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Integrating Urban Forests and Parks in Solid Waste Management in the Growing Urban Areas (A Case of Ward 15 in Dharan)

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Abstract
With cities rapidly growing worldwide, effective waste management has become a substantial challenge in both developed and developing urban settings. According to projections by the World Bank, global waste generation is expected to increase from 2.01 billion tons in 2016 to 3.40 billion tons in 2050, with low-income countries facing a threefold increase, amplifying challenges related to waste mismanagement. Dharan, a city in eastern Nepal, facing similar challenges, produces about 50.92 tons of municipal waste daily. Due to the absence of an official landfill site, a significant portion of this waste is disposed of in the Bajhagara forest area, causing adverse effects on the environment. This research aims to evaluate the current state of solid waste management practices in Dharan, Nepal, with a particular focus on the use of forest areas for disposal. It contributes to the existing literature on waste management by providing empirical insights into the current state of solid waste management and disposal practices in Dharan, Nepal. By employing mixed methods like literature, surveys and GIS mapping, it comprehensively examines the environmental, social, and economic dimensions of waste management challenges. This research also emphasizes the importance of urban forests and green spaces and aims to explore the potential for improving waste management to enhance the environment, biodiversity, and community well-being for Dharan sub-metropolitan city. Additionally, the findings hold relevance for policy formulation, urban planning, sustainable waste management practices, and the preservation of natural ecosystems.

Keywords
Sustainable Development, Solid Waste Management, Environmental management, Urban Forest, Dharan, Nepal.

1. Introduction

Solid waste tends to increase with rapid urbanization, improved living standards and changing consumption patterns. As a result, coping with the growing volume of solid waste has emerged as a significant challenge in numerous cities in developing countries [1]. Solid waste can become a valuable resource when handled appropriately; however, inadequate handling can result in substantial negative impacts on the environment and public health [2]. In a global scenario, 54% of the world's population currently resides in urban areas, and this figure is projected to escalate 66% by 2050. As urbanization continues, waste generation is projected to rise from 2.01 billion tons in 2016 to 3.40 billion tons by 2050, with a more than threefold increase in waste generated in low-income countries [1]. Unfortunately, at least 33% of global waste is mismanaged through open dumping or burning, prevalent in lower-income countries where landfills are yet to be available [1]. In recent times, cities and urban areas in Nepal have faced considerable challenges in managing their increasing waste due to rapid and uncontrolled urban expansion, lack of public awareness, and insufficient governance by local authorities. These issues have heightened environmental concerns, resulting in unhygienic waste handling and disposal problems. Consequently, waste management has become a major priority for Nepal's municipalities [3]. Dharan, a city in Nepal, is no exception to these environmental challenges. As per the survey conducted by the IUDP, Dharan in 2017 identified unmanaged waste as the primary environmental concern, accounting for 27% of the issues, followed by air pollution and parking problems. According to a report published by the Asian Development Bank in 2013, Dharan sub-metropolis generates approximately 50.92 tons of municipal waste daily [3]. Lack of an official landfill site further exacerbates the issue, leading to an unsanitary dumping in Bajhagara forest, causing air, water, and soil pollution, wildlife impact, habitat loss, health concerns for residents and adverse affect in neighboring municipalities.

The main aim of this research is to assess the current municipal solid waste management practices/strategy and the impacts of unsanitary disposal of solid waste in urban forests, focusing on the case of Bajhagara forest in Ward No. 15 of Dharan.

The specific objectives are:

- To assess the current municipal solid waste management practices and the impacts of unsanitary disposal of waste in forested areas.
- To gain insight into the perspectives and preferences of the local communities regarding the ongoing waste management practices.

Ward 15 holds particular significance in this context as it is home to the Bajhagara forest area, which serves as the location for current municipal solid waste disposal. This forest area plays a crucial role in the preservation of urban green spaces and biodiversity, but the haphazard dumping of waste without any pre-treatment has aroused a lot of environmental complications and challenges.

2. Literature Review

2.1 Urbanization and Solid Waste Management

Globally, waste generation rates are rising. In 2020, it was estimated that the world produced 2.24 billion tons of solid waste, equating to a footprint of 0.79 kilograms per person per day [1]. Due to rapid population growth and urbanization, annual waste generation is expected to rise 73% from 2020 levels, reaching 3.88 billion tons in 2050 [1]. The total quantity of waste generated in low-income countries is expected to increase by more than threefold by 2050 [1]. In low-income or developing countries, over 90% of waste is often disposed of in unregulated dumps or openly burned [1]. These practices contribute to health hazards, methane emissions, climate change, and urban problems [1]. Efficient waste management is vital for sustainable cities, presenting a major challenge for developing nations like Nepal [2]. In high-income countries, about one-third of waste is recycled or composted, but the cost is substantial, consuming 20% to 50% of municipal budgets [1]. Waste collection rates differ by income levels, with high- and upper-middle-income countries typically offering universal waste collection. In low-income countries, approximately 48% of urban waste is collected, dropping to around 26% outside urban areas. Middle-income countries show varied rural waste collection rates from 33% to 45% [1].

As per the World Bank survey report, global waste disposal methods include 37% in landfills, 33% openly dumped, 19% recycled or composted, and 11% incinerated [1]. Adequate waste disposal is primarily found in high- and upper-middle-income countries, while lower-income countries often resort to open dumping, with 93% of waste dumped in low-income countries and only 2% in high-income countries [1]. As per the ADB survey report of 2013, out of 58 surveyed municipalities of Nepal, majority of them were dumping their waste haphazardly in open areas and riverside [3]. Similarly, a study conducted by Nepal's Central Bureau of Statistics (CBS) highlighted solid waste as a significant environmental issue, comprising 59% of reported concerns, followed by sewerage at 25%, air pollution at 7%, and water pollution at 5% [4]. Additionally, a 2017 survey conducted by the (IUDP) in Dharan identified unmanaged waste as a significant concern, accompanied by issues such as unpleasant odors, air pollution, parking, and drainage problems [5].

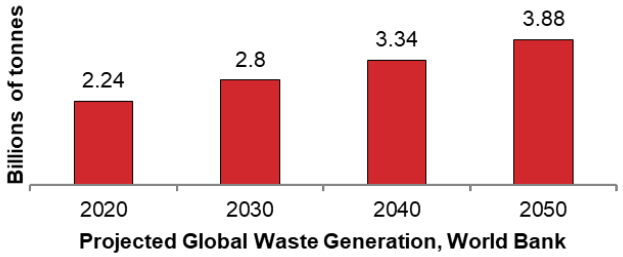

Figure 1: Projected global Waste Generation [1]

Global waste disposal method, World Bank

S.N.	Disposal method	Percent (%)
1	*Composting*	33
2	*Landfill*	25.2
3	*Recycling*	13.5
4	*Incineration*	11.1
5	*Sanitary Landfill*	7.7
6	*Open Dumping*	5.5
7	*Controlled Landfill*	3.7
8	*Others*	0.3

Figure 2: Global waste disposal methods [3]

2.2 Importance of Urban Forests and Parks

Urban forests, defined by FAO (2016), comprise all woodlands, clusters of trees, and individual trees located in urban and peri-urban areas, contributing significantly to physical and mental well-being. This encompasses forests, street trees, trees in parks and gardens, as well as trees in neglected areas [6, 7]. Recognized for enhancing air quality, social well-being, and overall urban life, cities globally are prioritizing the conservation and expansion of green spaces [6, 7]. Urban forests serve as a foundation for green infrastructure, connecting rural and urban areas and reducing a city's environmental impact [6]. They play a crucial role in purifying air, influencing urban climates, and supporting local livelihoods [7, 8]. Urban forests, from a social perspective, play a vital role in strengthening community bonds, enhancing food security for marginalized communities, connecting urban dwellers with nature, and promoting equity. Transforming small areas into pocket parks with trees and seating creates spaces for social interaction [7]. In Nepal, urban forestry has a rich history dating back to the Malla dynasty, with King Jayasthiti Malla initiating planting of trees along streets and wells [9]. This tradition continued, and in the 1960s and 1970s, significant tree planting initiatives were undertaken in Kathmandu during the Rana regime and the ring road plan [9]. Presently, the government remains committed to prioritizing urban forestry through diverse programs, such as the 'Nepal Clean Environment Grand Expedition 2075 AD' and the 'Forest Decade Program (2014-2023).' that promotes afforestation with the theme 'one house: one tree, one village: one forest, and one town: several parks' [9].

