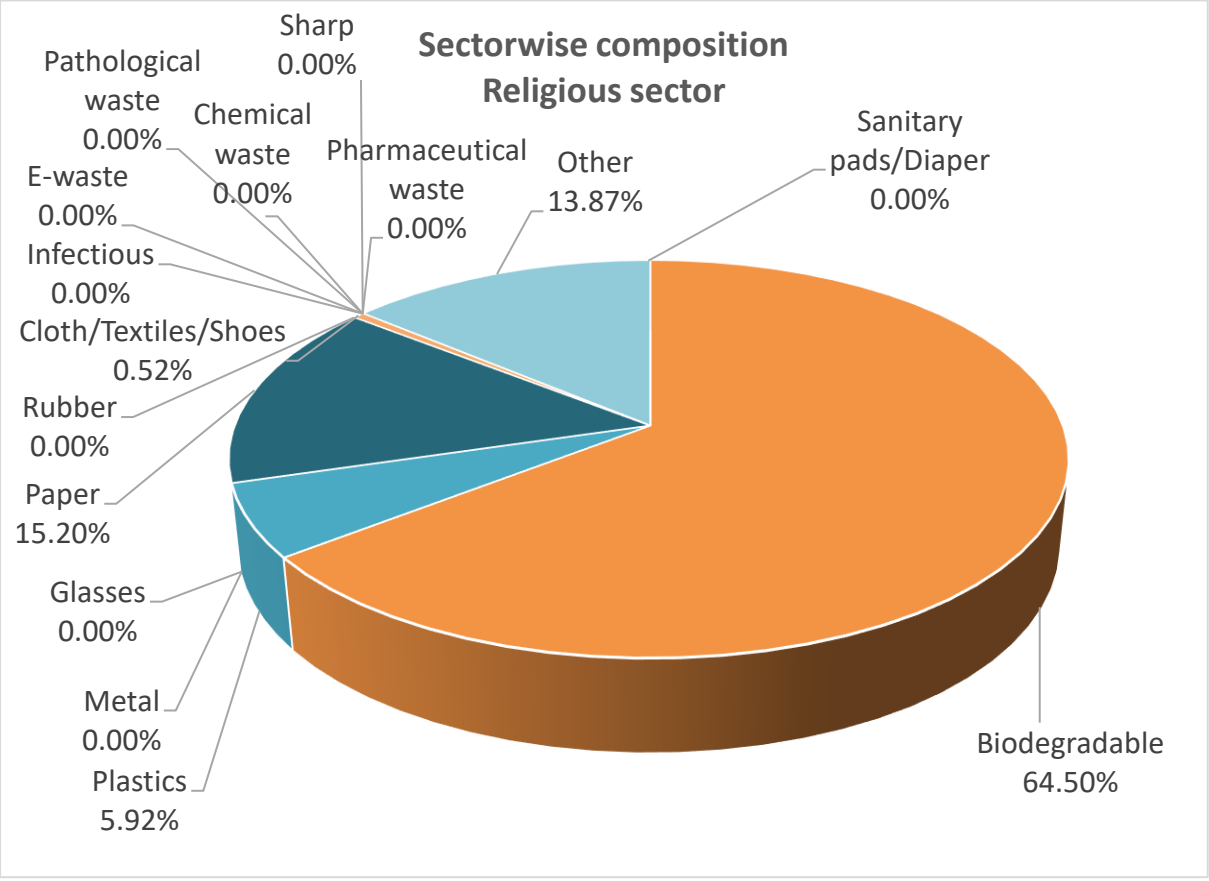

Figure 7: Religious waste composition of Birgunj Metropolitan City

The highest proportion of waste generated in the religious sector is biodegradable waste, accounting for 64.50%, followed by paper (15.20%), other waste (13.87%), and plastics (5.92%). Cloth and textiles constitute a minor share at 0.52%, while no measurable quantities were recorded for other waste categories. The religious sector plays a significant role in biodegradable waste generation, primarily due to organic

materials used in rituals, including offerings of food, flowers, plant-based decorations, and materials associated with religious celebrations. This data is illustrated in *Figure* 6.

e. Healthcare composition

The waste generated from hospitals, health post, health care centers, polyclinics, labs, pharmacy, etc. is categorized as healthcare waste. Health-care waste contains potentially harmful microorganisms that can infect hospital patients, health workers and the public. The waste generated from the healthcare facility constitute 85% general or non-hazardous, 15% hazardous/infectious/ risk in nature (WHO, 2014). Infectious, hazardous and risk waste are infectious, sharp and could harm the people and community. Risk waste needs to be treated properly before disposal. Risk waste should not be mixed with general waste as risk waste can contaminate the general waste due to various germs and bacteria.

