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Material Flow Analysis of Plastic Waste in Nepal

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Abstract

This study presents a comprehensive plastic waste inventory of Nepal using material flow analysis. The Basel, Rotterdam and Stockholm (BRS) plastic waste inventory toolkit was adopted for examining plastic waste generation, management practices, and leakage pathways across 13 local governments. Primary data were collected from eight sites through field sampling, while surveys and secondary data supported analysis in five additional municipalities. A stratified random sampling approach was used which generated 2,056 samples across households, commercial establishments, institutions, healthcare facilities, and religious as well as historical sites. The findings indicate that Nepal generates approximately 5,329 tons of municipal solid waste daily (1.97 million tons annually), of which 16% is plastic, equivalent to 865 tons per day (315,618 tons annually). Per capita plastic waste generation varies significantly, with metropolitan areas producing the highest amounts. Material flow analysis shows that 83% (87,679 tons/year) of plastic waste is collected, while 17% (54,061 tons/year) remains uncollected and is often burned, buried, or otherwise unmanaged. Only 14% plastics is recycled (43,833 tons/year), while over half (162,790 tons/year) is disposed of in controlled or uncontrolled sites. Approximately 17% (52,887 tons/year) leaks into the environment across the waste management chain. When accounting for open dumping; excluded in the standard methodology, mismanaged plastic waste rises from 34% to 59%.These findings underscore the urgent need for Nepal for transition towards a circular economy and zero waste approach, prioritizing improved waste systems, reduced plastic consumption, and stronger policy implementation.

Keywords: *Archetypes, plastic inventory, mismanaged plastic waste, plastic leakage, uncollected plastic waste*

1. Introduction

With the growth of the population in urban areas, the issues of solid waste management remain a significant challenge, as increased waste generation overwhelms existing infrastructure, including waste collection, transportation, and disposal facilities; existing infrastructure is now insufficient or outdated and cannot manage the increasing volume of waste, leading to improper disposal, environmental contamination, and public health risks. The lack of waste management infrastructure leads to the open burning of waste, with all of its negative environmental and human health impacts (Maharjan, 2019). Approximately 16% of total waste is plastic waste (ADB, 2013) attributable to the growth of urban populations and shifts to more "modern" or "western" lifestyles that rely heavily on plastic, including single use plastic.

Plastic pollution is a growing environmental challenge in Nepal, driven by rising consumption of single-use plastics, rapid urbanization and gaps in waste management capacity. The surge in plastic consumption has also resulted in large volumes of discarded, degraded, or damaged plastic materials, contributing to environmental pollution and potential human health risks (Frienkel, 2011). Both macro-plastics and micro-plastics accumulate in aquatic and terrestrial ecosystems, contaminating rivers, lakes, oceans, soils and wildlife habitats (Alves, 2023). Hazardous substances such as dioxins, furans, mercury, and polychlorinated biphenyls (PCBs) may be released through improper disposal methods, including open burning and uncontrolled landfilling (Lohani, 2022).

In Nepal, plastic waste is increasingly visible in urban, rural, and natural environments, including rivers, agricultural lands, and urban drainage systems. Plastic macro-particles were discovered in the dung of the greater one-horned rhino (*Rhinoceros unicornis*) in the Terai landscape of Nepal (Awasthi, 2023). An abundance of micro-plastics have been measured and recorded in the snow and stream water of Mount Everest (Napper, 2020). A recent study has found the accumulation of micro-plastics in most consumed fruits and vegetables (Lazăr et al., 2024).They also enter the food chain through plants, seafood, processed foods, and drinking water. In addition, micro-plastics enter the food chain when people heat food in plastic containers (Vitali, 2022).

According to the World Bank (2020), approximately 44% of global waste is mismanaged, often through open dumping (33%) and burning (11%). Moreover, approximately 93% of waste in low-income countries like Nepal is disposed of through burning or dumping on roads, in open land, or into waterways (Kaza et al., 2018).

The study carried out by ADB in 2013 revealed that Nepal generates 1435 tons/day and 5,24,000 tons/year of municipal waste, equivalent to 317gm/capita/day (ADB, 2013). The average household waste generation per person was 170 grams/day. Similarly, the report presented that sectoral waste generation (average daily waste generated per office, school, commercial establishment or shop, hotel and restaurant) was 1.4kg, 4kg, 1.4kg and 5.7 kg respectively. Similarly, households in the municipalities of the Terai region generate 80% more waste than the mountain municipalities. During the period of the study, only six municipalities used sanitary landfill sites for disposal with the remaining 45 local bodies practicing open dumping in the road and along the riverside. Similarly, 41 municipalities had a separate section or unit dedicated to solid waste management while 17 municipalities did not have it. The report also stated that medical waste was incinerated by hospitals in a chamber or via open burning. In some municipalities, medical waste was mixed with municipal waste and either dumped or burned. Both practices expose people and communities to contagious diseases.