2.3 Existing Solid Waste Management System and Practices

2.3.1 Waste Characteristics

The characteristics of Municipal Solid Waste (MSW) collected from any given area are influenced by a range of factors, including consumer patterns, food habits, cultural traditions, lifestyles, climate, and economic status [3]. In Nepal, studies have consistently shown that the majority of municipal waste is organic. A comprehensive study across 58 municipalities conducted by the Solid Waste Management & Resource Mobilization Center (SWMRMC) revealed the average

Nepal's Municipal Solid Waste Composition, ADB-2013

Waste Type	Household Sector (%)	Commercial Sector (%)	Institutional Sector (%)
Organic Waste	*66*	*43*	*22*
Plastics	*12*	*22*	*21*
Paper Products	*9*	*23*	*45*
Glass	*3*	*4*	*1*
Metals	*2*	*2*	*1*
Textiles	*2*	*2*	*2*
Rubber and Leather	*1*	*1*	*1*
Others	*5*	*4*	*8*

Figure 3: Nepal's MSW composition [3]

composition of MSW as follows: organic waste 56%, plastics 16%, paper and paper products 16%, glass 3%, metals 2%, textiles 2%, rubber and leather 1%, and other materials 4% [3].

2.3.2 Waste Generation

According to [10], the waste generation rate in municipalities of Nepal is about 3023 tons per day and the average per capita waste generation is 0.223 kg/person/day. Waste generation rates could also vary depending on the season, month, day of the week, population distributions, ecological regions economic status, and consumption patterns [3].

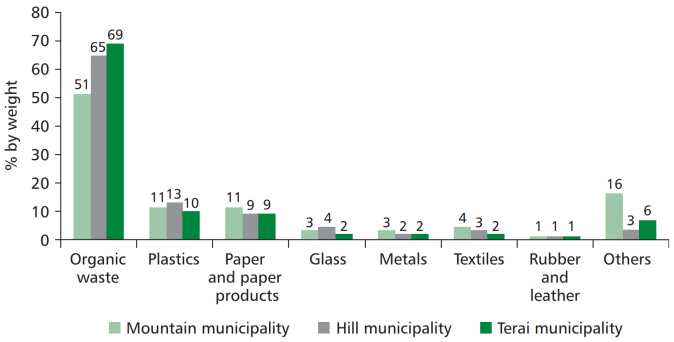

Figure 4: Regional MSW composition [3]

Households with monthly expenditures of NRs40,000 ($417) and above produce an average of 1.25 kilograms (kg) of waste per household per day, which is more than twice the 0.57 kg per household per day generated by households with monthly expenditures of less than NRs5,000 ($52) [3]. Likewise, the average household waste generation was observed to be higher in Terai municipalities (0.88 kg/household) and lower in mountain municipalities (0.49 kg/household) [3].

2.3.3 Collection and Segregation

According to a survey conducted by the ADB in 58 municipalities, it was noted that approximately 70% of households dispose of their waste directly into the main stream for collection and disposal without prior segregation. The remaining 30% of households, mainly in rural areas, engage in segregating kitchen waste for their specific needs [3]. The estimated average collection efficiency is 62%, but accuracy is hindered by the lack of a comprehensive recording system [2]. Many municipalities lack effective segregation programs, leading to the re-mixing of segregated waste during collection due to the absence of separate treatment methods [3].

2.3.4 Transport and Final Disposal

Nepal's waste disposal method, ADB 2013

S.N.	Disposal method	No. of municipality
1	*Open Dumping*	25
2	*Riverside Dumping*	13
3	*Open Dumping/Riverside Dumping*	6
4	*Sanitary Landfill*	6
5	*Controlled Dumping*	5
6	*Roadside Dumping*	1
7	*No Municipal System*	2

Figure 5: Nepal's Waste disposal method [3]

The availability of vehicles and equipment for waste collection and transportation varies significantly among municipalities in Nepal [3]. Primary waste collection typically involves rickshaws and carts, while tractors handle secondary collection or transportation, and dump trucks transport waste to disposal sites [3]. Not all municipalities have access to all three vehicle types, impacting the efficiency of waste transfer, from initial collection to processing centers or final disposal sites. Unfortunately, many municipalities have yet to identify suitable locations for treatment facilities and sanitary landfill sites [3]. As a result, untreated waste is often dumped in makeshift sites, posing health risks and environmental problems. Open dumping, observed in 45 out of 58 municipalities, including Dharan Sub-metropolitan City, involves waste disposal in forests, along riversides, and on roadsides [3]. Only six municipalities, including KMC, Lalitpur, Pokhara, Ghorahi, Dhankuta, and Tansen, have taken steps to construct sanitary landfill sites [2].

2.4 Community participation in Solid Waste Management

Waste (1996) defines a community as a group of individuals residing together within a certain framework of social organization and cohesion [11]. Community participation, as described by Gotame (2012), is the process by which individuals and families assume responsibility for both their personal well-being and that of their community, actively contributing to development [12]. Anschutz (1996) underscores the crucial role of community participation in solid waste management [11]. The Brundtland Commission highlights its importance in achieving sustainable development, especially in solid waste management [1, 3]. Relying only on local authorities is insufficient for maintaining clean towns. Promoting community participation through campaigns on 3R principles and enhanced solid waste management (SWM) is crucial [3]. When establishing new waste disposal sites, it's vital to engage nearby communities by considering their opinions and concerns in the planning process, ensuring proper site management, and incorporating social programs that benefit the local residents. Similarly, effective waste segregation and collection methods should involve close consultation and collaboration with communities to address their specific needs [3].

3. Methodology

The research aims to investigate the impact of integrating urban forests and parks into municipal solid waste management, specifically focusing on the Bajhagara forest in Dharan's Ward No. 15. It adopts a research paradigm blending both positivism and interpretivism, where positivism guides quantitative investigation into solid waste management practices, prioritizing objective measurements and data analysis, while interpretivism delves into social and cultural influences. The ontological claim asserts an objective reality in solid waste management, yet it's shaped by human perceptions and values. The epistemological approach combines elements of both positivism and constructivism. Positivism highlights empirical observation and measurable data, facilitating the evaluation of waste management

practices. Meanwhile, constructivism acknowledges knowledge as socially constructed, shaped by individual perspectives and experiences, which is pertinent in understanding perceptions and attitudes toward urban forests and parks. To fulfill the research objectives, a mixed-methods approach incorporating both qualitative and quantitative data collection techniques is utilized. The methodological framework comprises:

- Literature Review: Initial exploration of existing literature, municipal profiles, and relevant data sources.
- Field Surveys: Collection of primary data through surveys, interviews, and observations conducted in Ward 15 of Dharan.
- Quantitative Analysis: Utilization of quantitative data obtained from surveys and questionnaires conducted at various points within the study area.
- Qualitative Analysis: Examination of qualitative data gathered from interviews, field notes, and observations to gain deeper insights into stakeholders' perceptions and experiences.
- Sampling Approach: Adoption of a random stratified sampling approach in field surveys to ensure representation across diverse demographic groups within Ward 15.

4. Study Area

The study area for this research encompasses Dharan Sub-Metropolitan City located in province no.1 of Nepal, with a primary focus on Bajhagara forest, Ward 15.