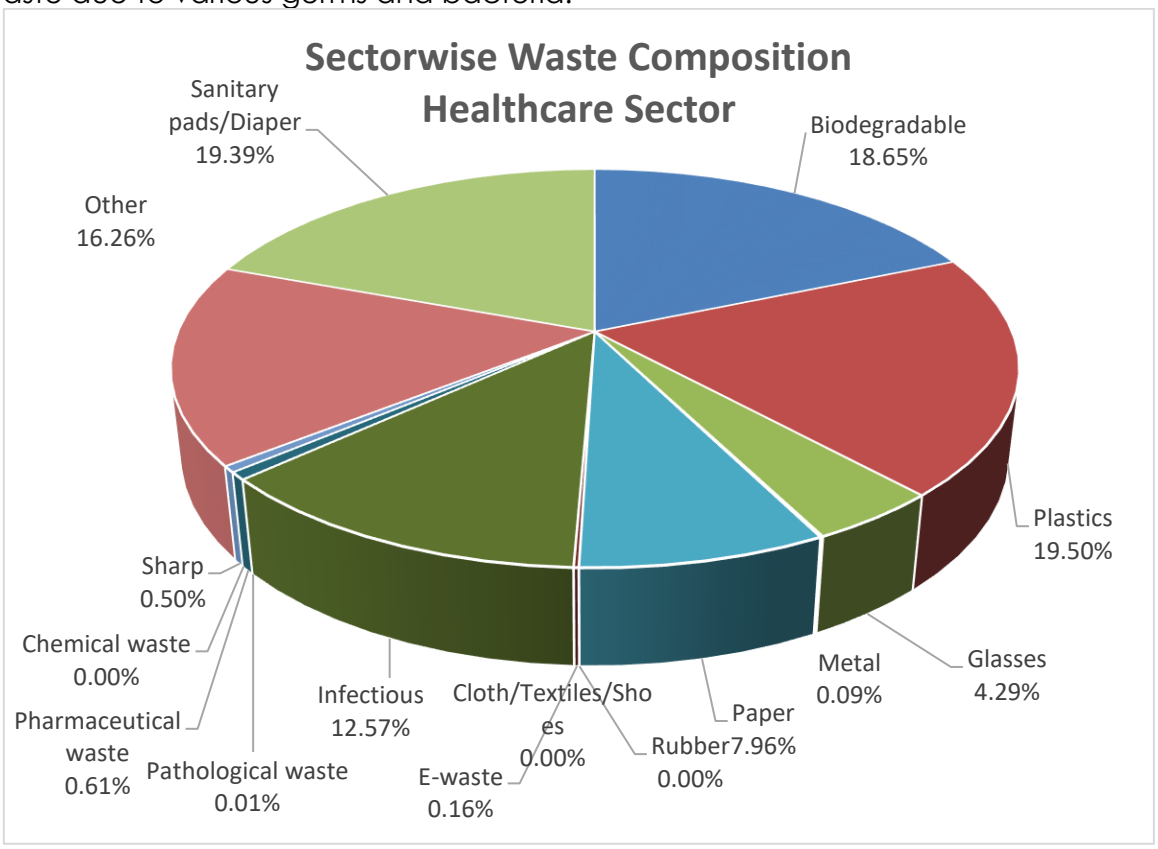

Figure 8: Healthcare waste composition of Birgunj Metropolitan City

The healthcare sector generates a diverse mix of hazardous and non-hazardous waste. The highest proportion is plastic waste (19.50%), followed by sanitary pads and diapers (19.39%), biodegradable waste (18.65%), infectious waste (12.57%), other waste (16.26%), and paper (7.96%). Other waste categories include glass (4.29%), sharps (2.42%), and smaller fractions of pharmaceuticals (0.61%), e-waste (0.16%), pathological waste (0.01%), and metals (0.09%). No measurable quantities were recorded for cloth/textiles/shoes, rubber, or chemical waste. This composition indicates that plastic waste and sanitary items contribute significantly to the overall waste volume, largely due to the high use of disposable materials in medical settings. To address this, the healthcare sector should adopt plastic reduction strategies and the use of eco-friendly, reusable alternatives. These measures can substantially reduce total waste volume and environmental impact. Furthermore, recyclable

materials such as paper, plastics, and glass should be properly segregated and directed to recycling streams, thereby lowering both the financial and institutional burden of waste management.

