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**ASSESSMENT OF MUNICIPAL SOLID WASTE MANAGEMENT AND THE
SOCIO-ECONOMIC CHALLENGES IN MOVING TOWARDS INTEGRATED
SOLID WASTE MANAGEMENT**

(A study of Rampur Municipality, Palpa)

by

Rupesh Pandey

A THESIS

**SUBMITTED TO THE DEPARTMENT OF MECHANICAL AND AEROSPACE
ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE IN ENERGY SYSTEMS PLANNING
AND MANAGEMENT**

**DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING
PULCHOWK, LALITPUR, NEPAL**

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The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis entitled “Assessment of Municipal Solid Waste Management and The Socio-Economic Challenges in Moving Towards Integrated Solid Waste Management (A study of Rampur Municipality, Palpa)” submitted by Mr. Rupesh Pandey (PUL-076-MSESP-014), in partial fulfillment of the requirements for the degree of Master of Science in Energy Systems Planning and Management.

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ABSTRACT

Growing urbanization and increasing trend of mass migration of population ends up in additional solid waste generation in populated area, turning the cities terribly dirty and insanitary. The matter of solid waste management remains unsolved owing to lack of applicable technical data, lack of participation and lack of resources. However, it desires a scientific handling of the waste and should seem terribly sophisticated till a well manage system is established. Thus this study has been done for the purpose of identification and categorization of solid waste in Rampur municipality, its environmental consequences and to get the existing solid waste management system and recommend the pros and cons of it and also to recommend the appropriate management system. The study was carried out in 75 houses having a small family size like a member of five (5) to seven (7) in Rampur municipality.

For the research field visits and desk studies for data collection were made through questionnaire survey, key informant survey and visits to the various households and the dumping sites were made. From the analysis, the composition of the waste are found as follow, organic waste-65%, Plastic-14% Paper-5%, Glass-6%, rubbers-4%, Hazardous-2%, Other-4%. The study has found that the average per capita per day waste of the study area to be 0.022 Kg/Person/Day. Average waste generation per person per day in municipality is found to be 0.08 kg, total waste generated in study area per day is 435kg and total waste generated in municipality per day is 3325kg. It has been observed that more than 65 percent of the waste generated at household i.e. source level in Rampur municipality is organic and agricultural waste. The door to door collection system is very much effective for best management of waste however lack of transfer station has added up for almost the same volume and composition of waste for final disposal. Waste then collected and dispatched to Bittar landfill site through Trucks, which is located at 5Km far from Rampur Municipality office.

From the study it was concluded that for MSW management in Rampur Municipality Sustainable solid waste management system ie, landfilling option was suggested and the detail cost estimation for the construction and operation was estimated. Furthermore, detail financial analysis for the landfilling option was also carried out.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
CO ₂	Carbon Dioxide
SWM	Solid Waste Management
MSWM	Municipal Solid Waste Management
ISWM	Integrated Solid Waste Management
GHG	Green House Gases
HH	Households
WTP	Willingness to Pay
UNDP	United Nations Development Program
NGOs	Non-Government Organizations
3Rs	Reduce, Reuse and Recycle
BCR	Benefit Cost Ratio
CBR	Cost Benefit Analysis
IRR	Internal Rate of Return
NPV	Net Present Value
SA	Sensitivity Analysis
CDM	Clean Development Mechanism
SOE	State of Environment
RM	Rampur Municipality

CHAPTER ONE: INTRODUCTION

1.1. Background

Municipal solid waste (MSW) could be a growing drawback within the urban areas round the world that's growing quicker than the speed of Urbanization. In 2002, 2.9 billion urban residents generated 0.64 kilogram (kg) of waste per capita per day that multiplied to 3.45% in Population and a thumping 87.5% in waste generation in 2012 (3 billion urban residents generated 1.2 metric weight unit of waste per capita per day). By 2025, it's projected that 4.3 billion urban residents can generate 1.42 metric weight unit of waste per capita per day (B. Maskey, 2018). The matter of solid waste management is anticipated to accentuate within the developing and beneath developed countries that lack the foremost in terms of technological advancement and socio-political setting favorable to beat such conditions. Regarding 20-50% of municipal budget in developing countries is spent on managing MSW however still 30-60% of the waste is uncollected and less than 50% of its population is served (A. Marga, 2008).

1.1.1. Solid Waste Management in World Context

Solid Waste Management within the developed world is more and more turning into a venture between nations, states, authorities, communities and therefore the personal sector. The statement of the "Waste Management Hierarchy" has been followed by most industrialized nations for the development of municipal solid waste (MSW) management methods. Further, anyone choice is employed among a given country varies looking for an oversized range of things, as well as topography, population density, transportation infrastructures, socioeconomics and environmental laws. Moreover, comparison national waste statistics isn't an easy task. Thought should first run to the wide completely different body definitions applied to MSW. Additionally, integrative classifications conjointly the manner during which the info are collected also take issue. Jointly, these factors will have a big influence on the cited knowledge (B. Maskey, 2018). The globe generates 2.01 billion tonnes of municipal solid waste annually, with a minimum of 33 percent of that – very conservatively- not managed in associate degree environmentally safe manner. Once trying forward, world waste is anticipated to grow to 3.40 billion tonnes by 2050 quite a double increase over identical amount. Overall there's a

correlational statistics between waste generation and financial gain level. Daily per capita waste generation in high-income countries is projected to extend by 19 percent by 2050, compared to low and middle-income countries wherever it's expected to extend by more or less 40% or additional (A. Marga, 2008).

1.1.2. Solid waste management in Nepal

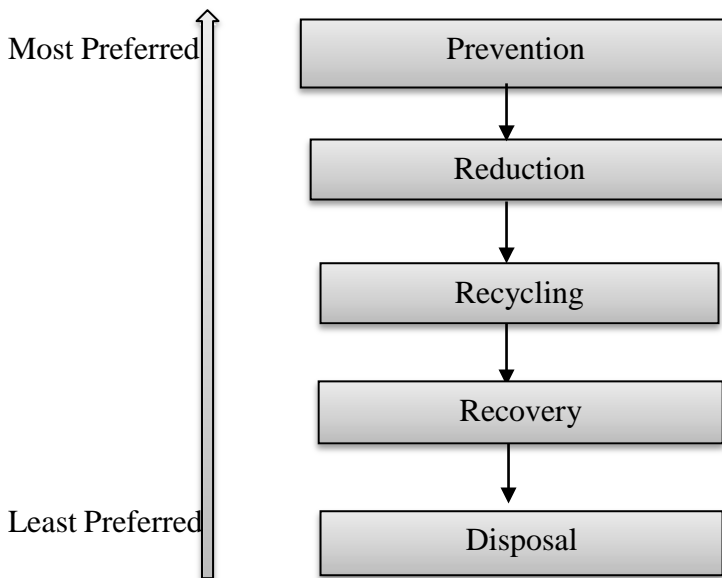
Solid Waste Management (SWM) is one in all the foremost environmental problems in several developing countries, as well as Nepal. Urban increase and economic development result in increasing generation of municipal solid waste (MSW). The employment of the merchandise that generates risky waste is associate degree another concern. Non-systematic disposal of medical wastes from hospitals and clinics additionally contribute to pollution and public health hazards within the localities. Therefore, SWM has become a significant concern for the municipalities in Nepal. Managing solid waste is one in all the foremost challenges in Urbanization. Several Urban areas in Nepal face difficulties with the availability of basic services like waste product treatment and solid waste management. Municipalities are entirely answerable for the gathering, transport, treatment and final disposal of Solid Waste. Several don't seem to be well equipped to try and do the work. Few have basic knowledge on waste generation and composition most lack finance and management capabilities to be each effective and economical during this space. A survey conducted by Asian Development Bank in 58 municipalities of Nepal in 2012 found that the common municipal solid waste generation was 317 grams per capita per day. This interprets into 1435 tons per day or 524,000 tons per annum of the municipal solid waste generation in Nepal. Several of those technically and financially affected municipalities are still active margin waste pickup from open piles and open dumping creating major health risks (D. Pokhrel and T. Viraraghavan, 2005). Haphazard depositing and burning piles of waste on roads and riversides could be a common sight, inflicting risky health and environmental issues unmoved moreover as downstream (C. Anderzén and V. Blees). In case of Kathmandu Municipality, wherever the solid waste management issues is found be to extremely unmanaged, four sections are operating parallel with environmental tasks; Environmental

Department, Solid Waste Management Section, maintenance Section and concrete setting section.