According to the IUDP 2017, forests cover more than 70% of the total land area of Dharan. Forests play a major role in balancing the ecosystem and maintaining the climatic and livable conditions of Dharan [5]. However, since it has been used as a dumping ground for municipal waste disposal since 1986 A.D., adverse effects on its environment and biodiversity can be observed. This situation has directly impacted the adjacent river body and the health of people in surrounding municipalities.

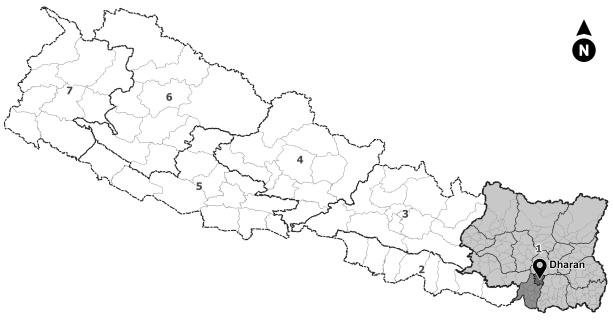

Figure 6: Study area location

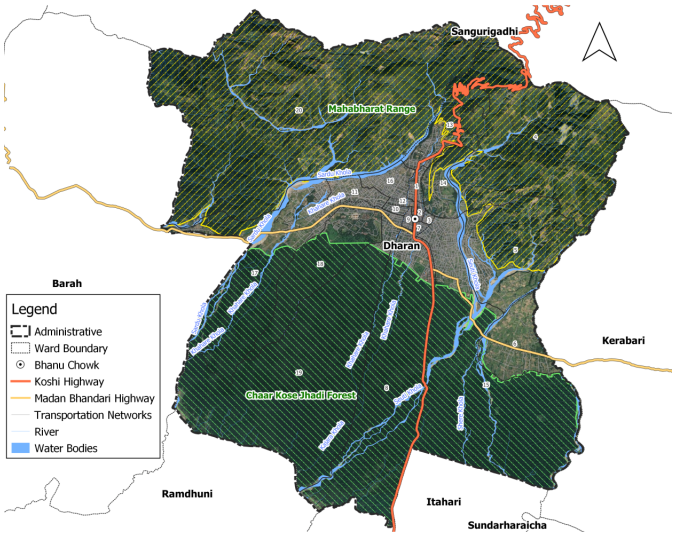

Figure 7: Physical setting, Dharan

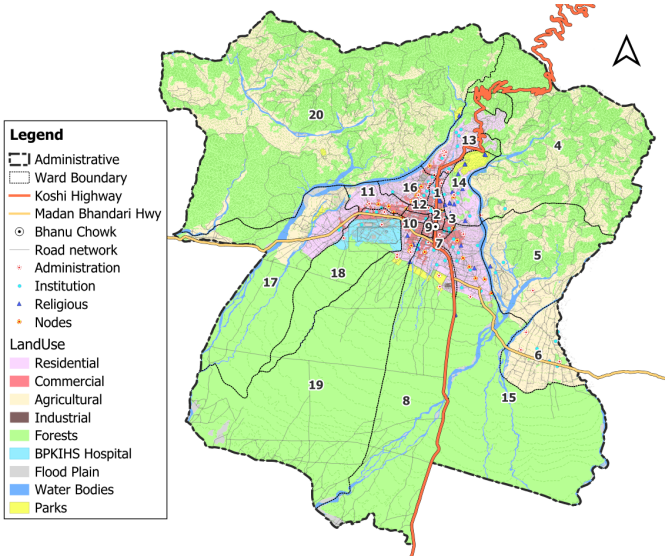

Figure 8: Land Use Map of Dharan

Categories	Area (sq.km)	Percentage (%)
Built area	3.45	1.78
Forest	135.74	70.33
Water Body	0.01	0.67
Agriculture	45.98	23.82
River bed	7.09	3.67
Cutting cliff	0.87	0.45

Figure 9: Land Use Categories [5]

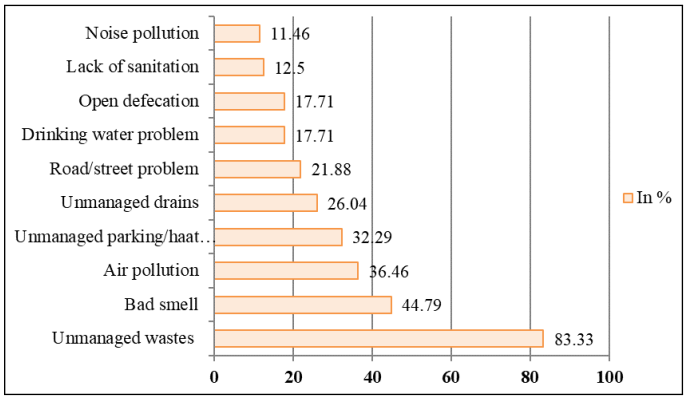

Figure 10: Community problems, Dharan [5]

According to the survey conducted by IUDP Dharan in 2017, unmanaged waste is the major communal and environmental problems experienced by the inhabitants; followed by bad smell, air pollution, parking, drainage etc [5].

Similarly, Dharan is experiencing rapid urbanization and along with the population growth, the waste generation pattern is also arising. This makes it a pertinent case study for gaining insights into the challenges and opportunities associated with urban development and environmental conservation.

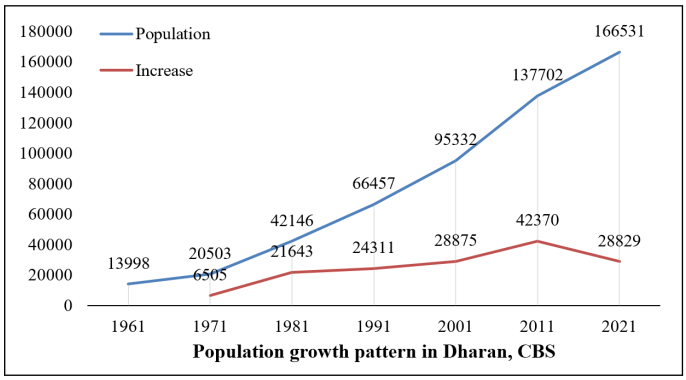

Figure 11: Population growth trend (CBS)

4.1 Case Area: Bajhagara Forest, Ward no. 15

The selected study site is Ward 15 within the Dharan Sub-metropolitan city, comprising a total population of 27,411 individuals, with 12,845 being males and 14,596 females (CBS 2021). This ward spans across an area of 25.54 square kilometers and encompasses 4,726 households [5].

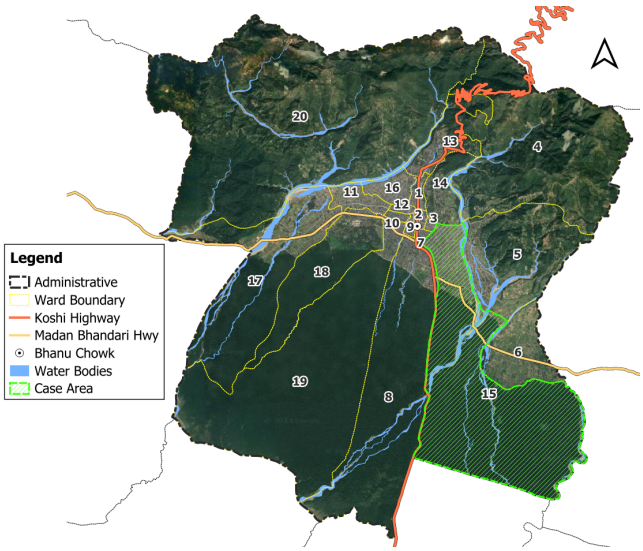

Figure 12: Map of designated case area

Ward no.	Household (2017)	Population	Male	Female	Area (Sq. Km)	Density
15	4,726	27441	12845	14596	25.544	1074
Total	32,683	166531	78410	88121	192.98	866

Ward 15 has become a focal point of concern due to its proximity to the municipal dumping site, which has adverse effects on nearby forests and rivers.