A new baseline study on solid waste management was conducted in 60 new municipalities of Nepal in 2016 (Pathak, 2017). The study found that the average waste generation per household was 115 grams/day. It further revealed that the average daily waste generation rates for various sectors: 3.25 kg per school; 0.95 kg per office; 1.1 kg per shop; and 3.1 kg per hotel or restaurant. It also highlighted regional differences in household waste generation, with households in the Terai region producing 0.60 kg per day, compared to 0.47 kg in the hill regions and 0.46 kg in the mountain regions. The average municipal waste generation was estimated as 180 grams per capita per day, or 419 metric tons per day, significantly lower than in 2013.

The Waste Management Baseline Survey of Nepal (CBS 2021) provided updated data, focusing on waste collection trends and sectoral contributions. The report was prepared based on a survey conducted in 2019/20; it covered 271 municipalities in Nepal. It revealed that municipalities collected an average of 2,231 metric tons of waste annually in 2017, 2,164 metric tons in 2018, and 2,233 metric tons in 2019. Daily collection rates per municipality remained consistent, averaging 6.1 metric tons in 2018 and 2020 and 5.9 metric tons in 2019. On average, urban municipalities generate substantial daily waste, averaging 4619 tons/day. The sector-wise waste generation analysis (collective numbers for all of Nepal) identified households as the largest waste generators (1784 kg/day), followed by business complexes (1142 kg/day), educational institutions (477kg/day), health institutions/hospitals (467 kg/day), industry (436kg/day) and others (313 kg/day). The analysis showed that household waste accounted for nearly double the amount generated by business complexes, underscoring the critical need for targeted interventions in residential areas to address waste generation.

The production of MSW depends upon the economic status, lifestyles, cultural traditions, and habits of inhabitants, as well as the systems in place (or not in place) within the community. The composition of MSW is changing with increasing use of packaging materials and plastics. According to the ADB report (2013), the composition of waste consisted of organic waste (56%), followed by plastic (16%), paper and paper products (16%), glass (3%), metals

(2%), textiles (2%), rubber (1%), leather (1%), and others (4%).

As per the baseline survey 2020 (CBS 2021), waste is being handled via three main methods: dumping in a landfill site (used by 48.6% of people and communities); burning (used by 32.1%); and river dumping (used by 27.4%).

From the literature review, plastic waste management in Nepal is characterized by fragmented data (WWF, 2024), limited source segregation, substandard waste collection systems, open dumping practices, and significant leakage of plastic waste into the environment (Pathak, 2017). These challenges are further compounded by weak policy implementation and the lack of reliable and comprehensive data on plastic waste generation, composition, and flow across the waste management chain (WorldBank, 2020). The absence of systematic data limits the ability of policymakers and local governments to design evidence-based interventions and effective strategies to reduce plastic pollution.

In this context, this study aims to establish baseline data on plastic waste in Nepal, quantify the fate of plastic waste management via the material flow analysis from generation to final disposal. A Material Flow Analysis (MFA) helps bridge this information gap by systematically quantifying plastic inputs, stocks, and outputs, thereby revealing inefficiencies, losses, and critical leakage points within the system.

By mapping the flow of plastic waste, the MFA (BRS, 2021) enables identification of major sources of plastic generation, levels of collection and recovery, the role of informal waste workers, the proportion of plastic that is mismanaged or ends up in landfills, the location and number of open dumping sites, and effects on natural ecosystems. This evidence is crucial for designing targeted interventions such as improving source segregation, strengthening recycling value chains, supporting the informal sector, and prioritizing investments in infrastructure.

Furthermore, the MFA supports the evaluation of existing policies and regulatory measures, including bans on single-use plastics and institution of Extended Producer Responsibility (EPR), by assessing their real-world impact on plastic flows. It also provides a robust baseline against which progress towards zero waste, a circular economy, and plastic pollution reduction targets can be measured over time.

Overall, conducting an MFA of plastic waste management provides a scientific and transparent basis for decision-making, enhances accountability among stakeholders, and supports the transition from linear "take-make-dispose" systems to more circular and sustainable plastic management approaches.

2. Materials and Methods

2.1 Study Area

For the study, the local governments (in this research considered as archetypes) were defined and selected based on the country's census data, which covered all the provinces and three ecological regions of Nepal. Altogether 13 archetypes were considered for the study where primary data was collected from 8 sites while surveys and secondary data were used for other 5 sites accounting to total 13 archetypes.

The local governments were selected based on accessibility, their interest to participate in study, and prior initiation taken on waste management. The archetypes and samples details are illustrated in Table 1.