3.3 Findings of Plastic Waste Audit

The plastic waste audit was conducted across various sectors, including households, institutions, commercial establishments, industries, religious sites, and healthcare facilities. The audit revealed that household were the largest contributors, generating 68% of the total plastic waste. Institutional accounted for 15% followed by 10% from healthcare sector and Commercial accounted for 7%. No measureable plastic materials were obtained from religious sites. These findings are illustrated in Figure 9.

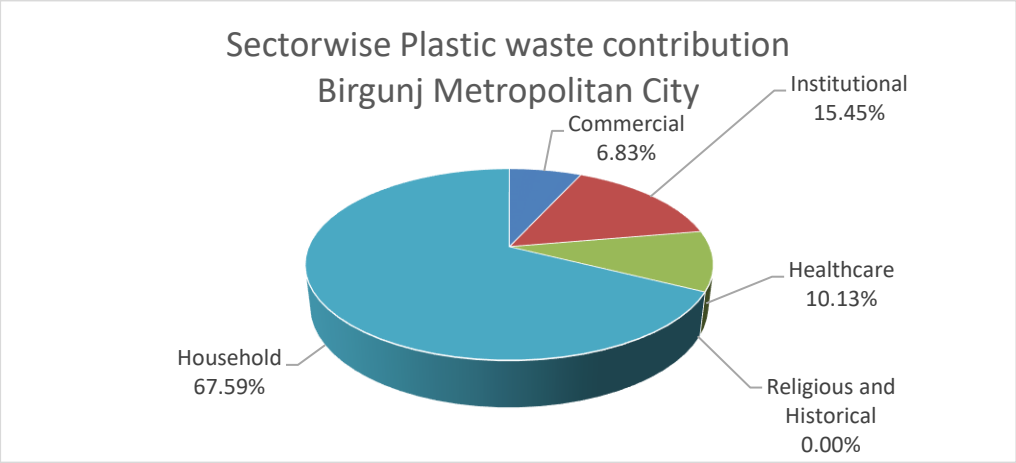

Figure 9: Plastic materials generated by different sectors

As per the analysis of plastic waste data based on seven different types of plastics, it was found that Other Plastic (O) accounts for the majority, contributing 30%, followed by LDPE (26%), HDPE (20%), PET (19%) and PP (4%). The minimal contributions were observed from PVC and PS which is illustrated in the figure10. This data highlights the dominance of mixed and difficult-to-recycle plastics, particularly in the "Other" category, which may include multi-layered packaging, contaminated plastics, or items not clearly labeled. The significant presence of LDPE, HDPE, and PET materials that are recyclable indicates a strong potential for improving plastic recycling systems. Plastic identification, source segregation, and investment in recycling infrastructure could further enhance recovery rates and reduce plastic pollution.