Additionally, this ward is experiencing rapid growth and the emergence of new developments. Sustainable waste management cannot be achieved solely through the conventional approach of waste collection, transportation, and disposal. Merely relocating waste from one area to another does not address the underlying issues. Therefore, effective waste management entails more than just crisis management associated with these activities [13]. Hence, it is crucial to evaluate the efficiency of the existing waste management system and find ways to alleviate the adverse impacts of solid waste on these forests.

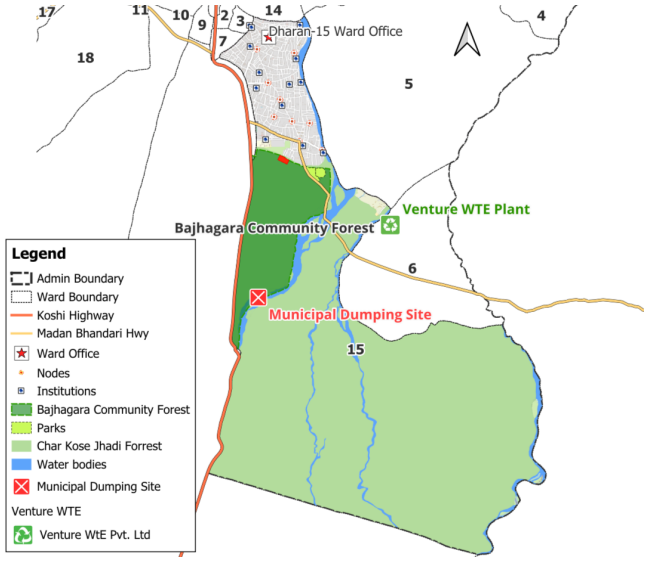

Figure 13: Case area, Ward 15

5. Findings

As per the ADB report in 2013, the municipal waste generation rate was 424.62 grams per capita per day, while household waste generation rate amounted to 212.31 grams per capita per day within Dharan city [3]. Commercial areas generate 7.53 tons/day, with households contributing to 25.46 tons per day [3]. According to the Dharan SWM team, 10-15% of bio-degradable waste is individually composted by households, while 20-30% of non-bio-degradable waste is collected or sold to recyclers and kabadiwalas. The SWM team collects the remaining waste daily, weekly, or every 15 days, depending on location and frequency of waste generation. Dharan's municipal waste includes residential, commercial, mixed-use, school, and cottage industry waste, with households being the primary source, followed by commercial and institutional waste.

Municipal Waste Generation Rate, ADB 2013

Municipality	Dharan
Average HH Waste (kg/day)	*1.17*
Average HH size(number of members)	*5.53*
Average per Capita HH Waste (g/capita/day)	*212.31*
Total HH Waste (tons/day)	*25.46*
Total Commercial Waste (tons/day)	*7.53*
Total Institutional Waste (tons/day)	*0.44*
Average per Capita MSW (g/capita/day)	*424.62*
Total MSW Generation (tons/day)	*50.92*
Estimated Waste Collection (tons/day)	*35.0*
Collection Efficiency (%)	*68.7*

Figure 14: MSW Generation, Dharan [3]

Municipal Solid Waste Composition of Dharan, ADB-2013			
Waste Type	Household Sector (%)	Commercial Sector (%)	Institutional Sector (%)
Organic Waste	*58.34*	*25.57*	*22.39*
Plastics	*15.49*	*18.27*	*21.29*
Paper Products	*11.30*	*17.09*	*37.81*
Glass	*2.43*	*7.99*	*3.70*
Metals	*6.24*	*6.76*	*3.89*
Textiles	*2.96*	*4.23*	*2.26*
Rubber and Leather	*0.75*	*0*	*1.18*
Others	*2.48*	*20.09*	*7.47*

Figure 15: Dharan's MSW Composition [3]

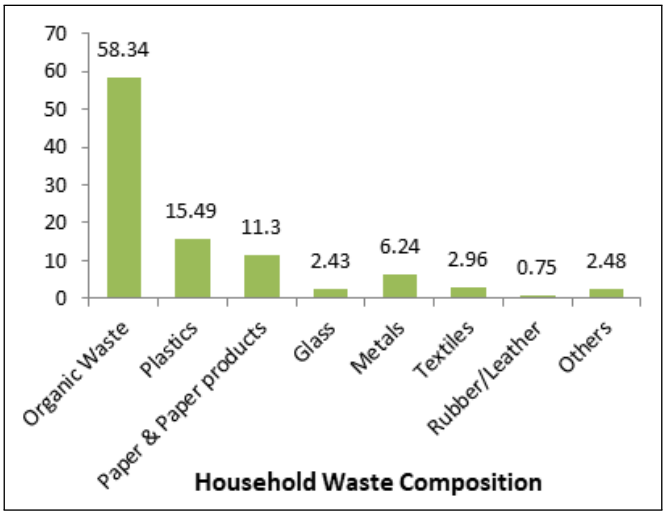

Figure 16: Household Waste Composition, [3]

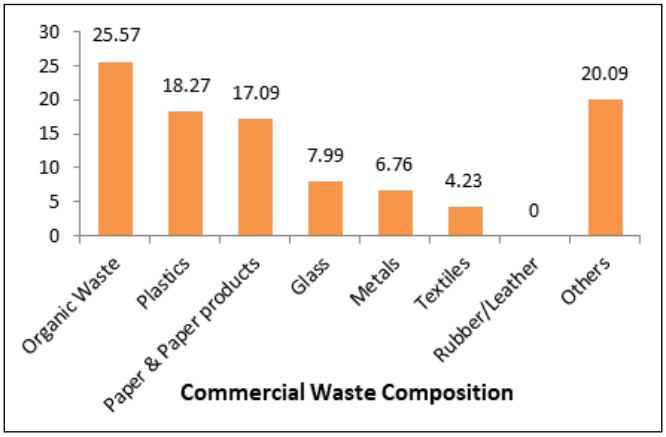

Figure 17: Commercial Waste Composition, [3]

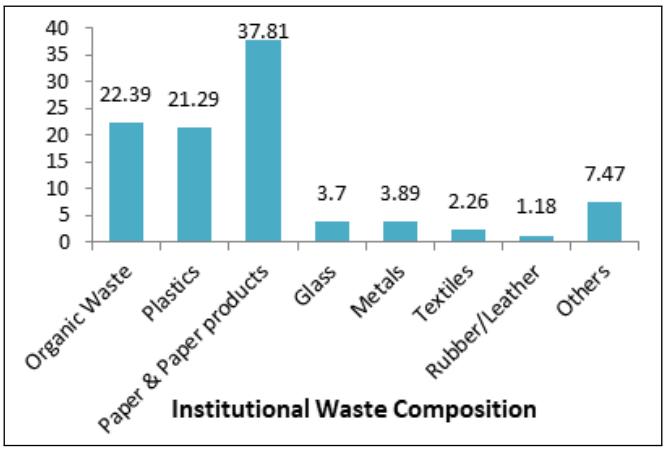

Figure 18: Institutional Waste Composition, [3]

5.1 Existing Solid Waste Management System and Practices

The sub-metropolitan city has department of forest, environment and risk management to analyze and control all the relevant forest and environmental issues and hence is responsible for regulating the policies and managing all the activities that is concerned with solid waste management of the overall city. The sub-metropolitan city has enlisted service providers responsible for managing solid waste, operating under the oversight of an environmental officer and a team led by an in-charge. According to the SWM in-charge Mangal Pariyar, the SWM team comprises 9 waste collection vehicles and 75 members, with 63 actively engaged in fieldwork and 12 handling office-related tasks. They are responsible for managing solid waste within areas designated by the municipality, but wards 5, 6, and 20 are excluded from present collection coverage area, as well as the BPKIHS area, handle their waste independently. Among the 42,396 households in the city, about 34,000 households have access to services provided by solid waste management organizations. This implies that a majority, consisting of approx. 8,300 households, are responsible for disposing of or managing their waste independently.