Table 1: Sample details in each archetype

S.No.	Type of Archetypes	Type	Site selected in each Archetype
1.	Archetype 1	Metropolitan City	4
2.	Archetype 2	Sub-Metropolitan City	2
3.	Archetype 3	Municipality	5
4.	Archetype 4	Rural-Municipality	2

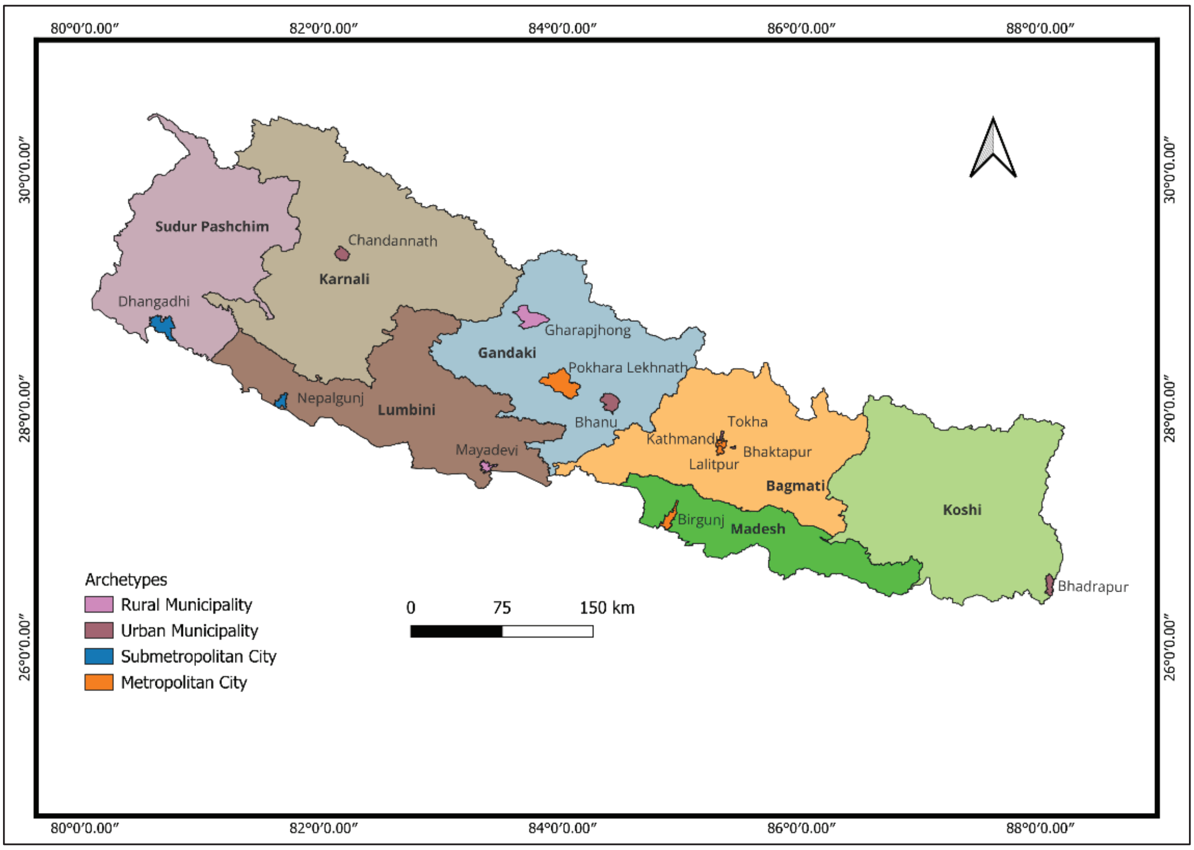

Figure 1: Map of Study Area

2.2 Methods and Methodology

Primary field data were collected from eight selected local governments, supplemented by surveys and secondary data from five additional municipalities. This broader coverage captured diverse municipal archetypes, reflecting differences in size, urbanization, service delivery capacity, and waste management practices. It strengthens the generalizability and contextual understanding of plastic waste management across Nepal.

The plastic inventory was conducted over a two-year period (2024–2025) across thirteen study sites. The assessments were carried out at different time intervals to capture variations in plastic waste generation and composition over the study sites. Due to resource and logistical constraints, the inventory was not designed to account for seasonal variation, and data collection was not conducted systematically across all seasons.

A random stratified sampling technique was used for the selection of the sample sites in each of the archetypes. In the first strata, sites that represented each of the four archetypes were selected. In the second strata, samples were selected in each of the archetypes, including each of the identified generation points or sectors; that is, commercial, institutional, households, religious/historical places and healthcare institutions (hospitals or smaller healthcare facilities). Regarding the number of samples of households within in each archetype, the research followed the guidance of the UN-HABITAT Waste Wise Cities Tool (UN-HABITAT, 2021) i.e., 120 households for Metropolitan Cities and Sub Metropolitan Cities and 90 households for Municipalities and Rural Municipalities).

In addition to this, the number of samples of other non-households were taken by using Cochran's Formula of sample size calculation.

Sample Size Calculation for each Archetype using Cochran's Formula:

$$n_o = \frac{Z^2 . p. (1-p)}{e^2}$$

Where,

- no = required sample size
- Z^2 = Z-score (based on confidence level, (2.58 for 99%)
- p = estimated proportion of the population (use 0.5 if unknown, as it gives the maximum variability)
- e = margin of error (in decimal, e.g. 0.05 for 5%)

On site waste characterization of waste specifically plastic waste was carried out for the quantification of plastic waste in all archetypes considering all the sectors such as household, institution, commercial entity, industrial facility, health sector facility, etc., by using a combined methodology comprised of the assessment methodology developed by HECAF360 and UN HABITAT. This enabled the report to capture diverse scenarios of various waste categories from various households and non-households.