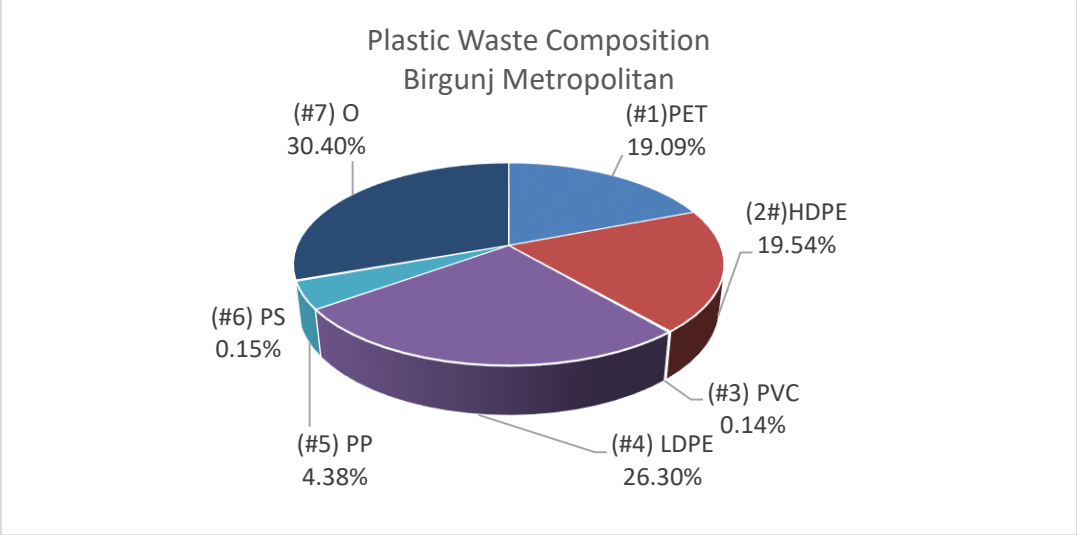

Figure 10: Generation based on plastics types

As per the analysis examining the plastic waste generated by different sectors It was found that healthcare facilities produced the most HDPE, PP and PS plastics, while commercial generated the highest amounts of PET, PVC and LDPE, similarly institutional sector generated the highest amount of O-type plastic. Households sector contributed primarily to LDPE, Other, PET and HDPE plastics. Religious sector contributes no measureable amount of plastic waste. These results, shown in Figure 12, indicate that proper segregation at the source could make healthcare waste a significant income source through recyclable materials. Overall, PET, HDPE, and LDPE were the most commonly used plastics across all sectors, followed by PS, PP, PVC, and O-type plastics.

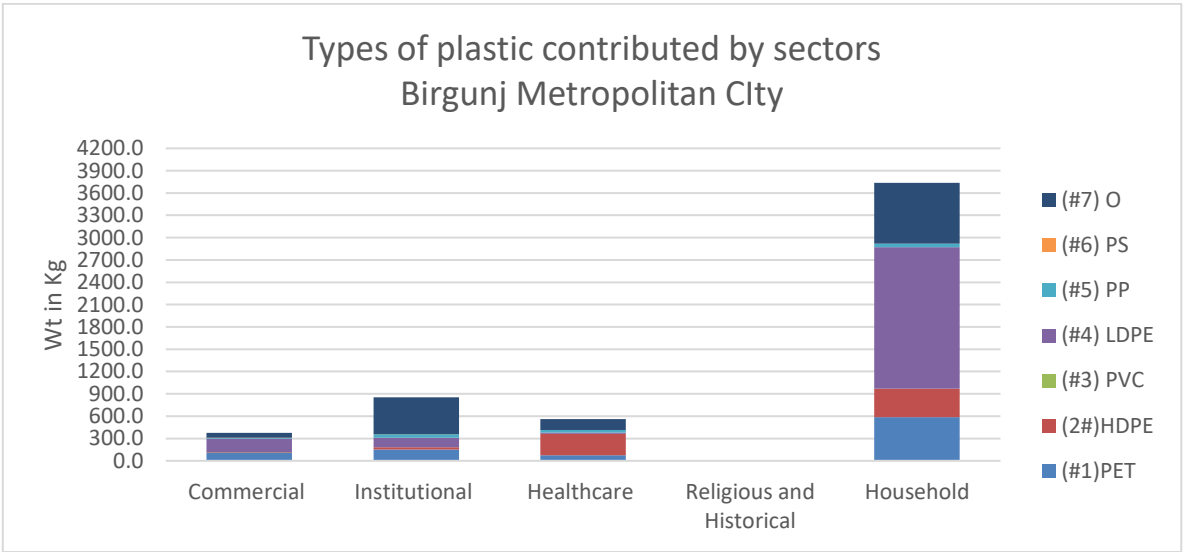

Figure 11: Types of plastic waste contributed by sectors

4 Recommendations

Short-term recommendation

1. Institute the waste management system in municipality
    a. Constitute a municipal waste management committee representing all the sectors from the waste is generated
    b. Allocate a relevant focal person for supervision and monitoring of waste management.
2. Conduct regular awareness campaign for segregation at source and other capacity development activities
3. Collaborate with the technical experts and relevant stakeholders such as private sector, business organization, recycling vendors and companies
4. Develop a safe and environmentally friendly waste management system from waste generation to final waste disposal based on zero waste concept.
    a) Design and implement a suitable and doable waste segregation system at household and other sectors through participatory approach.
    b) Design and implement safe waste collection and transportation systems.
    c) Design and construct a municipal level centralized material recovery facility (MRF) with the designated waste compartment for waste storage
    d) Develop proper and safe waste disposal mechanisms ensuring the occupational health and safety
    e) Promote recycling opportunities and household composting
5. Develop a systematic recording system for waste generation and sale.
6. Provide training to all healthcare staff on safe health care waste management systems as per their role in their operation.
7. Develop and design the waste transportation and disposal system