At present, only Venture WTE Pvt. Ltd segregates organic waste from non-organic waste. Approximately 50% of organic waste and 30% of recyclable waste are segregated for composting and recycling, while the remaining 15-20% non-recyclable waste is transported to the Bajhagara forest dumping site near the Seuti River in Dharan-15. The recovered non-biodegradable waste undergoes recycling, while the processed biodegradable waste is converted into CNG gas and fertilizers. The CNG gas

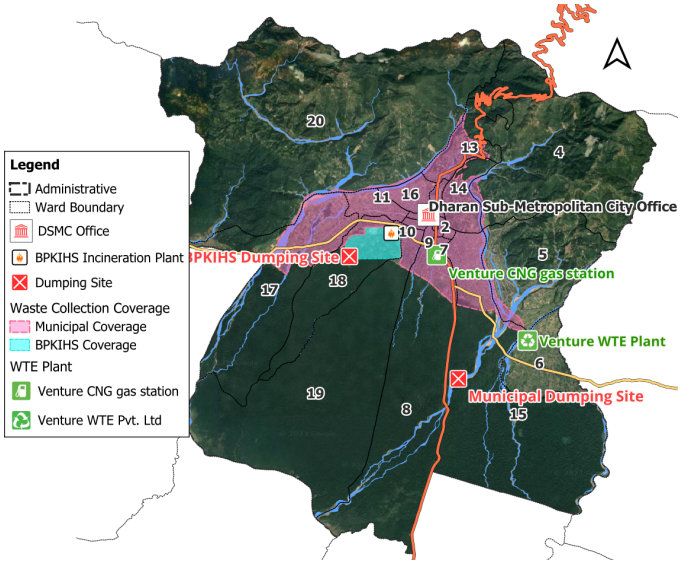

Figure 19: Solid Waste Management System, Dharan

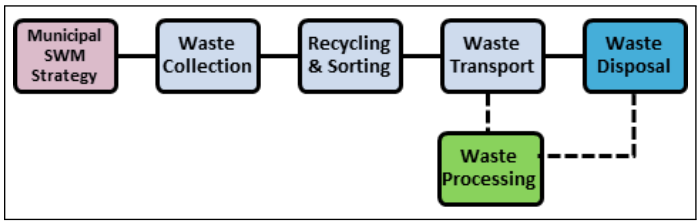

Figure 20: Municipal SWM strategy

is priced at up to Rs 130 per kilogram and is currently utilized in vehicles such as scooters and auto rickshaws. The fertilizer is packaged in 2kg, 5kg, and 10kg bags, retailing for Rs 60 per kilogram. The remaining municipal waste is disposed of in the Bajhagara forest dumping area located in ward no. 15.

5.1.1 Waste Collection and Transportation

Dharan city offers door-to-door waste collection services, covering all wards except ward numbers 5, 6, 20, and the BPKIHS area. Waste collection occurs on a daily, weekly, or 15-day interval basis, depending on the location and the volume of waste generated. The SWM team operates with a fleet of 9 vehicles, consisting of 3 trippers and 6 tractors, for waste collection. The crew members engage in waste collection from early morning to late evening, adjusting their schedules based on demand and necessity. On average, the city collects approximately 25-35 tons of waste daily, subject to varying circumstances. Of the collected waste, 10-13 trips are directed to the Venture WTE plant for further processing, while the remainder is transported to the dumping zone located in the Bajhagara forest area, ward-15.

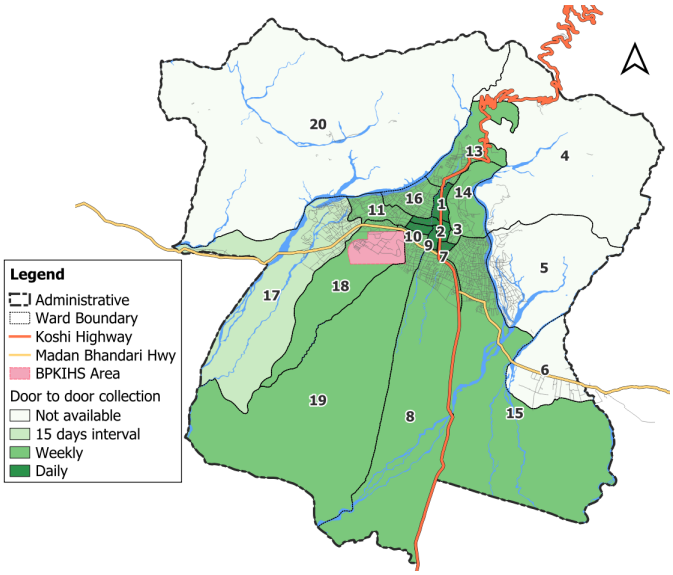

Figure 21: Door to door collection

5.1.2 Waste to Energy Initiative

Dharan is home to the Venture WTE Pvt. Ltd waste-to-energy plant, located in Panbari, which was inaugurated in 2022. This facility has a daily processing capacity of 50 tons of waste. A significant portion of household waste in Dharan is directed to the Venture WTE plant. The solid waste management (SWM) team collects an average of 25-35 tons of waste daily but as of present (2023), only 8-12 trips is transported to the waste to the processing plant. The remaining waste is disposed of at a dumping site located in Bajhagara forest, ward 15. Venture WTE Pvt. Ltd separates organic and non-organic waste, processes the organic waste and turn it into CNG gas and fertilizer, selling them at Rs. 130 per kilogram and Rs. 60 per kilogram, respectively. The remaining non-recyclable waste goes to a landfill, and recyclables are sorted and sold. According to plant manager Hari Upreti, about 60-65% of the waste could become valuable manure, with 17-20% being reusable, and 20% going to a landfill. The plant is not operating at full capacity due to policy issues affecting efficiency, particularly the absence of policies addressing the sale and use of alternative fuels like CNG and natural gases, hindering market access for these fuels.

Figure 22: Venture WtE plant Pvt. Ltd.

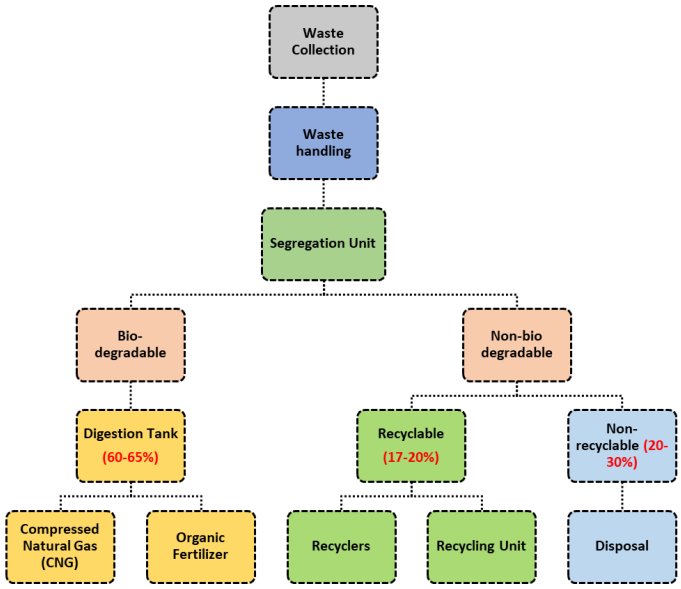

Figure 23: Waste Treatment Process, Venture WTE Pvt. Ltd

Figure 24: Waste Segregation and Treatment Process, Source: Venture WTE Pvt. Ltd

5.1.3 Waste Disposal

In Dharan, there is no official designated landfill site for waste disposal. Instead, most of the city's municipal waste is disposed of in an informal dumping zone located in Bajhagara community forest and along the bank of river Seuti. Though the majority of the waste collected by the waste management department is directed towards Venture WTE Pvt. Ltd., the remaining portion is directly deposited in the forested areas.