The Solid Waste Management Section of KMC has the responsibility for the whole solid waste management in Kathmandu in keeping with the 2001 census, solely regarding 15% of Nepal's total population board Urban areas (C. Anderzén and V. Blee). The shortage of employment opportunities in rural areas and the concentration of the many facilities and services like education and health care in urban centers, the speed of urbanization is extremely high, inflicting solid waste management to become a significant challenge in most urban centers in Nepal, notably the larger ones (A. Marga, 2008).

1.1.3. Waste Management Hierarchy

Waste Management Hierarchy is that the point arrangement of management practices from the smallest amount most popular technique to most popular one. Keeping the money hurdles, environmental welfare and therefore the long run consequences in mind, bar is taken into account to be the foremost effective observe, whereas disposal while not segregation is taken into account the smallest amount most popular.



1.1.4. Municipal solid waste management and its functional elements

MSWM is that the management of generation, segregation, storage, collection, transfer and transportation, resource recovery and process, treatment, and disposal of solid waste by exploitation the foremost economical technique in an environmentally friendly, socially acceptable, and economical means that while not compromising the health hazards of the folks. Inadequate assortment and transportation systems, improper treatment, and marketing of solid waste cause serious health hazards and environmental pollution. Each method of the MSWM plays an important role within the effective implementation of policies associated with SWM. In Nepal, urbanization is increasing at an increasing rate on municipal services, significantly to manage the ever-increasing amounts of waste. At present, most of the waste generated in municipalities isn't being adequately managed thereby making serious health and environmental hazard (WaterAid in Asian country, 2008).

1.1.5. Municipal solid waste classification

A study conducted by the Asian Development Bank in 2013 calculated that the composition of Municipal Solid Waste are given; Organic waste 56%, plastics 16%, paper, and paper product 16%, glass 3%, metals 2%, textiles 2%, rubber, and leather 1% and others 4%. Municipal wastes square measure typically classified supported their sources of generation. Municipal solid waste may be classified as follows:

Table1: Municipal Solid Waste Classification

Sources	Usual facilities, activities or sources of generation	Composition of solid Waste
Residential	Single and joint family, detached dwellings and apartments.	Food wastes, papers,plastics, textiles, wood,glass, household Hazardous wastes.

Sources	Usual facilities, activities or sources of generation	Composition of solid Waste
Commercial	Stores, restaurants, markets, offices, buildings, hotels, services stations, Auto repair shops etc.	Paper, cardboard, plastics, wood, food, waste, glass, metals, liquid wastes, hazardous wastes etc.
Industrial	Schools, Hospitals, Governmental centres, Industrial areas, constructions.	By products or raw materials, hazardous waste,
Construction and demolition	Construction sites, road repairmen's and renovation sites, rising of buildings etc	Wood, Steel, Concrete, Dirt
Treatment plant sites	Water, waste water and industrial treatment processes etc.	Treatment plant wastes, principally composed residual sludges
Agriculture	Food and raw crops, orchards, dairies, feedlots, farms etc	Spoil food wastes, agriculture wastes, rubbish, and hazardous wastes.

1.2. Rampur Municipality Profile

1.2.1. Geographic Location

The study was administrated in Rampur municipality of Palpa district, that is in province no. 5. The municipality was established on 18th May 2014 by merging the present Gadakot, Gejha, Khaliban, and Darchha village development committees. The municipality is at elevation of 1100m from the ocean level and covers a complete space of 123.5 kilometer sq.. The natural depression is finite by the Syangja district within the

north, the Tanahun district within the northeast, and therefore the Nawalparasi district within the east.

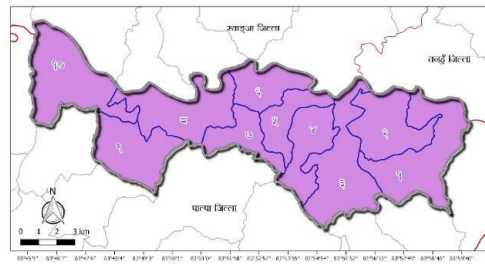


Figure 1: Map of Rampur Municipality

Source: Rampur municipality profile, 2076

1.2.2. Demographic Details

Total Population	-	42,451
Population of male	-	21,785
Population of female	-	20,666
Total household	-	8,456
Growth Rate	-	5.02%
Total Municipality Area	-	123.34 sq. km
Population Density	-	344.179 persons per sq. km
Household size	-	5.02

Source: Rampur municipality profile, 2076

1.2.3. Climatic Condition

It is slightly hot in summer and moderately cool in winter. The highest temperature So far recorded is 35.5°C and lowest 4.0°C. The average annual rainfall is 477.26 mm.

1.2.4. Land Use

Table 2: Land Use of Rampur Municipality

Land Use	Sq. m	% of total municipal Area
Agricultural	6720.07	54.49
Forest	4779.89	38.76
Residential	133.65	1.08
Business Zone	12.05	0.10
Industrial Zone	0.08	0.01
Public Sector	684.03	5.55
Others	2.08	0.02
Total	12331.85	100.00

Source: Rampur municipality profile, 2076

1.2.5. Access to Sanitation

Regarding the supply that is Rampur municipality profile 2076, 100.00% of the households within the municipality have toilets. Whereas, 49.04% have fashionable toilets with flushing system and 50.96% have simply pit latrines.

1.2.6. Social Infrastructure

Educational Centres

Rampur is one of the well-known education centers in Palpa District in Lumbini Province of West southern Nepal, especially for vocational institutes like Civil overseer, Agricultural, and Veterinary Education. Rampur produces the finest students every year through the following educational centers:

Table 3: Educational Centres

Total Number Of Primary Schools	Total Number of Lower Secondary Schools	Total Number of Secondary Schools	Total Number of Campuses	Total Number of Technical Schools
31	7	20	2	2

Source: Rampur municipality profile, 2076

Health Centres

Rampur is the center for health services for adjoining villages. It has mainly one major hospital and number of other health centers and clinics. The followings are their details:

Table 4: Health Centres

Total Number of Hospitals	Total Number of Beds	Total Number of clinics
1 (Rampur Hospital in ward # 5)	50	8

Source: Rampur municipality profile, 2076

Recreational Centres

Following details, shows the recreational centres of Rampur Municipality.

Table 5: Recreational Centres

Tourism and Religious Place	Parks	Cinema Hall	Picnic Spots	Community Hall	Playgrounds
129	49	1	38	Muslim, Jaycees Hall and Sabha Griha(5)	32

Source: Rampur municipality profile, 2076

Commercial Centres

Following details, shows the commercial centres of Rampur Municipality.

Table 6: Commercial Centres

Hotels and Lodges	Major Hotels	Shops (small to big all kind)	Restaurants	Haat Bazar
168	Namaste hotel and Shree Nagar Hotel	1271	150	1

Source: Rampur municipality profile, 2076

Industries

Following details, shows the industrial numbers and main products of Rampur Municipality.

Table 7: Industries list

Number of Industrial District	Number of Industries inside RID	Number of Industries outside RID	Main products
Rampur Industrial Division (RID)	1556	75	Food stuff, furniture, plastic products, metal sheets, bakeryetc.