Long-term recommendations

- Adopt the universal principle of waste management
    - Precautionary principle
    - Polluters pay principle
    - Proximity principle
    - Duty of care principle
    - Extended Producer Responsibility principle
- Allocate yearly budget for waste management of the municipality.
- Develop and execute strong policy, strategy and guidelines relevant to the local context including the following issues
    - waste reduction
    - source segregation
    - plastic use minimization including the prohibition of single use plastics and sachets
    - penalty and reward mechanism
    - Green procurement
    - Disposal mechanism for different types of waste
- Optimize waste collection routes, increasing coverage and improving efficiency.
- Integration of healthcare waste management in the municipal waste by

  - Establishing the waste treatment center for the treatment of waste generated from small healthcare facilities
  - If private hospitals and other private healthcare facilities are willing to collaborate with the municipality to manage their waste, the facilities should pay the fees allocated by the municipality under the "Polluter's Pay Principle".
  - Provide necessary infrastructure to small health care facilities under municipality
  - All healthcare facilities should strictly treat infectious waste through disinfection methods before disposal to the municipality.
- Develop community engagement, public participation and consultation and education and awareness activities of the concept of sustainable waste management on a regular basis.
- Initiate and promote an incentive and reward policy on a timely basis in various sectors to improve solid waste management.
- Develop and execute fee structure for private sectors for collection and management of waste.
- Develop a data management system, monitoring of waste, update data on the timely basis and disseminate to the relevant stakeholder and the public.
- Develop the monitoring mechanism either internally or externally
- The municipality should take strong actions against the use of polythene bags applied the government threshold on polythene bags.
- Conduct the recycling factories and vendors mapping and promote the local recycling facilities including the vendors.

5 Conclusion

The assessment of waste management practices in Birgunj Metropolitan City highlights both progress and persistent gaps in the existing system. While the municipality has established a structured collection and transportation mechanism, invested significant resources, and introduced basic segregation and disposal practices at the landfill site, several challenges remain. Waste segregation at the source is still inadequate, healthcare and other risk waste are not effectively managed, and open dumping at the landfill continues to pose environmental and public health risks. Moreover, limited infrastructure in rural areas has contributed to unsafe practices such as open burning and burial of waste.

The findings indicate that households are the primary source of municipal solid waste, with biodegradable waste forming the largest share. However, rising volumes of plastics, healthcare-related waste, and other non-biodegradable materials demand immediate attention. The plastic waste audit further reveals that a large proportion of plastics are recyclable, yet due to weak segregation and lack of recycling infrastructure, most are lost to the landfill or exported for processing. This not only strains the local environment but also undermines opportunities for resource recovery and local economic benefits.

The waste composition of each sector showed that biodegradable waste found highest in sectors like household, commercial and religious sectors. The health sectors produce more plastic waste whereas institution produces "other waste". It is because healthcare sectors use single-use medical supplies, infection control mechanisms such as masks and gloves, packaging and disposables in testing and diagnostics used in laboratories.

In addition to this, among these categories, PET and HDPE are recyclable whereas PVC can never be recycled. Moreover, remaining plastics i.e., LDPE, PS and other plastics can sometimes be recycled but it depends on the products and most of other plastic are non-recyclables. Therefore, it is clear that only 39% of the plastic waste generated from the municipality are recyclables and rest of the plastics have low chance of recycling which contains the wrapper and sachets of junk food. 41% LDPE plastic basically consist of polythene bags so this could also be recycled that clearly depicts that more than 65% are recyclable plastics which could be sent for recycling. By reducing non-recyclable plastic will almost 35%of the plastic waste. The Other category of waste also contribute almost 30% including the single use plastics, packaging material and sachets. These plastics should be discouraged to use.

Despite these challenges, Birgunj has strong potential to develop a model waste management system based on zero waste. The presence of registered plastic industries, the possibility of decentralized composting in rural areas, and opportunities for systematic material recovery facilities (MRFs) at the municipal level create pathways for sustainable solutions. By adopting zero waste principles, strengthening healthcare waste management, and enhancing collaboration with private sector and recycling vendors, Birgunj can transition towards an environmentally sound and economically viable system.

In moving forward, the municipality must act decisively implementing the short-term measures to strengthen segregation, awareness, and monitoring, while also committing to long-term strategies that institutionalize sustainable waste management through policy, infrastructure, and financial mechanisms. With integrated efforts and active participation of all stakeholders, Birgunj Metropolitan City can significantly reduce its environmental footprint, safeguard public health, and serve as a leading example of sustainable urban waste management in Nepal.