Material flow analysis (MFA) was conducted using the Basel, Rotterdam and Stockholm (BRS) Plastic Waste Inventory Toolkit across 13 local governments. Data were collected through key informant interviews with 120 municipal officials and waste management staff to assess plastic waste generation, management, recycling, disposal, and leakage pathways, identifying key intervention opportunities.

For leakage estimation, waste management practices were assessed through site observations, waste quantification at disposal facilities, and surveys with relevant personnel. At disposal sites, quantitative data on incoming waste were collected either from daily records where weighbridges were available or, in cases where weighbridges were absent, non-functional, or data were unavailable, by recording the number of trucks arriving at the site over a seven-day period. Subsequently, waste composition analysis and audits were conducted using the quartering technique, whereby a representative final sample of 50–70 kg was extracted for detailed assessment. In addition to surveys and interviews, further data collection was conducted to support the inventory process.

3. Results and Discussion

3.1 Plastic waste generation scenario

The inventory process of the plastic waste characterization study revealed that Nepal generates approximately 1,97,2613 tons of solid waste per year; which is, 183 gm/capita/day. This is equivalent to the baseline survey conducted in 60 new municipalities of Nepal (Pathak, 2017) and lower than value from study conducted by ADB in 2013.

The table illustrates per capita waste generation across different municipal archetypes, highlighting a clear variation based on the level of urbanization. Metropolitan cities generate the highest amount of waste at 390 grams per capita per day, reflecting higher consumption patterns, increased use of packaged goods, and urban lifestyles. Sub-metropolitan cities produce comparatively less waste at 250 grams per capita per day, while small urban municipalities show a slightly higher value of 260 grams, possibly due to growing consumption without equally efficient waste management systems. In contrast, rural municipalities generate only 10 grams per capita per day, indicating significantly lower consumption levels, greater reliance on reuse practices, and limited access to commercial products. Overall, the data demonstrates a strong urban–rural disparity, where waste generation increases with urbanization, emphasizing the need for targeted waste reduction and management strategies; particularly in rapidly growing urban areas.The total plastic generation scenario is presented in figure 2.

Table 2: Per Capita Waste Generation in Various Archetypes in Nepal

Archetypes	Mega (Metropolitan City)	Medium (Sub-Metropolitan City)	Small (Urban Municipality)	Rural Municipality
gm/capita/day	390	250	260	10

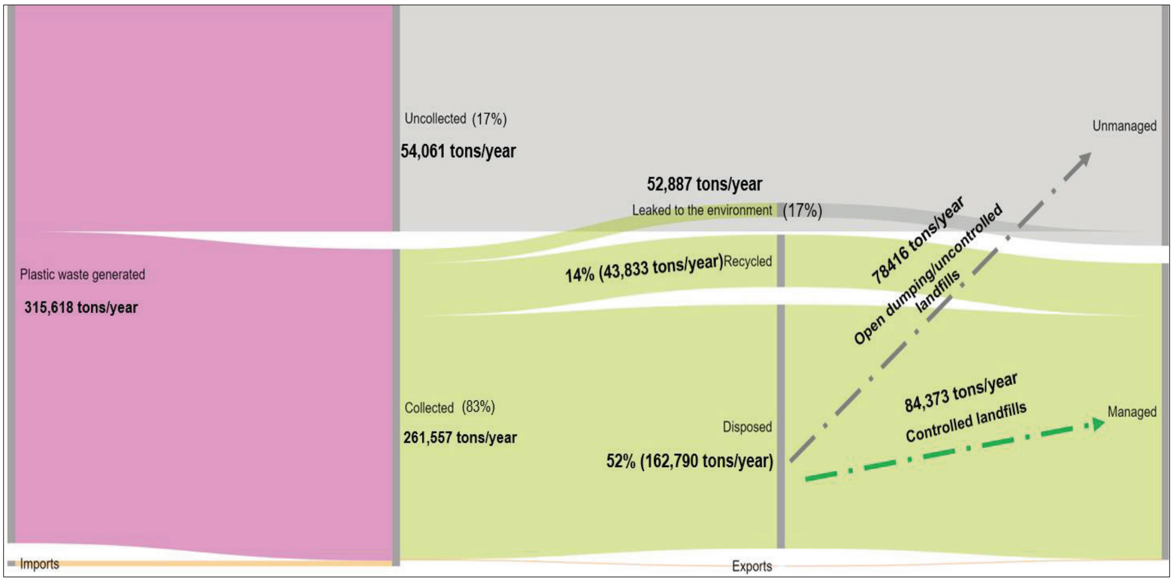

Figure 2: Sankey Diagram of Material Flow

The inventory estimated Nepal's annual waste generation is 19,72,613 tons/year and out of which 16% i.e., 315,618 tons of plastic waste are generated annually. While the plastic proportion is consistent with the 2013 ADB study, the total plastic waste exceeds the SWITCH-Asia in 2025 estimate (242,000 tons), likely reflecting increased plastic consumption, changing lifestyles, and greater demand for plastic products.