Types of Shops	Quantity(N)
1. Retailer Business	
Local shops(Kinara)	165
Fruits and Vegetable	55
Meat	30
Cloths	52

Pharmacy shops	27
Ready-made dress and customatic	275
Utensils	22
Hardware	25
Other construction accessories (Cement, rod etc...)	8
Stationary	21
Mud utensils	4
Shoos and Slippers	30
Mixed kinara/cloths shops	15
Mixed kinara shops	50
Total	778
2. Distributer Business	
Kinara shops	28
Cloths	18
Dealers	19
Total	65
3. Tea Shops and Hotels	
Tea, breakfast and Sweet shops	205
Restaurants	150
Hotel and Lodge	28
Total	383
4. Personal Service Shops	
Salon	15

5. Public service oriented shops	
Photo Studio	15
Law service	14
Clinic	6
Photocopy shops	21
Total	56
6. Retailer service industries	
Tailor	62
Jewellery	28
Agricultural equipment	12
Radio, watch repair shops	12
Workshops	18
Total	132
7. Industries and Mills(Small and Medium)	
Rice, wheat mills	25
Mustard oil mills	5
Hand mills	3
Mud utensils	2
Bakery Industries	3
Bricks Factory	2
Poultry farm	52
Furniture	35
Total	127

Source: Rampur municipality profile, 2076

Banks/Financial Institutions

Rampur is also a center for financial activities. Lots of people from adjoining VDCs come here to deposit cash for saving and to get loans for business and other purposes. There are 8 Banks, 15 Micro Finance and 28 other Finance Cooperatives in the municipality.

Brief socio-economic information

The brief socio-economic information of Rampur Municipality is shown in the table:

Table 8: Socio-Economic Information

Name	Rampur Municipality
District	Palpa
Year of Establishment	2071 B.S
No. of Wards	10
No. of Urban Wards	4
No. of Rural Wards	6
Total Area	123.34 sq km
Major Rivers	Kaligandaki River, Nisdhi etc...
Total Road length	>240 km
a)Black Topped Road	82.52 km
b)Graveled	50.18 km
c)Earth	106.61 km
Population (2076)	42,451
No. of Households (2076)	8,456
No. of Shops	1271
Industries	127

No. of Restaurants	150
Annual Population Growth Rate 2076	5.02
Haat Bazar	3

(Source: Rampur Municipality Profile 2076)

1.3.Financial Analysis of Rampur Municipality

The "local autonomy act 1999" has provided ample rights and basis for all the gov. bodies to spice up or collect funds in various forms (i.e. local tax, revenue, tariff, etc.).On this basis, Rampur Municipality collectively collects various sorts of taxes and prepares a budget in line with its priority. The foremost vital sources of economic gain of the Municipality are:

- Donation from GON
- Donation from Lumbini Provision
- Revenue from Regional GON
- Revenue from Federal GON
- Transport department
- Internal Resources

1.3.1. Budget for 2078/79 and allocation for SWM

The total budget for the fiscal year 2078/79 of Rampur municipality is NPR 830,000,000.00. Whereas the budget assigned for SWM is concerning NPR 1,50,00,000 that involves be 1.81% of the total budget.

1.3.2. Different Expected Sources of Income of Rampur municipality for Fiscal Year 2078/79

The major source of income of municipality is donation from government which is 71 % followed by revenue from federal government 13%. Other sources are donation, service transport, internal resources etc.

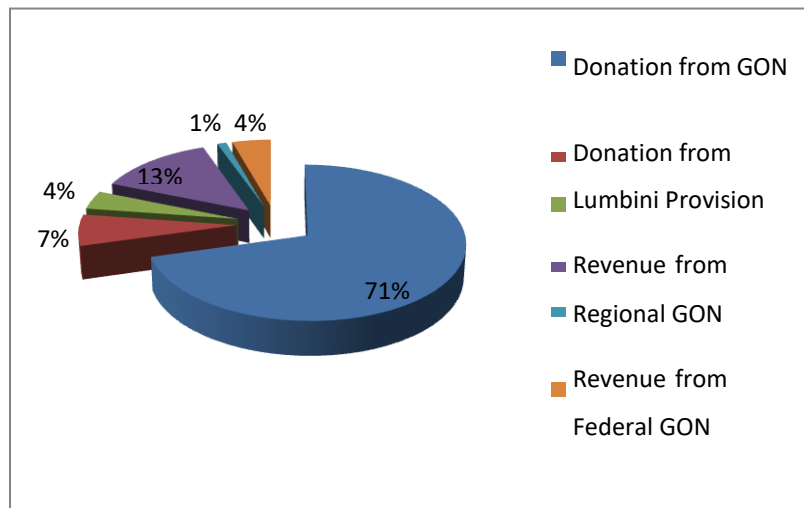


Figure 2: Sources of income of Rampur Municipality for fiscal year 2078/79 in percentage

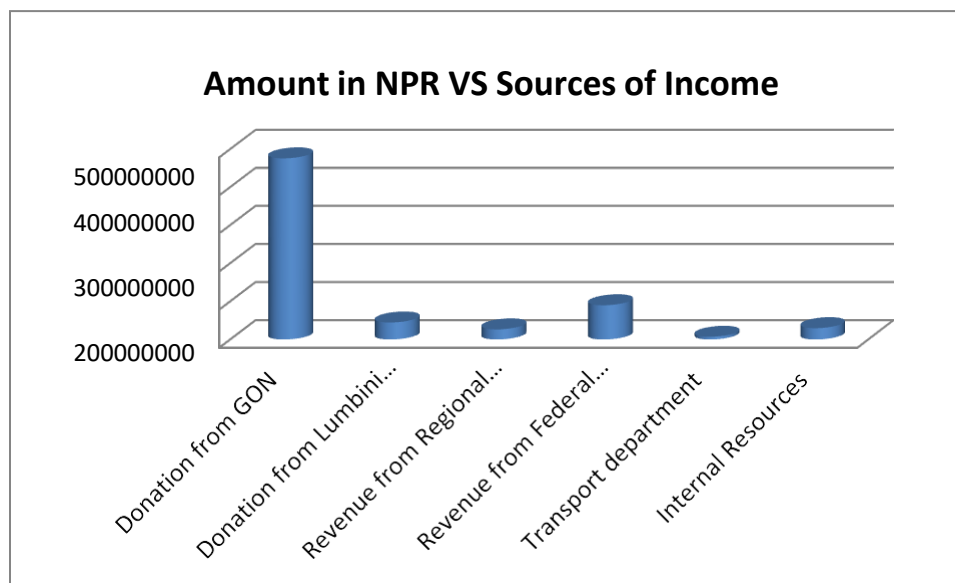


Figure 3: Sources of income of Rampur Municipality for fiscal year 2078/79

1.4.Rationale of the study

The generation of waste may be a standard development but its safe disposal may be an important draw back. Improper disposal might cause substantial environmental threats and health problems, thus it is necessary to assess the solid waste management system of any city to assure sensible public health and thus the environment. The speedy increase among the degree of solid waste not only creates problems for the environment and health but there is collectively a gradual increase in worth and provides difficulties of municipal solid waste management. This has place increasing pressure on the infrastructure and authorities responsible for the management of solid waste. In Nepal, the number of urban centers has inflated noticeably. There is downside notice acceptable locations and getting public approval for landfill or dump areas. Large investments unit required for constructing the new landfill facilities. It's therefore prudent to appear for and implement long integrated waste management ways that guarantee a sustainable approach to waste management services. Rampur municipality is one in every of the aggressive urban centers of west southern Asian country, really less and restricted studies square measure administered on the solid waste management of Rampur municipality. This study is run to gauge the current apply and suggest the suitable ways in which and alternatives to handle the matter of solid waste in Rampur Municipality and choose the lapses among the management system.

1.5. Statement of the Problem

With the speedy increase globally likewise as in our country, the number of varied types of waste generated has collectively inflated unprecedently. The assorted wastes generated have collectively inflated unprecedently. The assorted wastes generated from types of sources unit found to be prejudicial to human health, environmental welfare, and thus the complete system. With the dearth of correct coming up with and scientific technologies, solid waste management has shown a significant threat to the surroundings and health sectors. And might continue among the longer term for the additional serious if any imperative and eventful steps unit taken instantly. Municipal solid waste management has become a theme of concern to the authoritative bodies attributable to ever increasing population, and lack of correct rules and cash resources.