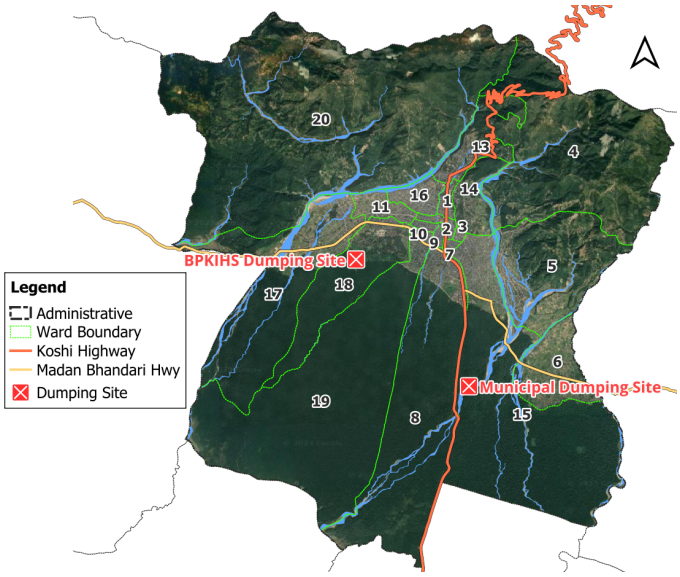

Figure 25: Waste Disposal Site, Dharan

5.2 Dumping in Urban Forests: A Case Study of Bajhagara Forest

5.2.1 Overview of Bajhagara Forest

Bajhagara Forest Users Committee was officially formed on 2059 BS (2002 AD). It is located in the heart of the ward no 15 of Dharan sub-metropolitan city and covers the total land area of 2.88 sq. km. The boundaries of Bajhagara forest area is demarcated as:

- East: Seuti River
- West: Koshi Highway
- North: T.U. IOE ERC boundary wall and settlements
- South: Seuti River Bridge

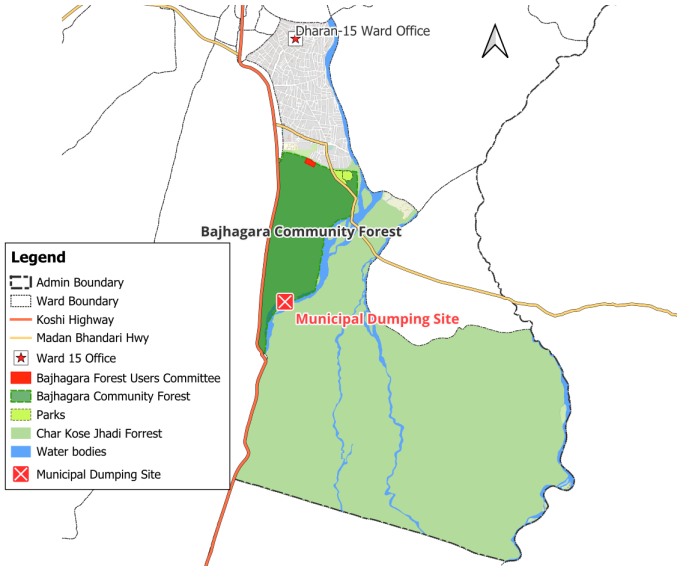

Figure 26: Location of Bajhagara Forest, Dharan-15

Flora and Fauna The Bajhagara community forest is home to a variety of plants, wildlife and ecosystems. The biodiversity of the Bajhagara community forest encompasses various plant species, as well as animal and bird species, along with their respective ecosystems. According to the Bajhagara forest profile and KII, the native tree species are: Sal, Karma, Banyan, Harro, Barro, Amla, Bhalayo, Hallude, Kumbhi etc. Similarly, the native wildlife species are: Leopard, Rabbit, Chhittal, Monkey, Langur, Coyote, Squirrel, Wild Cat, Porcupine, Monitor Lizard, Pangolin etc. And lastly, the native bird species are: Hornbill, Parrot, Theuwa, Mynah, Red Billed Blue Magpie, Cuckoos, Peafowl, Red Jungle fowl, Sparrow etc.

5.2.2 Extent of Haphazard Dumping

In Dharan, the absence of an official landfill site has led to the dumping of municipal waste in the Bajhagara forest of ward no. 15 . This practice has persisted since 1986 A.D.

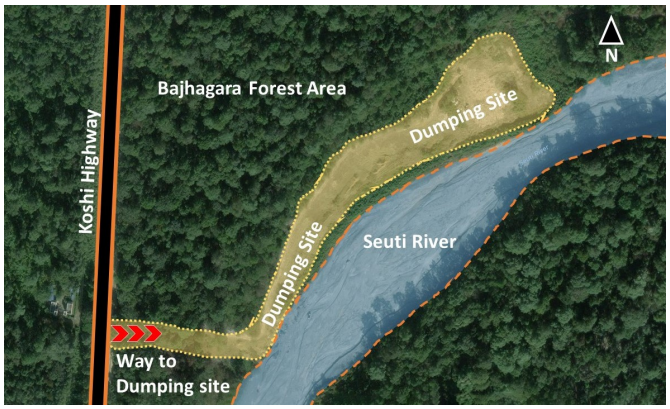

Figure 27: Location of Municipal Dumping Site

Figure 28: Access from Koshi highway

While urban forests are vital for ecological balance and the maintenance of climatic conditions in urban areas, there has been a notable absence of exploration and implementation of environmentally safe solid waste disposal methods in these areas. According to SWM personnel, approximately 10-13 tons of waste are directly deposited into the Bajhagara forest on a regular basis. Furthermore, waste segregation or segregated collection has not been implemented, resulting in the disposal of predominantly mixed-type waste without any pre-treatment. The indiscriminate dumping in Dharan has resulted in significant environmental complications. Leachate produced from the waste has degraded soil fertility, posing risks to the flora and fauna of the Bajhagara and surrounding forested regions. The presence of leachate makes accessing the dumping area difficult and has adverse health impacts on recyclers, waste workers, and Solid Waste Management (SWM) staff. Though municipal authorities are investigating an

eco-friendly landfill site in Dharan, outcomes are currently unknown.

Figure 29: Present status of Municipal Dumping Site

Additionally, the industrial estate near Bajhagara forest in Dharan 8 poses a significant environmental threat. The uncontrolled discharge of toxic wastewater from industrial activities such as rice packaging and manufacturing plastic pipes directly contaminates the nearby Bajhagara forest area. The wastewater, filled with harmful chemicals, flows from the estate's drainage, creating dark, foamy water that poses serious environmental risks to the forest, located just 50 meters south. Unlike household waste, industrial wastewater is concentrated with toxins and chemicals that pose a severe threat to the forest's plants, animals, and biodiversity. Continuous discharge can contaminate soil, hinder plant growth, and contribute to groundwater pollution, disrupting the forest ecosystem and causing habitat loss. Proximity to the industrial estate further intensifies the problem. Urgent measures, including strict rules, proper waste management, and wastewater treatment, is essential to prevent irreversible damage to Bajhagara forest and the surrounding environment.