The per capita plastic waste generation is 29 gm/capita/day. On the basis of archetypes, metropolitan cities generating 68,873 tons/year; sub-metropolitan cities generating 28,036 tons/year; urban municipalities generating 213,564 tons/year; and rural municipalities generating 5,145 tons/year. This provides the baseline for understanding the scale of plastic waste produced across various administrative categories.

Regarding the fate of plastic waste flow in Nepal, out of the total plastic waste generated, about 83% (261,557 tons/year) is collected by formal and informal collection services and the remaining 17% (54,061 tons/year) is not collected and is instead burned, buried, or thrown away. The observed collection frequency is higher than the 62% average reported in the 2013 ADB study, indicating an improvement in municipal solid waste service coverage over time. This increase may be attributed to strengthened municipal waste management systems, expansion of collection services, and increased urban awareness. However, differences in study scope and rapid urbanization may also influence comparability of the estimates.

In terms of downstream management, out of 83% collected waste, 13.9% (43,833 tons/year) of the total plastic waste generated is recycled, largely through informal and small-scale recycling systems. However, 16.7% of plastic waste leaks into the environment at various stages of the waste management process, from source segregation to final disposal. The largest share, 51.6% is ultimately disposed of at designated disposal sites, including both controlled landfill facilities and uncontrolled open dumping areas. The data clearly reveals less than 1% data gap which is due to the data gap of informal recyclables extraction during the collection and transportation which has no record or documentation. The data analysis indicates a data gap of less than 1%, possibly attributed by the unrecorded extraction of recyclable materials by the informal sector during waste collection and transportation processes, for which no formal documentation or records are available.

The Sankey diagram reveals that of total plastic waste generated, 17% is uncollected and 17% leaks into the environment. The standard toolkit defines mismanaged plastic waste as consisting of only uncollected and leaked plastics. But in case of Nepal, many municipalities dump waste in open areas or pits before managing it or without managing it; this does not comprise effective waste management. As a result, the study includes dumped waste in the data for "mismanaged waste" along with uncollected and leaked materials. Only recycled waste and waste designated for disposal in controlled landfill sites is considered well-managed for the purposes of this study. The full percentage of mismanaged waste is 59% of total waste (185,904 tons/year) (note that uncollected waste and leaked waste have a combined total of only 34%). Leakage after the disposal of plastic waste into rivers or other water sources, the environment, and land are not quantified by the MFA toolkit.

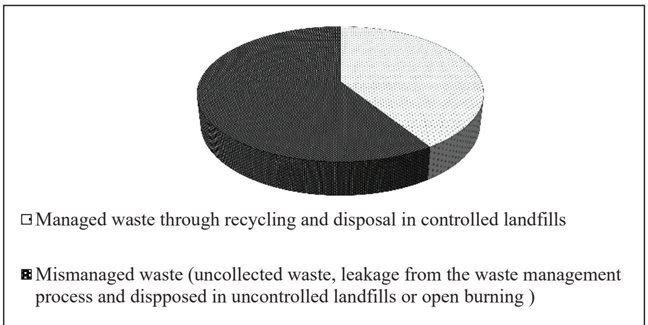

Figure 3: Management Vs Mismanagement of plastic waste in Nepal

Compared with the SWITCH-Asia (2025) estimate of 85% mismanaged plastic waste, this study found 59%, indicating a substantial reduction in plastic leakage, open dumping, and burning.

3.1.1 Fates of Plastic Waste in Various Archetypes in Nepal

The flow of plastic waste in different stages of the plastic waste management system in Nepal as summarized in Sankey Diagram Figure 2, describes the fates of a range of different plastic waste, thereby allowing comparisons for quantities and types of plastic waste recycled, disposed, leaked, and uncollected. The brief description of each of the indicators aligning the indicators for waste management at both the national and at various archetypes level are described as follows.

3.1.1.1 Collected Vs Uncollected plastic waste: The details of the collected and uncollected plastic waste are illustrated in figure 3.