1.6. Research Questions

- What unit the characteristics of the solid wastes generated among the municipality?
- What unit the prevailing systems of assortment, transportation, and final disposal of waste?
- What unit the current socio-economic challenges of the municipality in moving towards ISWM?
- To that extent unit willing to acquire associate environment-friendly assortment and final disposal of MSW?

1.7. Research Objectives

1.7.1. Main Objective

To assess the effectiveness of MSW management system in Rampur Municipality and its socio-economic challenges in moving towards ISWM system.

1.7.2. Specific Objectives

- To find the existing system of collection, transportation and final disposal of MSW in Rampur Municipality.
- To identify current socio-economic challenges in moving towards ISWM.
- To recommend the sustainable solid waste management plan ie Landfilling options, along with detailed engineering design, cost estimation and financial analysis of the project for an environment friendly collection and final disposal of MSW in Rampur Municipality.

1.8. Limitations

- The study was confined in urban wards of municipality i.e. except ward no. 1, 2, 7, 8, 9 and 10.
- The study was focused in the overall management system of solid waste with no lab base experiments.

- No sophisticated instruments were used for the purpose of study, as the study was confined in the management system no laboratory analysis was carried out.

1.9. Significance of the Study

Waste generation may be a development but its safe disposal poses a significant drawback. Unmanaged or improper disposal of wastes winds up in environmental pollution that affects humans, and various animals, and very important health problems. Thus it's extremely necessary to examine for assure sensible public health and surroundings. In Nepal, the number of Urban centers has inflated significantly, but there unit problems with finding acceptable locations and getting public approval for landfill or dump areas. Large investments unit required for constructing the new landfill facilities. It's therefore crucial to appear for and implement long integrated waste management ways that guarantee a property approach to waste management services. Rampur may be a growing city with the population increasing at a speedy rate. Several people from neighboring places migrate to Rampur for the type of facilities and amenities it offers. As a result of the population goes on increasing, the waste generated among the place collectively naturally spikes. That the study is run to gauge the current apply and to suggest the suitable ways in which and alternatives to handle the matter of solid waste in Rampur municipality and choose the gaps among the management system.

CHAPTER TWO: LITERATURE REVIEW

2.1 Information Review

It is a well-known indisputable fact that Solid waste is one of the most important contributors to degradation of environmental welfare and public health in Kingdom of Nepal. The ever-growing population and disproportionate policies for solid waste management area unit inflicting issues during a very serious manner. Though few policies and plans associated with the manufactory, agriculture, urban development, and infrastructure development are detected with work management no specific policies are enforced.

Financial components are major factors in determinant the effectiveness of the waste management system. Although each ward allocates sure budgets for waste management, it's proved to be decent. NGOs have opportunities to the budget from varied donor agencies. A number of the agencies funding NGOs/ INGOs area unit World Bank, UNDP, and GTZ. They supply each technical yet as money help supporting varied sectors of development.

The municipal association of Kingdom of Nepal (MUAAN) and also the Urban Development through native efforts (UDLE) project of GTZ area unit presently introducing coaching courses to varied municipalities on waste management.

2.1.1. Municipal Solid Waste Current State in Nepal

Nepal lacks correct visioning and springing up with inside the general solid waste management system. A study conducted in 2016 showed that the composition of municipal solid wastes contained chiefly Organic matter 68% and 51% in Households and business waste severally, whereas, the dominant fraction was paper and paper product 41% in institutional waste. The findings of this study showed that the municipal waste of all municipalities is well viable for producing compost. The families within the main in rural areas of municipalities do family composting traditionally, but the urban households, where less land is on the market, unit usually doing family composting (SWMTSC, 2017). Municipalities unit unable to achieve their goal of solid waste management as a results of a inadequacy of technical and human resources, data, math's

records, correct springing up with, meagerly budget, less public and private participation, and surplus political issues.

2.1.2. Current Approaches and practices of Solid Waste Management in Nepal

- Door to door collection
- Source segregation at the household level
- Composting at the household level(Reduce/ reuse)
- Initiating User's fee system-ownership/rights
- Involvement of NGOs and private sectors.
- Vermi-composting
- Waste Collection and transport to landfill sites not regular
- Garbage of waste remain in the public place for long time
- Dumping of household waste on the banks of river.

2.1.3. Ninth Regional 3R Forum in Asia and the Pacific progress Report for Nepal 2019

- The level of participation of households in "Source" segregation of municipal waste stream was found to be below satisfactory <50%
- Country's organic wastes were reported to be mostly landfilled.
- The major waste management areas that have strong involvement of private and businesssector were reported to be waste collection, resource recovery and waste recovery.
- Specific rules and regulations introduced to separate, store, treat, transport and dispose the hazardous waste were reported to be SWM Act 2011 and National Health CareWaste Management Guidelines.

2.1.4. Solid Waste Management of Kathmandu Metropolitan City (Environment Audit Report, 2015)

As per the information provided by KMC, the per capita generation of waste in capital of Nepal was obtained as 30g/person/day. Similarly, the information additionally shows that the most important portion of waste is organic i.e. 63.22%. Plastic and paper comprise major parts of inorganic wastes. Out of thirty five wards, the KMC itself has been

collection wastes from twelve wards, one ward has totally relied on PSOs and in twenty two wards the KMC and personal sectors are together collection the waste. As per the information provided by the KMC, it's operated seven trucks, one power trailer and one hundred thirty manual carts for collection wastes from the supply. The KMC has prescribed numerous 134 routes of waste assortment by vehicles throughout the natural depression.

SoE Nepal, 2002

According to the report, it had been calculable that in 1997, residents from the country's 58 municipalities generated just more or less about 3,04,848 loads of municipal waste, that is 83% of the whole solid waste generated within the country. Agricultural waste and industrial waste created up solely 11 % and 6 % respectively of the whole waste generated that shows the HH waste is that the main supply of municipal waste in Asian nation. The per capita waste generation in Asian nation ranges from 0.25 to 5kg/day.

In the recent years solid waste management has become a significant challenge in in Katmandu, the capital town and in alternative urban areas of the country. The haphazard disposal of southwest in densely inhabited areas; environmentally sensitive areas, riverbanks and heritage sights haven't solely place forth adverse impacts on public health conjointly the setting however also deteriorated the social rank of the individuals.

One of the foundation causes of the SWM is that the public angle. "Out of sight, out of mind" is that the commonest response of the general public to the matter of the SWM in Asian nation. Equally the authority in Asian nation related to waste management has restricted their tasks to sweeping and marketing the waste in places wherever they receive no public complaints. General Public takes waste as a nuisance instead of a resource.

MLD, SWMRMC, 2004

The report assumes regarding 75% of the waste stream comes from the households and remaining 25% from the industrial and public establishments. As per SWM and RMC, per capita waste generation rates within the municipalities varies wide from 0.11 kg/day to 0.7 kg/day at home level. The six fold variation in per capita waste generation rates at home level within the completely different municipalities isn't perceivable considering

the population size and level of economic activities within the completely different municipalities. However, average per capita waste generation of 0.3 kg/day at home level and 0.4 kg/day at the municipal level correlates well with the municipalities of comparable population distribution and economic activities during this a part of the planet.

An overview of the assorted MSW generation and assortment information indicates a poor information. The variation of the per capita generation of waste from households between closely set municipalities of comparable fashion and economy shows different variations. As an example the Katmandu municipality contains a per capita waste generation of 0.39 weight unit whereas the neighboring Lalitpur has 0.54 kg.

Despite the shortcomings within the accessible information, considering the per capita waste generation same as 2003, the whole MSW generated everywhere Asian nation for the year 2008, supported population projection, is calculable to be 1586 tons/day. This amounts to associate annual generation of 578919 tons. More that the gathering potency is analogous to 2003; the whole waste collected by the municipalities within the year 2008 for disposal purpose is regarding 244303 tons.