Figure 30: Waste water discharge from Dharan Industrial estate

Figure 31: Leachate contamination due to industrial discharge

5.2.3 Impact on flora and fauna

In this forested area, various types of municipal waste, including organic, inorganic, and bio-waste, are haphazardly deposited, causing detrimental effects on both soil quality and biodiversity. This indiscriminate dumping has resulted in significant environmental complications, endangering plant and animal life in the Bajhagara area and its surrounding forests. Species such as monkeys, chital, and cows have suffered severe consequences due to the presence of these dump sites, with many falling victim to toxins found in the accumulated waste, leading to a decline in their populations. Primarily, monkeys, deer, and cows from nearby temples roam around these debris piles. Additionally, the leachate produced from the accumulated waste over time has caused soil fertility degradation and potential habitat loss. The presence of leachate makes accessing the dumping area on foot challenging, especially during the rainy season. Moreover, it has significantly impacted plant growth, disrupted the ecosystem, and compromised the health of waste recyclers, waste workers, and solid waste management staff.

Figure 32: Animal's presence in dump site

5.2.4 Impact on the riverside

The water quality of the nearby river has suffered a significant decline due to the presence of the dump site along its banks. While direct dumping into the river has been halted as a result

of protests from affected communities, the indirect effects stemming from nearby dumping are clearly evident along the riverside. A multitude of non-recyclable materials such as plastics, construction debris, glass, and metal parts are visible along the riverbank. This particular river is classified as an Ephemeral River, meaning it typically flows only during the rainy season. As a result, waste accumulates steadily along the riverbank year-round. When the monsoon season arrives, the river carries these accumulated waste particles downstream, leading to a negative impact on water quality and causing repercussions for the nearby municipalities.

Figure 33: Presence of waste nearby riverside

5.2.5 Dumping area coverage

The dumping area spans a considerable length of 585.76 meters along the riverside, featuring diverse widths ranging from 20 meters to 30 meters and up to 90 meters. The dumping site is divided into three sections, each serving a specific purpose in the waste management process. The initial segment serves as the entrance point to the site, providing a welcoming gateway for incoming waste disposal activities. This segment spans a width ranging from 20 to 25 meters, ensuring ample space for the smooth ingress of vehicles and personnel involved in waste management operations. The middle section serves as a transportation zone, featuring an 8-meter-wide road for the transfer of waste from the city to the main dumping area using tractors and trippers. And the final section forms the primary dumping area where the bulk of waste accumulates. Waste workers and recyclers operate within this section, sorting and managing certain portions of recyclable waste.

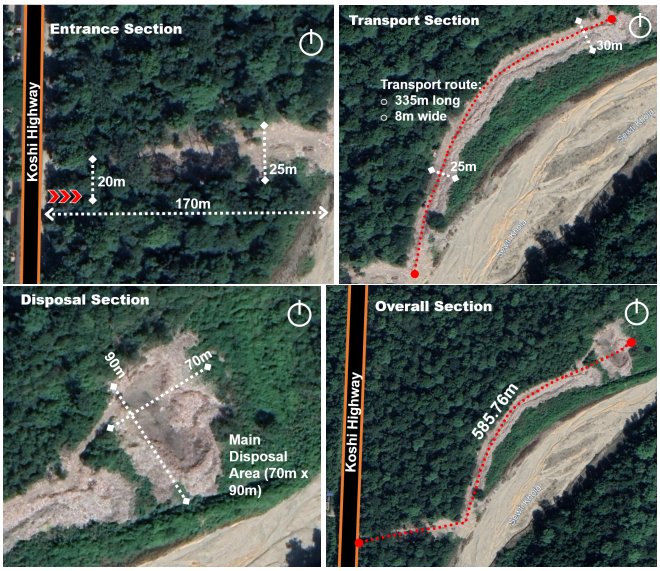

Figure 34: Segments of Dumping Site

Figure 35: Dumping Coverage Area

This site has served as a municipal dumping ground for over three decades and continues to be operational. Consequently, the dumping site has expanded over time. Currently, it occupies a total land area of 17,785 square meters (approximately 0.017 square kilometers or 0.02 square kilometers), constituting 0.69% of the overall Bajhagara forest land area.

5.3 Community Perception and Concerns

A survey involving more than 50 respondents from Ward No. 15 of Dharan was conducted to study the community's sentiments and attitudes towards solid waste management. The survey aimed to understand the extent of people's involvement, their awareness of eco-friendly waste management initiatives, and their aspirations for a cleaner and greener urban environment. The research study utilized random sampling techniques, involving an approximate sample size of 50 respondents. The sample size was

Demographic information of respondents: 50 respondents

Category	Value	Number	Percentage (%)
Gender	Male	22	44
	Female	28	56
	Others	0	0
Age	15-24	3	6
	25-50	34	26
	Above 50	13	68
Occupation	Housewife	11	22
	Student	4	8
	Service	19	38
	Business	13	26
	Others	3	6
Marital Status	Married	45	90
	Unmarried	5	10
Household Ownership	Owned	29	58
	Rented	21	42
Education	Under SLC	9	18
	SLC	13	26
	Intermediate	18	36
	Bachelor	7	14
	Masters	3	6

Figure 36: Demographic information

determined based on various classifications, including age, gender, class, type of building use, location (Tole), and tenancy status. It is important to note that the survey was capped at 50 respondents once the saturation level was achieved.

Methods like household questionnaires, survey and interviews were adopted to assess and visually represent factors such as people's awareness and participation in waste management, efforts to reduce waste, challenges in waste management, and their preferred methods for waste disposal. The data acquired from household surveys and interviews is presented in the provided charts.

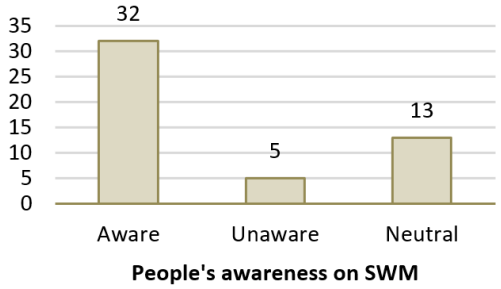

Figure 37: People's awareness on Solid Waste Management

The survey on people's awareness on current municipal waste management and dumping revealed that 64% respondents were aware of the present situation, while 10% were unaware and the rest 26% were neutral.

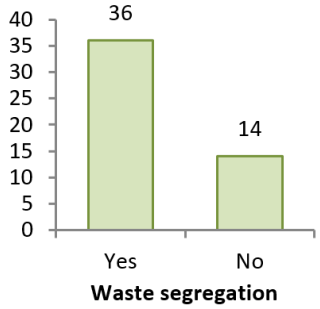

Figure 38: Waste segregation practices

The survey revealed that 72% of the respondents were implementing the waste segregation strategy while the rest 28% were not involved in any kind of segregation practices.

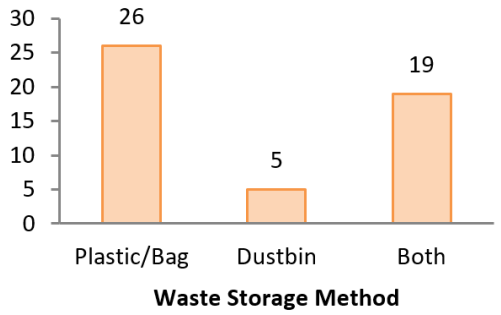

Figure 39: Preferred waste storage method

More than 50% respondents use plastic bag to store their waste and 38% of the respondents use both plastic bag and dustbin while the rest 10% use dustbin only for storing the household waste.

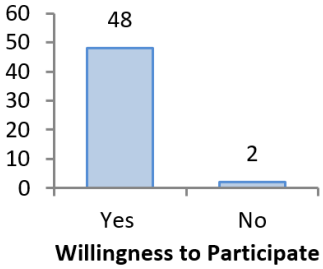

Figure 40: Willingness of the respondents

According to the field survey report, more than 95% respondents were willing to participate in the waste management practice and waste reduction initiatives.