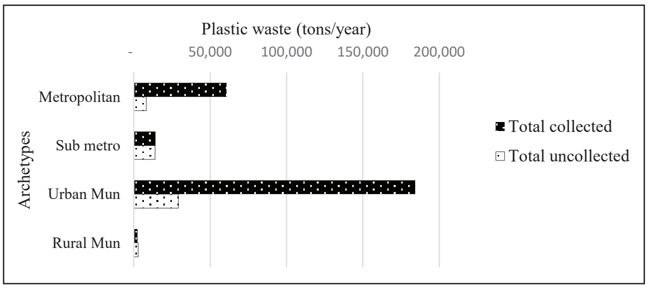

Figure 4: Collected Vs Uncollected Waste across Various Archetypes

The figure 4 presents a bar graph comparing collected and uncollected plastic waste across various archetypes. In terms of collection efficiency, metropolitan cities perform relatively well, collecting 88% (60,739 tons/year) of the total generated waste. Urban municipalities also maintain a high collection rate of 86% (184,302 tons/year). In contrast, sub-metropolitan cities collect only 50% (14,131 tons/year) of the total waste generated, compared to a reported collection coverage of 70–90% in large cities ADB (2013). This decline may be attributed to Nepal's administrative restructuring, which expanded sub-metropolitan boundaries by incorporating surrounding rural areas. As a result, waste collection services have become more challenging to deliver consistently due to dispersed settlements, difficult terrain, and limited infrastructure in the newly integrated areas. In addition to this, rural municipalities collect 46% (2385 tons/year), which is similar to the study data of ADB 2013 (below 50% in several smaller municipalities). It indicates that there is still a significant gaps in waste collection infrastructure outside major cities.

Field surveys revealed that metropolitan cities and urban municipalities collect almost all municipal waste within city areas. However, in most cases, waste management (particularly waste collection and transportation to designated landfills or disposal sites) is outsourced to private sector operators under contracts with local governments. In this context, private sector engagement has proven to be effective in reducing uncollected plastic waste and improving collection coverage.

Although a collection system exists in sub-metropolitan cities, limited accessibility in certain areas leads to a higher proportion of uncollected waste. For example, in one of the sub metropolitan cities surveyed during the inventory, waste collection services covered only about 50% of the wards in the cities. In inaccessible or rural areas, collection services were often completely absent, resulting in practices such as open dumping or burning of plastic waste by local residents. This situation is likely representative of other sub metropolitan cities as well. Moreover, in rural municipalities, low levels of waste generation in inaccessible areas discourages local governments from providing collection services. As a result, local residents manage their waste independently, primarily through open burning or burial.

3.1.2 Final Disposal and management of Plastic Waste

The performance of various administrative levels varies significantly in this regard and is illustrated in the form of bar graph.

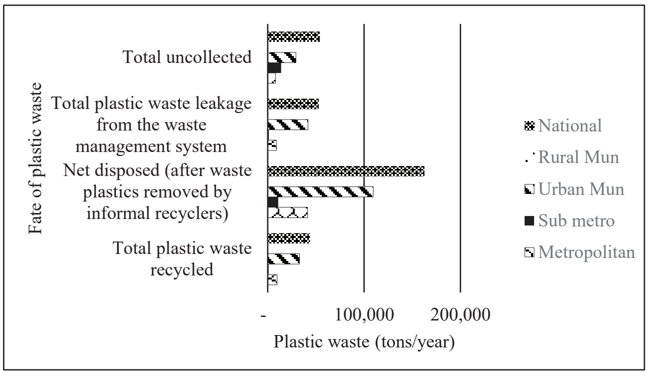

Figure 5: Final Disposal and Management of plastic waste in Nepal

Metropolitan cities show comparatively stronger recycling performance (14%, 9,636 tons/year) and higher collection coverage; however, they still dispose of a large volume of plastic waste (60%, 41,165 tons/year) and experience notable leakage (13%, 9,112 tons/year), indicating gaps in segregation and advanced recovery systems. Sub-metropolitan cities generate and manage moderate volumes, but recycling remains low (3%, 923 tons/year) compared to disposal (39%, 10,877 tons/year), reflecting limited infrastructure and weaker material recovery mechanisms. Urban municipalities represent the most critical pressure point, with the highest levels of disposal (51%, 109,391 tons/year), leakage (20%, 41,774 tons/year), and uncollected waste (14%, 29,262 tons/year) but also has the highest recycling rate of 15% (32,850 tons/year) of total waste generated in this archetype. This suggests rapid urbanization without adequate expansion of waste management capacity. In contrast, rural municipalities handle smaller overall volumes, yet recycling is only 8% (423 tons/year) and improper disposal into the environment remains the dominant practice, highlighting limited technical capacity, infrastructure gaps, and low formal recovery systems. Overall, while metropolitan areas perform relatively better, all categories show a strong dependence on disposal over recycling, underscoring the need for systemic improvements tailored to each municipal context.

According to the surveys with recycling vendors, the plastic waste that they send to recycling consists of HDPE and polythene bags (LDPE); most other plastics are not recyclable and thus are sent to designated disposal sites.

This data indicates that although recycling practices exist, a substantial amount of plastic waste still ends up at disposal sites, where it is largely recovered by the informal sector but is not documented. Furthermore, the disposal of plastic waste at uncontrolled disposal sites and its open burning by local communities and informal actors remains widespread.

3.1.4 Plastic Waste Leakage

Leakage during the various stages of waste management system in Nepal is largely driven by weaknesses in downstream management, particularly during sorting and at designated disposal sites. Although improvements in collection systems are necessary, the largest reductions in plastic leakage will come from strengthening sorting facilities, improving landfill and disposal site management, eliminating open dumping, and adopting controlled recovery and disposal systems in line with zero waste and circular economy principles.