58 municipalities of Asian nation are generating or so 1369 tons/day MSW within the year 2003. Out of total generated MSW solely 577 tons/day has been collected. The gathering potency of MSW was regarding forty two.20%. In Butwal municipality, 23.48 ton waste is generated per day trip of that solely 18.20 ton (77.52%) is collected. In Nepal, waste management system is new and was developed when with the institution of SWMRMC in 1979.

Khadka et al. 2004

Prior to 1980, solid waste had been regionally managed in urban areas of Asian nation with none issue. the majority the wastes were used as organic manure. By 1980's it's been discovered that the fast increase and increasing affluent has considerably modified the degree and kinds of waste generated. As a result, the municipal solid waste has emerged as distinct urban setting waste material with important implication on public health and also the native environmental quality (Khadka et al. 2004). Relating to the

solid waste management, SWMRC act (1987), municipal act and native self-governance act (1999) create the municipalities to manage the solid waste to stop adverse effects on natural and cultural setting and to safeguard the general public health.

SWMRMC, 2008

Proper assortment, transfer and disposal of solid waste square measure major issues faced by the 58 municipalities of Asian nation. Regarding 62% of the waste is organic and regarding pure gold of the waste is reusable/recyclable, remaining waste ought to be finally disposed of e.g. by healthful land filling. Medical wastes square measure incinerated by hospitals themselves in majority of municipalities. But in some cases, it's burnt or simply inexpertly drops. The foremost common method of managing industrial waste is stream marketing. the amount of human resources operating within the waste management is varied from 1324 in Katmandu to no solid waste workers in Khandabari municipality that shows the acute variation. Municipalities square measure unable to attain their goal of SWM due to lack of technical human resources, data, applied mathematics records, correct coming up with, short budget, less personal participation and excess political problems.

PPPUE, Final Report, 2009

Disposal and treatment of commercial and municipal wastes will turn out emissions of most of the vital greenhouse gases (GHG). The foremost vital gas made from the solid waste treatment and disposal is alkane series (CH₄). Lowland gas consists of roughly fifty per cent greenhouse gas and fifty per cent CH₄ by volume. However, the share of greenhouse gas in lowland gas is also smaller due to decomposition of substrates with a high hydrogen/oxygen magnitude relation (e.g., fats, hemicelluloses) and since a number of the greenhouse gas dissolves in water at intervals the location. Waste disposal practices of concern for CH₄ emissions vary within the degree of management of the position of waste and management of the location.

The composition of waste is one in every of the most factors influencing each the number and also the extent of CH₄ production at intervals waste disposal sites. MSW usually contains important quantities of degradable organic matter and is potential to supply

comparatively high CH₄. Alternative factors like temperature, moisture, pH scale and nutrients accessible.

Approximately three to four per cent of annual world evolution CH₄ is calculable to be made and free into the atmosphere from the solid waste treatment and disposal (IPCC, 2006). It's due to this solid waste disposal and treatment is a crucial supply of the GHG emission globally.

2.2.Reviews of Acts and Laws

2.2.1. The constitution of Nepal

- Rights to scrub Environment: each national shall have the rights to measure in an exceedingly clean and healthy atmosphere. (Article-30)
- Right about Health (Article-35)

2.2.2. Solid waste (Management and Resource Mobilization Act, 1987)

Duties and functions of waste management Centres.

- To undertake basic construction, repair and maintenance works so as to regulate Solid Wastes and acquire the cooperation of municipalities for the aim, if thus deemed necessary.
- To create necessary arrangements of the disposal of solid wastes in pollution free manner.
- To form arrangements for the mobilization of the collected solid waste by mistreatment them in an exceedingly form appropriate for his or her utilize.

2.2.3. Environment Protection Act, 2076

Environment Protection Act re-defined the following terms:

- “Wastes suggests that the liquid, solid, gas, slurry, smoke, dust, radiated components or substances, or similar different materials disposed in an exceedingly manner to degrade the environment”. (section 2(H))
- “Disposal suggests that the act of emission, storage or disposal of sound, heat or wastes”(Section2(i))

2.2.4. Solid waste Management Act 2068

- Solid Waste suggests that domestic waste, industrial waste, chemical waste, health establishment connected waste or harmful waste and this word shall additionally mean the materials that that be used presently, thrown away or in rotten stage or in solid, liquid, gaseous, thick liquid, smoke, or dirt kind emitted out damaging the atmosphere or materials and equipment's used for electrical or info technology.
- Suggests that the method by that the solid waste is modified into appearances or property into the other helpful substance or product, fertilizer, gas, energy or different substance by that solid waste management is created.
- Native body shall be chargeable for the management of solid waste by construction and operation of infrastructure like transfer station, lowland website, process plant, compost plant, bio-gas plant and additionally assortment of waste, final disposal and process.
- The native body shall be chargeable for the arrangement or its use in the other approach of the solid waste collected within the course of cleanup, throwing or putting of solid waste collected within the course of cleanup, throwing or putting of solid waste at solid waste assortment center, transfer center or process website.

2.2.5. Solid waste Management Rules, 2013

- The native body shall, whereas fixing segregation a minimum of of organic and non-organic solid waste at its sources beneath section vi, need to build managements and segregation of harmful or chemical waste on an individual basis.
- The native body shall conduct programs for increasing people's awareness in relevancy applying applicable technology for creating segregation through reduction of generation of solid waste at its supply and management beneath Sub-rule(1)
- Native Body shall, whereas fixing time, place and manner of Solid Waste discharge, confirm taking under consideration the straightforward, comfy manner for transportation, process and final disposal of solid waste.
- The native body could confirm a separate time, place and manner for transportation of solid waste up to the process website.

2.3.Solid Waste Management Options

Solid waste management consist management of production, collection, transportation, processing, and disposal in a very manner that's below the most effective principles of public health, economics, engineering, and different environmental considerations (Afrozat el., 2010). Inappropriate waste handling, storage, collection, and disposal practices cause environmental and public health risks in urban and peri-urban areas.

2.3.1. Solid waste Composting

Solid waste Composting are often composted and also the compost obtained is often used as Associate in nursing fertilizer on agricultural fields. Organic compost is wealthy in plant macronutrients like atomic number 7, element metal, and different essential micronutrients. Composting is self-made as a result of it's a cheap and less-infrastructure set-up and additionally creates compost that may be a marketable byproduct. In addition to creating a contribution to agriculture, the sale of organic waste reduces waste collection and disposal Kumar (2008). As per the MNRE in Bharat, "Composting may be a process during which micro-organisms, chiefly fungi, and microorganism, convert degradable organic waste into humus-like substances. This finished product that seems like soil is high in carbon and atomic number 7 and is a superb medium for growing plants (MNRE, 2003). Composting may minimize the requirement for expensive waste disposal strategies like landfilling and combustion. Composting reduces the amount of waste attending to landfills; biological decomposition of most of the solid waste generated in urban centers is maybe the foremost engaging and property different to waste exercise. As per CORE (2008), composting will scale back the quantity of materials discarded in landfills by up to five hundredth. Utilization of composted organic waste materials as fertilizers won't solely lead to augmented production through its potential for the contribution of essential nutrients however also will facilitate in minimizing sanitary , environmental, and conservation issues. Compost could give Associate in Nursing simply out there and reasonable supply of chemical and soil conditioner for low-income earners in urban and peri-urban areas. Process of solid waste may function one in all the most effective chemical alternatives if well processed and managed since inorganic fertilizers square measure in most cases unaffordable to resource-poor farmers (Kimbi

and Semoka, 2004). Successful composting needs among different things, appropriate materials and also the construction of applicable bio-digestion facilities. Previous studies discovered that concerning 70%-80% of urban solid waste generated is Associate in nursing agricultural waste that's perishable. It's additionally vital to develop a system of waste separation and trucking to the composting facility. Composting may be a really viable recovery different over solid waste management. Most native authorities became economically strained in providing economical management of solid waste. Therefore, the likelihood of changing municipal solid wastes to organic earth-like material mistreatment composting will give a major contribution to the answer. As indicated earlier that concerning eightieth of solid waste generated is perishable which might be became compost if applicable methods square measure in situ. This approach reduces pollution and provides self-made composting for urban agriculture and supply of financial gain for urban dwellers will sustainably be done below specific teams.