6 Annexes

Annex 1: Photographs

Briefing to School representative on waste assessment

Materials handover to volunteers required for waste assessment

Plastic distribution to households for waste collection

Labeling of bucket for volume calculation

Training for support staff and volunteer on waste assessment

Pre-weighing of bucket before assessment

Photo 19: Waste sorting of household waste

Photo 10: Assessment of health care waste

Photo 21: Plastic audit of HCFs waste

Photo 22: Vehicle used for the transport of health care waste

Photo 2: Survey with local near the dumping site

Photo 3: Local vendor and scrap dealer

Annex 2: Letter from Birgunj Metropolitan City to HECAF 360

वीरगंज महानगरपालिका

Birgunj Metropolitan City

नगर कार्यपालिकाको कार्यालय
आदर्शनगर, वीरगंज, पर्सा
मधेस प्रदेश, नेपाल

वीरगंज, पर्सा
मधेश प्रदेश (नेपाल)
२०७४

मितिः२०८१/१०/१४

प.सं. ०८१/०८२
च.नं. ५५५२

हेल्थ इन्भारोमेन्ट एण्ड क्लाइमेट एक्सन फाउन्डेशन (हेकाफ ३६०)
लाजिम्पाट, काठमाडौं-२

विषयः जानकारी सम्बन्धमा।

उपरोक्त विषयमा ताहाँ कार्यालयले यस बीरगंज महानगरपालिका भित्र उत्पादित ठोस फोहर लगायत प्लाष्टिकजन्य फोहोरको लेखाजोखा तथा अध्ययन गर्न संस्थाका प्राविधिक टोलिलाई आवस्यक सहयोग र समर्थन गरिदिने व्यहोराको पत्र प्राप्त भएको छ।

यस वीरगंज महानगरपालिकाले फोहरमैला व्यवस्थापनलाई पहिलो प्राथमिकतामा राखि काम गर्दै आइराखेको अवस्थामा ताहाँ थी हेल्थ इन्भारोमेन्ट एण्ड क्लाइमेट एक्सन फाउन्डेसन (हेकाफ ३६०) सो सम्बन्धमा अध्य्यन, अनुसन्धान तथा लेखाजोखा गर्नेकार्यमा आवस्यक सहयोग, समर्थन तथा सहकार्य गरिने जानकारी गराइन्छ।

.....
राजेशमान सिंह
प्रमुख

"औद्योगिक तथा व्यापारिक शहर सुसंस्कृत, सभ्य हाम्रो वीरगंज महानगर"
आर्दशनगर, वीरगंज, नेपाल फोन : ०५१-५२२८०२, फयाक्स : ०५१-२२०१४
Adarsh Nagar, Birgunj(Nepal),Ph.:977-051-522802, Fax:051-22014
Web site :- www.birgunjmun.gov.np, Email:-info@birgunjmun.gov.np

Annex 3: List of Volunteers and Local Supporting Staff

List of Volunteers assigned for Municipal Waste Assessment at Birgunj Metropolitan City, Birgunj			
S.N	**Name Of Volunteers**	**Wards Assigned**	**Institution**
1	Sudhir Sah	8,9	Nepal Commerce Campus
2	Rajnandani Gupta	5,16	Thakur Ram Campus
3	Aakriti Hamal	2,14	Mamta Vidhya Mandir
4	Anjali Kumari	1,10	Thakur Ram Campus
5	Rajina Khatoon	3,15	Thakur Ram Campus
6	Kiran Mandal	6,12	HKMC
7	Mihika Thapa	4,13	Birgunj Commerce Campus
8	Aaditya Mahato	7,11	Thakur Ram Campus
9	Anju Kumari	-	Thakur Ram Campus

List of Support Staff assigned for transportation and waste assessment at Birgunj Metropolitan City, Birgunj		
S.N	**Name of Staff**	**Designation**
1	Mr.Mansur Miya	Driver
2	Mr.Saroj Raut	Support Staff
3	Mr. Jitendra Prasad Kuswaha	Driver
4	Mr. Nagendra Prasad Sah	Driver
5	Mr.Mukesh Raut	Support Staff
6	Mr. Laxman Mister	Support Staff
7	Mr. Promod Raut	Support Staff
8	Mr. Lal Babu Mali	Support Staff
9	Mr. Brij Kishor Kusuwaha	Driver