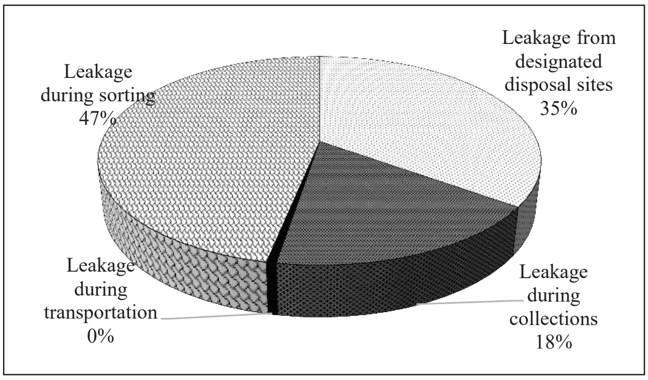

Figure 6: Proportion of plastic waste leakage in local government of Nepal

Plastic waste leakage is dominated by losses at sorting facilities; 47%, (24,751 tons/year) making it the most critical intervention point. High losses in this area are due to poor facility design, manual handling without containment, inadequate storage, and weak linkages to recyclers that lead to stockpiling and material loss. At 35% (18,468 tons/year), leakage at designated disposal sites also remains a major environmental problem. This is cause by open dumping, poorly managed or non-engineered landfills, and dispersal by wind and monsoon runoff. Collection-stage leakage accounts for 18% (9,363 tons/year), largely due to open or damaged vehicles, overfilled containers, and inefficient collection schedules, directly affecting streets and drainage systems. In contrast, transportation contributes only 0.58% (304 tons/year), suggesting relatively controlled transport systems or possible under-reporting, and confirming that leakage is primarily driven by downstream stages of the waste management system rather than transport. A detailed breakdown of plastic waste leakage from Nepal's waste management system, disaggregated by each archetype is expressed in Figure 6.

Across municipal categories, urban municipalities contribute the highest volume of plastic leakage, at 20% of all plastic waste (41,774 tons/ year), followed by metropolitan cities at 13% (9,112 tons/year). Sub-metropolitan cities and rural municipalities contribute relatively smaller quantities, at 16% (1,202 tons/year) and 4% (800 tons/year) respectively. Many improvements need to be made to reduce leakage; for instance, urban municipalities have insufficient waste management and most of them contract for waste management service with private companies that focus on disposing of waste rather than managing it to reduce leakage.

Overall, Figure 7 underscores that improving disposal site management and eliminating open dumping would yield the largest reductions in plastic leakage nationally, while targeted interventions in urban municipalities are essential to address high proportional losses. Strengthening collection systems, upgrading disposal facilities, and integrating informal recovery mechanisms are critical to reducing plastic leakage across all municipal archetypes.

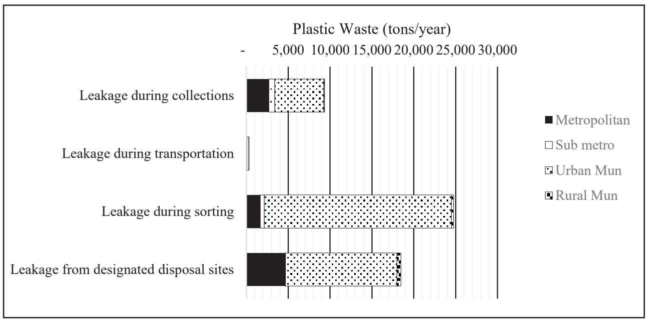

Figure 7: Plastic Waste Leakages from Waste Management Practice by Archetypes (tons/year)

3.1.5 Mismanagement of Plastic Waste

Finally, the total mismanaged plastic waste, which includes uncollected, leaked, and improperly disposed waste, is highest in rural municipalities at 69% (3559 tons/year), followed by sub metropolitan cities at 54% (15,108 tons/year), urban municipalities at 33% (71,036 tons/year) and metropolitan cities at 25% (17,245 tons/year). Nationally, about 34% (106,948 tons/year) of plastic waste is mismanaged, indicating the urgent need for improved collection, recycling, and containment strategies to reduce environmental leakage and promote sustainable waste management.

Using the methodology of the toolkit, only leakages and uncollected waste are considered as mismanaged, yielding data that shows that 34% of waste in Nepal is mismanaged. However, the toolkit's methodology ignores waste dumped in open dumps, which of course is a serious problem in Nepal. Thus, in the context of Nepal, it is important to add open dumping to the percentage of mismanaged waste. Doing so yields an estimate of 59% of Nepal's waste as being mismanaged that is, 185,904 tons/year, which includes not only plastic leakage and uncollected waste but also waste dumped in open dumps or open burning.

3.1.6 Plastic Waste Imports and Exports

Nepal imports raw plastic materials, primary forms as raw materials, and finished products, including packaging, single-use plastics, and consumer goods. Domestic plastic industries mainly focus on manufacturing of packaging materials such as plastic bags, bottles, and wrappers. Limited eco-design practices and the absence of mandatory recyclability standards contribute to increased plastic waste generation. According UNCOMTRADE[1] data from 2024, Nepal imported 20 tons/year of plastic waste and exported 4 tons/year; 16 tons/year of plastic remains in Nepal, a huge amount.