2.3.2. Waste to Energy conversion

Waste to Energy conversion Waste-to-Energy combustion (WTE) is outlined as a method of controlled combustion, mistreatment an indoor device to thermally break down flammable solid waste to Associate in Nursing ash residue that contains very little or no fuel which produces, electricity, biogas, or different energy as a result (Themelis, 2008). The energy needs of a community are often happy to some extent by energy recovery from wastes as a much better different to landfilling. Energy recovery may be a methodology of ill the energy in Municipal Solid Waste. Energy hold on in wastes may be a fraction of the input energy spent in creating those materials. Because of the distinction in resources (materials/energy) which will be recovered, energy recovery falls below material recovery on the hierarchy of waste management Kumar (2010).

2.3.3. Recycling Solid waste

Recycling Solid waste Plastic waste additionally has nice potential for resource conservation and GHG emission reduction, like manufacturing fuel from plastic waste (Spokas, 2007). Recycling has additionally been viewed as a veritable tool in minimizing the number of home solid waste that enters the dumpsites. It additionally provides the required raw materials for industries. These management aspects of

exercise, reuse, disposal, and others, need those members of the several community bear in mind of correct management techniques and also the potential impacts of improper management. Residents of Rampur municipal too ought to bear in mind of this management technique if the general public and environmental issues related to plastic waste square measure to be avoided. Often in developing cities, there square measure found "buyers" of waste materials like cardboard and glass (UNEP, 1996; USEPA, 2002). These patrons may facilitate to divert several materials out of the waste stream. Since exercise materials may be a financially viable enterprise, tiny enterprises have and can still arise whenever there's a chance. In fact, the thieving of source-separated reclaimable materials has been documented in several pilot schemes in each developed and developing nations (UNEP, 1996). Municipalities mustn't solely acknowledge the exchange recyclables, however they ought to additionally embrace it, by permitting tiny interposes to handle the matter, valuable funds square measure saved, jobs square measure created and lowland house is saved. Maybe through micro-loans or small-scale help, native governments may support and legitimize these entrepreneurs.

2.3.4. Landfill option /Dumping solid waste

Most of the MSW in developing countries is drop ashore in a very a lot of or less uncontrolled manner. These dumps create terribly uneconomical use of the out there house, enable free access to waste pickers, animals, and flies, and infrequently turn out unpleasant and dangerous smoke from slow-burning fires (Bartoneet al., 1991). The marketing of solid waste in landfills is maybe the oldest and also the most typical style of final disposal. Several "landfills" square measure nothing quite open, typically controlled, dumps. The distinction between landfills and dumps is that the level of engineering, planning, and administration concerned. Open dumps are characterized by the lack of engineering measures, no leachate management, no consideration of landfill gas management, and few, if any operational measures such as registration of users, control of the number of "tipping fronts" or compaction of waste.

2.4. Cost Benefit Analysis

2.4.1. The concept

Cost-benefit analysis (CBA) consistently analyses the economic justification of a possible investment call. It involves distinguishing, measuring, associate degree

inserting a cost on the prices and edges of a selected project proposal then comparison these prices and edges of a selected project proposal then comparison these costs and edges as an aid for decision-making. Analysis could be a discounting live of project good that originated within the USA in 1936 and has become a worldwide tool to gauge selections between different comes in decision-making (Pearce et al., 1993). CBA is additionally involved with the identification, quantification, associate degreeed valuation of data regarding edges and prices to work out the price of an enterprise. Once prices and edges are known, if they're to be compared, they need to be Valued. Since the sole sensible thanks to compare differing merchandise and services directly is to administer every a cost, correct costs for the prices and edges had to be found within the analysis.

2.4.2. The process approach

This method approach Bojo al. (1988) as cited by Kessy (1993) provided an outline of systematic procedure in CBA as follows:

- The institution of a choice criterion: the factors by that the project are judged, is clearly outlined at the onset of study.
- This might involve considering the spatial arrangement consequences of the project like the impact on completely different social and economic teams.
- Identification of the prices and edges concerned within the project The quantification of prices and edges: all the prices and benefits known in step 2 on top of square measure quantified as way as attainable.
- Valuation of prices and edges involves estimating the non-public and social values of the results led to by the project.
- Setting associate degree acceptable time horizon is employed to work out the time horizon of the project Discounting involves employing a real non-public or social rate of discount to estimate the worth these days of a stream of future prices and edges.
- Uncertainty and sensitivity analysis of the variables with the best uncertainty regarding the long run square measure known and sensitivity analysis is completed to indicate however changes in these could have an effect on the project outcome.

- Conclusion/recommendations supported criteria utilized in the analysis; a conclusive statement regarding the economic potency of a project is given.
- This can be used as a basis to suggest to the decision/policy manufacturers whether or not to simply accept or reject the project.

2.4.3. Payback period

Payback amount Refers to the time needed to recoup the funds exhausted in associate degree investment, or to succeed in the break-even purpose (Willians, 2012). The payback amount is sometimes expressed in years. Ranging from the investment year by calculative cyberspace income for every year: web income year one= money flow year 1- money Outflow year 1. Then additive income= (Net money flow Year one +Net income year a pair of + web income year three, etc.) Accumulate by year till additive income could be a positive number: that's the payback year. The payback amount has some limitations like follows; doesn't take into thought the continuance of money and so might not gift actuality image once it involves evaluating the cash flows of a project conjointly doesn't take into account risk, financing, or alternative vital issues, like cost whereas another live off come like NPV is often most well-liked. The payback amount doesn't specify any needed comparison to alternative investments or perhaps to not investment. The payback amount ignores the money flows on the far side the payback amount. Most major capital expenditures have an extended lifetime and still offer money flows even when the payback amount. Since the payback amount focuses on short-run profitability, a Valuable project could also be unmarked if the payback amount is that the solely thought (Farris et al., 2010).

2.5. Decision Criteria

As way as (CBA) carries 3 criteria measure unremarkably utilized in project analysis all of that utilize the discounted prices and edges (=present value) of the project over time (Armitage, 1998). These criteria involve Net present value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of come (IRR). However, vital things for thought during this analysis involve; discount rate, identification of prices and edges, and valuation of advantages and prices.

2.5.1. Net present value (NPV)

Net present value is defined as the net value of a future stream of costs and revenues discounted back to the present at a predetermined interest rate. NPV is a tool that can indicate a net value when evaluating management alternatives. It is usually expressed in cash per acre or amount of money from a given investment on a given piece of land. The NPV can be calculated using the following equation:

$$\text{NPV} = \sum_{t=0}^T B_t (1 + i)^{-t} - \sum_{t=0}^T C_t (1 + i)^{-t}$$

Where: NPV = Net Present Value

B_t = the project benefits in year t

C_t = the project costs in year t

r = discount rate

t = the number of years in the planning horizon

The criterion for project acceptance is: accept if NPV > 0.

2.5.2. Selection criterion

The investment is claimed to be economically economical if the NPV is completely larger than Zero. Or the project with the next positive range or larger than zero is that the one that's selected; the money come on the project is economically acceptable. One advantage of NPV over alternative discounted measures is that it makes no distinction in the slightest degree on what purpose within the computation method, the netting-out of advantages and prices takes place in spite of whether or not it's wiped out the center or finish of the project life. However, since NPV is associate degree absolute and not a relative live it imposes a significant disadvantage as a result of no ranking of acceptable different project or management level is feasible mistreatment this criterion. A little extremely enticing project could have a smaller NPV than an outsized marginally acceptable project. Another limitation is that this live cannot be applied unless there's a comparatively satisfactory estimate of the chance prices of capital. It's to use the NPV methodology properly; it's far more troublesome to use the IRR methodology correctly (Bierman, 1986). The weaknesses of NPV are that, it is very sensitive to the discount rate: a small change in Discount rate causes a large change in the NPV. As the estimate of the suitable discount rate is doubtful, this

makes NPV numbers much undecided. Also NPV often relies on uncertain forecasts of the future cash flows (Lin et al., 2000).