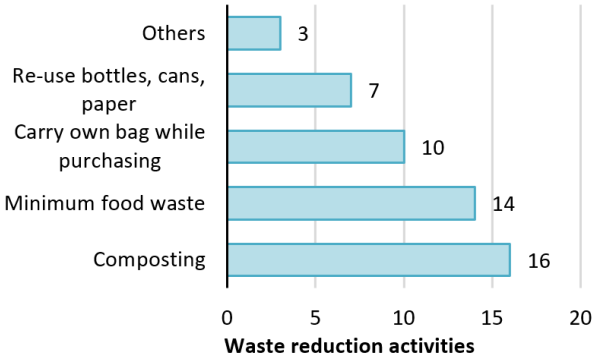

Figure 41: Waste reduction initiatives

Through the field survey, respondents were found out to be involved in different waste reduction initiatives like composting, minimum food waste, carry own bag etc. This showcases the willingness of respondents to cooperate in waste management aspect individually.

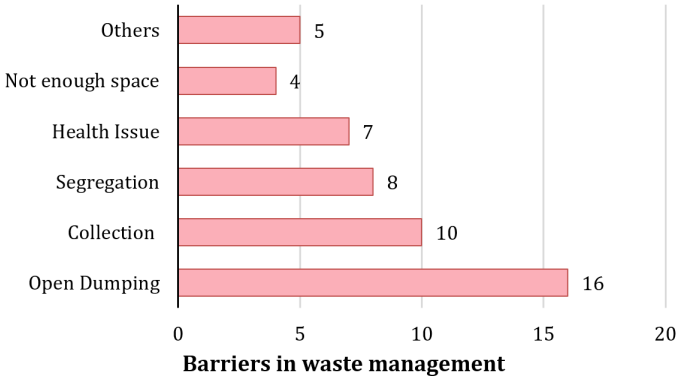

Figure 42: Barriers in waste management

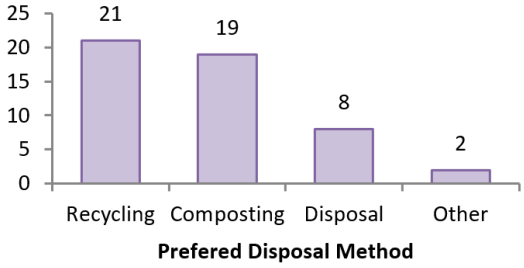

Figure 43: Respondent's preferred waste disposal method

Barriers in waste management according to the respondents' perception was also examined. It was found that open

dumping was most significant barrier followed by irregular collection, then implementation of waste segregation strategy and so on.

Similarly through the field survey, the preferred waste disposal method according to the respondents was also uncovered. Recycling was the most preferred method of waste disposal followed by composting, and so on. Which reveals the awareness and viewpoint of the respondents regarding environmental-friendly waste disposal methods. The study also revealed community dissatisfaction with open dumping and disposal in nearby forests, highlighting the residents' willingness to support eco-friendly waste management initiatives and their aspiration for cleaner, greener urban spaces and environments in Dharan. Moreover, the survey revealed that some households are already implementing basic level waste management practices such as segregation and composting, indicating an initial shift toward sustainable waste management practices at the household level. These findings emphasize the vital role of community involvement in shaping effective and environmentally conscious waste management strategies.

6. Discussion

6.1 Assessment of Current Waste Management Practices

In Dharan, a registered solid waste management team, supervised by an environmental officer, oversees municipal designated areas. With 63 field workers and 12 office staff, the team manages household waste from 16 wards, leaving ward 4, 5, 6 and BPKIHS area to handle their waste independently. With over 50 tons generated daily, there is no implementation of waste segregation or a segregated waste collection strategy, complicating further disposal process. It was observed that the existing SWM strategy faced challenges in efficiently managing and disposing the increasing urban-generated waste. Dharan generates 22 tons of organic and 15-20 tons of inorganic waste daily. However, collection efficiency stands mere at 70%, and only about half of the collected waste undergoes treatment before final disposal. The Venture Waste to Energy plant, established in 2017 can process 50 tons of waste daily but operates at only 50% capacity due to policy complications. The plant produces CNG gas and organic fertilizer, but the market access for these products is limited. According to the plant manager Hari Upreti, currently there is an absence of policy that addresses the sales and use of alternative fuels like CNG and natural gases, limiting the market access for WTE plant produced fuels, further limiting waste-to-energy production. Furthermore, the absence of a designated landfill site results in haphazard waste dumping in the Bajhagara forest of ward no. 15 since 1986 A.D. Despite the ecological importance of urban forests, there has been a lack of environmentally safe waste disposal methods implemented in these areas. Approximately 10-13 tons of waste are dumped directly into the Bajhagara forest regularly, without segregation or pre-treatment. This indiscriminate dumping has led to significant environmental issues, including soil fertility degradation and risks to flora and fauna due to presence of harmful toxins and leachate in the dumpsite. The presence of leachate also poses health risks to waste workers. While authorities are considering an eco-friendly landfill site in Dharan, the outcomes are uncertain. To improve the current situation, comprehensive policies for segregation, efficient collection, WTE optimization, proper landfills, and support for alternative fuels are crucial for a more sustainable waste management system in Dharan.

6.2 Community perception and preference

The study explored community perspectives on current waste management practices and waste disposal in nearby forests. Results revealed community dissatisfaction with the adverse effects of open dumping and disposal activities. Community engagement highlighted residents' willingness to support eco-friendly waste management and a desire for cleaner, sustainable urban environments in Dharan. Additionally, household-level of waste management practices like segregation and composting were adopted, indicating an initial move toward sustainability. These findings emphasize the importance of community involvement in shaping effective and environmentally conscious waste management strategies.

7. Conclusion and Recommendation

In summary, Dharan is experiencing rapid urbanization, resulting in increased waste generation due to population growth and changing consumption patterns. With daily waste generation exceeding 50 tons and no implementation of waste segregation practices, the disposal process is becoming increasingly complex. The traditional approach of waste collection, transport, and disposal proves inadequate, merely shifting problems rather than solving them. Despite the presence of a waste-to-energy (WTE) plant in Dharan, operated by Venture WTE Pvt. Ltd., it has not been successful in managing the city's entire waste volume. The plant's maximum daily processing capacity exceeds 50 tons, but the lack of policies addressing alternative fuel sales limits its operation. Additionally, the absence of an environmentally sound landfill has led to significant challenges, with unregulated dumping in the Bajhagara forest area adversely impacting the environment, biodiversity, nearby water bodies, and surrounding municipalities. Ward 15 faces significant waste management challenges due to its proximity to the municipal dumping site. Without immediate intervention, this situation will worsen, leading to further environmental degradation, threats to public health, and a diminished quality of life for residents.

However, there is always hope for positive change. Implementing decentralized waste management, starting with source segregation and promoting the 3R principles, can significantly reduce landfill-bound waste. Addressing policies regarding alternative fuels can enhance Waste-to-Energy efficiency, the volume of landfill requirements and dependency can be greatly minimized. Similarly, investing strategically in collection and transportation, equipped with smart monitoring, can ensure efficient tracking, treatment, and disposal of waste, preventing indiscriminate dumping. Community engagement and government support are also

crucial for successful waste management initiatives. Through collaborative efforts between communities and local authorities, specific actions and programs can be implemented to manage and clear existing dumping grounds and affected areas. These efforts may involve community-led clean-up campaigns, educational initiatives to raise awareness about proper waste disposal practices, and coordinated plans for the removal and remediation of dumpsites. After clearing the dumping area, a feasibility analysis can be carried out to identify environmentally-safe waste disposal methods and potential locations for a sanitary landfill, ensuring long-term solutions.

By adopting sustainable waste management practices and collaborative efforts, we can reduce environmental impacts, preserve biodiversity, and secure a healthier future for the inhabitants of Dharan.

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