According to fiscal data from the Department of Custom portal for the year 2081/82 (that is, 2024-2025), Nepal imported 205,740 tons of plastics from various partners across the world, investing more than USD 161 million per year. Among the total imports, the highest share was in the form of primary or raw materials, consisting of 117,866 tons of plastic and equivalent to more than USD 92 million per year. Similarly, as per the data, Nepal is importing 235 tons/year of plastic waste with HS Code 3915 under the heading of "Waste, paring and scrap of plastics".

In the same fiscal year, Nepal exported approximately 10,160 tons of plastic materials to various international trading partners, generating over USD 11.5 million annually. Of the total exports, a significant share comprised plastics in primary or raw form, amounting to 238 tons, predominantly polypropylene, with an estimated value exceeding USD 149,000 per year. However, available data indicate that plastic waste exports are not recorded under HS Code 3915 ("Waste, parings and scrap of plastics").

While import and export data exist for plastic materials there is significant inconsistencies between global and national plastic waste trade data, highlighting the need for systematic verification and reconciliation of these datasets. Moreover, recent data on plastic waste recycling and export are largely unavailable, indicating major gaps in plastic waste trade documentation.

4. Conclusion

The National Plastic Inventory highlights that plastic waste constitutes a significant and growing component of Nepal's municipal solid waste stream, accounting for approximately 16% of total waste generation (315,618 tons/year). While 83% of plastic waste (87,679 ton/day) is collected through formal and informal systems, 17%, (54,601tons/day) remains uncollected and is managed through open burning, burial, or uncontrolled disposal. These practices, combined with system inefficiencies, contribute to notable plastic leakage, with 17% (52,887 tons/year) of total plastic waste leaking into the environment at different stages of the waste management chain.

Downstream management of plastic waste remains heavily disposal oriented. Although 14% (43,833 ton/year) of plastic waste is recycled, recycling activities are largely driven by informal and small-scale actors, indicating the importance of the informal sector and the absence of a robust, formalized recycling system. The majority of plastic waste i.e., 52% (162,790 tons/year) is ultimately disposed of at designated disposal sites, many of which are uncontrolled open dumps rather than engineered landfill facilities, posing long-term environmental and public health risks.

Out of total plastic waste leakage, almost 65% (34,114 tons/year) are from the collection and sorting stages; reflecting weak source segregation, limited infrastructure, and inadequate operational standards. Rural municipalities face the greatest proportional challenges, characterized by low collection coverage (46% collection frequency, 1,367 tons/year), high levels of uncollected waste (i.e., 54%, 2,760 tons/year), and minimal access to environmentally sound disposal facilities.

[1] UN Comtrade is the UN's official database for international trade statistics. It contains detailed information on the import and export of goods and services between countries worldwide, covering both historical and current trade flows

Although recycling occurs across all municipal typologies, it is largely driven by the informal sector and remains limited in scale and efficiency. The dominance of low-value and non-recyclable plastics, particularly multilayer and sachet packaging, further constrains recycling potential and underscores the need for upstream interventions. The absence of reliable data on plastic waste trade and effective implementation of available policy mechanisms further undermine efforts to regulate plastic flows and recover material value.

Overall, the study highlights a systemic shift in Nepal's waste management landscape, where increasing formalization through private sector has not translated into improved resource recovery or reduced leakage. Instead, the current system remains heavily disposal-oriented, with no incentives for waste reduction, recycling, or circular economy approaches. Addressing plastic pollution in Nepal will therefore require coordinated action across the entire value chain, strengthening policy enforcement, upgrading disposal and treatment infrastructure, integrating informal recyclers, improving data transparency, and reducing the production and use of non-recyclable plastics. Without such integrated reforms, plastic waste will continue to pose growing environmental, public health, and economic risks across the country.

Finally, the analysis shows that plastic waste leakage in Nepal's waste management system is primarily driven by inefficiencies in downstream handling stages, particularly at sorting facilities and disposal sites. The high proportion of leakage at sorting facilities highlights the urgent need to improve facility design, strengthen containment systems, and enhance operational management and linkages with recyclers to prevent material loss. Similarly, significant leakage at disposal sites indicates the necessity of transitioning from open dumping to properly engineered and managed landfill systems. While collection-stage leakage also requires improvements in collection infrastructure and scheduling, the minimal leakage during transportation suggests that interventions should prioritize strengthening sorting and final disposal practices. Addressing these critical points will be essential to significantly reduce environmental plastic leakage and move towards a more efficient and sustainable waste management system.

The findings also highlight the urgent need for Nepal to shift from disposal-based plastic waste management to a circular economy and zero waste approach. Key priorities include improving landfill management, ending open dumping, expanding source segregation, integrating informal recyclers, implementing Extended Producer Responsibility (EPR), strengthening waste trade documentation, and addressing rising plastic consumption with the goal of reducing it.

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