2.5.3. Benefit cost ratio

The Benefit-cost ratio (BCR) is the present value of benefits divided by the present value of cost. It is the method of evaluating the proposed investment in terms of all relevant investors' costs and benefits associated with it, including social costs and benefits. Benefits cost analysis is the technique for comparing the stream of net benefits produced over time by competing investment opportunities (Hella, 2007). Benefits and costs are accounted for at the time they are earned or spent and the cash flow is extended for several years. Usually, the number of years is assumed to be useful life of the useful economic life of the proposed project. Since the project life extends over several years, the cash flow must be discounted to compensate for the time value of money. The decision rule in the benefit-cost analysis is to accept all projects with benefit-cost ratios greater than one when discounted at the selected opportunity costs of capital. It can be calculated by the following formula:

$$\text{BCR} = \frac{\sum_{t=0}^T \mathbf{B} (1 + i)^{-t}}{\sum_{t=0}^T \mathbf{C} (1 + i)^{-t}}$$

The BCR express the benefit generated per unit of cost and it was interpreted as follows:

BCR>1: present value of benefits exceeds the present value of costs.

BCR=1: present value of benefits equals present value of costs.

BCR<1: present values of costs exceeds the present value of benefits

Selection Criterion

Projects with a BCR of 1 or greater are economically acceptable when the costs and benefits streams were discounted at the opportunity cost of capital. The absolute value of the BCR varies depending on the discount rate chosen; the higher the discount rate, the smaller the BCR.

2.5.4. The internal rate of return

Internal Rate of return (IRR) is expressed as an interest rate, much as the rate earned on a certificate of deposit or a saving account (Armitage, 1998).

It is a discount rate, at which discounted costs equal discounted revenue, or the rate at which the projected NPV of future cash flow is zero. It does not require the use of a discount rate for its calculation because the IRR is the discount rate that makes the net present worth of the incremental cash flow equal to zero. It is calculated by the following formula.

$$\sum_{t=0}^T B(1+i)^{-t} - \sum_{t=0}^T C(1+i)^{-t} = 0$$

OR,

$$\sum_{t=0}^T B(1+IRR)^{-t} - \sum_{t=0}^T C(1+IRR)^{-t} = 0$$

Decision criterion

If the IRR is greater than the cost of capital, accept the project. If the IRR is less than the cost of capital, reject the project.

For the ease calculation, this study adopted the NPV method. IRR and BCR do not show the size of the net effects. Reliance on both the IRR and BCR can easily lead to a result in which the total economic effects from an investment that has been selected are smaller than if the NPV indicator is selected. With NPV the reinvestment can be controlled.

2.6.Sensitivity Analysis

Sensitivity Analysis (SA) is an analytical framework for managing uncertainty. The target is to cut back the probability of enterprise unhealthy comes whereas not failing to simply accept smart comes so as to confirm that the discount rate (and/or horizon value) utilized by the investigator is suitable and isn't only chargeable for the result of a project appraisal, the investigator may need to perform a sensitivity analysis (Franzelet al., 2001). This will be wont to improve the strength of a CBA, and is especially helpful wherever there's uncertainty over the discount rate.

Sensitivity Analysis is additionally another necessary tool in higher cognitive process and in developing recommendations for call manufacturers, higher communication, inflated understanding or quantification of systems and model development. During this study the main target of SA was on the primary 3 uses uncertainty regarding their future values. Since the parameter values and assumptions of any economic analysis/model are subject to vary or error, SA was done to research these potential changes and errors and their impact, i.e. the distinction they create to the conclusions drawn from the economic analysis once there's uncertainty regarding future values. SA offers data that's necessary in developing versatile recommendations that rely upon circumstances. It's conjointly necessary in distinguishing sensitive or necessary variables. Secondly, SA offers data for inflated understanding or quantification of the system by estimating the connection between input and output variables, and lastly, what proportion worse off the choice manufacturers would be if they unheeded the modified circumstances and stayed with original or another strategy (panel, 1997). However, Franzelet al. (2001) reported that the strategy has one live defect since it fails to account for the possibilities of future outcomes of involved analysis.

Sensitivity analysis was used by FAO(1992), Gittinger (2001) and Senkondoet al. (2000) to assess the impact of changes in key parameters like input-output coefficients, discount rates or costs of inputs and outputs and to return up with alternative values of NPV that were wont to take investment projected.

CHAPTER THREE: MATERIALS AND METHODOLOGY

3.1. Research Plan and Design

This research was attempted to assess the Municipal solid waste management and the socio- economic challenges in moving towards integrated solid waste management (A study of Rampur Municipality, Palpa), with both explanatory as well descriptive research designs were employed in this research with the use of both primary and secondary data for analysis. This study was conducted on the basis of the flow chart which is presented in figure below.

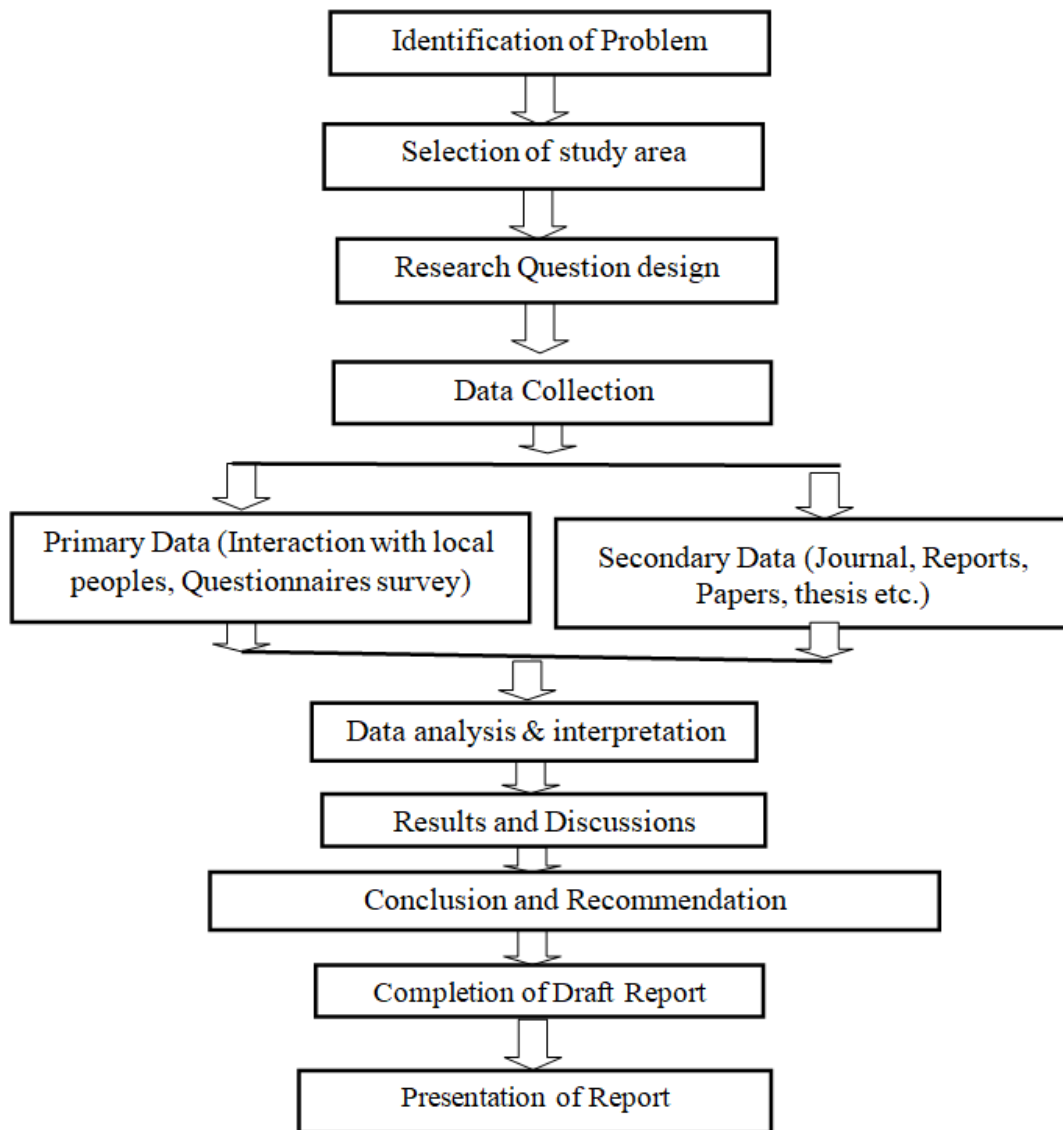
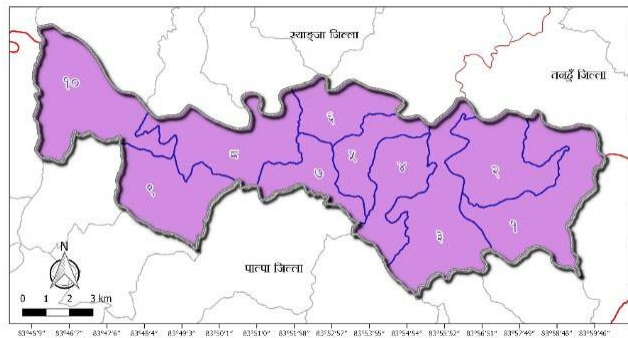


Figure 4: Methodological Framework of research

3.2. Study Area

The study was administrated in Rampur municipality of Palpa district, that is in province no. 5. The municipality was established on 18th May 2014 by merging the present Gadakot, Gejha, Khaliban, and Darchha village development committees. The municipality is found at an elevation of 1100m from the ocean level and covers a complete space of 123.5 kilometer sq. The natural depression is finite by the Syangja district within the north, the Tanahun district within the northeast, and therefore the Nawalparasi district within the east.



Source: Rampur Municipality Profile

3.3. Data Sources

The study was based on primary and secondary data described below:

1 Primary data

- Sampling of commingled MSW and analysis for composition.
- Questionnaire based HH survey of the local communities receiving MSW management services.
- KII with concerned Municipality officers.
- Visual inspection of MSW collection and final disposal activities.

2 Secondary data

- Municipal record books, published municipal profiles, unpublished municipal records etc.

- CBS publication

3.4.Data collection Tools/ Technique

3.4.1. Primary Sources

For characterizing the MSW generated in the city, a simple commingled waste sampling method was used. In the method, 10 kgs of representative commingled (mixture of recyclable and non-recyclable) wastes are taken out from the final waste disposal site, the components of the wastes was segregated and the weight by the mass of each categorical waste are measured then its resultant compositions was determined in percentage.

Most of the remaining data was generated from a questionnaire-based household survey (Random Sampling Method) and key informant interviews. Most of the questions are closed-ended for Household surveys regarding their perception, satisfaction, and willingness to pay for the overall improvement of the Solid Waste Management System in the municipality.

For KII, most of the questions were asked in the open-ended format regarding the current management practices, their effectiveness, and financial and other factors causing hurdles in the Integrated Solid Waste Management System.

A series of visual inspections were made from the place of waste collection to the place of final disposal sites for understanding the actuality of the situation.

3.4.2. Secondary Sources

Records on the total waste generation rate, collection, disposal, and the involved cost for waste management practices were reviewed for the purpose of collecting data. Published Municipal profiles, unpublished municipal records, reports and computer recorded data are used as major secondary sources.

3.4.3. The Sampling Framework

There are 4,017 households in ward no 3, 4, 5 & 6 of Rampur Municipality. In the case of household survey, following formula was used. The sample size of the households for questionnaire survey was determined at 95% confidence level by using the formula adopted by Arkin and Colton (1963).

$$n = \frac{NZ^2 P(1 - P)}{Nd^2 + Z^2 P(1 - P)}$$

Where, N = 4,017 (total number of households)

Z = 1.96 (at confidence level of 95%)

P = 0.05 (estimated population proportion)

d = 0.05 (error limit of 5%)

While using this formula, the minimum sample size of the research is $71.69 \approx 72$ samples. Thus, for low error in the research a total of 75 households were surveyed through questionnaire survey in ward no 3, 4, 5 & 6 of Rampur Municipality.

Table 9: Sampling Framework

S.No	Participants	Methods	No. of Participants
1.	Committee of Municipal solid waste Management, Municipal authoritative bodies	Key Informant Interview, discussion	5
2.	Households (Ward No 3, 4, 5 & 6) Whereas, Total Number of Households(N)=4,017	Questionnaire (Random Sampling Method)	75
3	Educational Centers (Ward No 3, 4, 5 & 6) Whereas, Total Number of Educational Centers(N)=26	Questionnaire (Random Sampling Method)	19

S.No	Participants	Methods	No. of Participants
4	Health Centers (Ward No 3, 4, 5 & 6)Whereas, Total Number of Health Centers(N)=4	Questionnaire (Random Sampling Method)	3
5	Recreational Centers (Ward No 3, 4, 5 & 6) Whereas, Total Number of Recreational Centers(N)=105	Questionnaire (Random Sampling Method)	43
6	Commercial Centers (Ward No 3, 4, 5 & 6) Whereas, Total Number of Commercial Centers(N)=810	Questionnaire (Random Sampling Method)	67
7	Industries (Ward No 3, 4, 5 & 6) Whereas, Total Number of Industries(N)=980	Questionnaire (Random Sampling Method)	70
8	Bank/Financial Institutes (Ward No 3, 4, 5 & 6) Whereas, Total Number of Bank/Financial Institutes(N)=37	Questionnaire (Random Sampling Method)	25

Source: Rampur municipality profile, 2076

3.5.Data Analysis

Records on the total waste generation rate, collection, disposal, and the involved cost for waste management practices are reviewed to collect data. Published Municipal profiles, unpublished municipal records, reports, and computer-recorded data were used as a major secondary source.

3.5.1. Identification of cost and benefits of alternative MSW

The CBA methodology involved identifying total benefits and costs. The costs were classified into fixed cost and variable cost, depending on whether they are incurred only once during the establishment of a project (hence establishment costs) or whether they recur even after the project is established (hence operating costs) (Msikiza, 2003). In this study, the costs of land preparation for composting, site for biogas production, machines, and equipment were classified as a fixed cost (FC), since they were incurred only once during project establishment. While the costs of various types of inputs, including labor, fuel, sorted wastes, trucks, and maintenance and repair of trucks and machines were classified as variable costs (VC) since they recur even after project establishment.

The net benefit, which indicated the improvement, was valued according to the prevailing market prices to get current money per product recovered. It was measured by subtracting total costs from total benefits (Senkondo, 1992). In comparing four options which are composting, recycling, waste to energy, and final disposal or dumping, the net benefits were compared to determine which was better. The net benefits were compared between waste to energy, recycling, composting, and final disposal, which evaluate for economic feasibility. The total benefits represented the advantages of waste to energy, recycling, composting, and final disposal, which included the direct and indirect benefits. The total benefits and costs were expressed in an Equation. (1) and (2) as follows:

$$TB = BEconomic + BSocial + BEnvironment \dots\dots\dots(Equation 1)$$

$$TC = CEconomic + CSocial + CEnvironment \dots\dots\dots(Equation 2)$$

Where:

TB denotes the total project benefits,

BEconomic represents economic benefits,

BSocial denotes social benefits

BEnvironmental denotes environmental benefits

TC represents the total cost of using resource using recycling, waste to energy, dumping and composting

C Economicseconomic costs,

C Social denotes social costs and

C Environmental representsenvironmental costs.

Net benefit can be expressed by: Eq. (3)

$$NB = TB - TC \dots\dots\dots (Equation 3)$$

The net benefits were expressed as net present value, calculated as the current value of future cost and income streams. The NPV test discounts future project CBA as follows

$$NPV = \sum_{t=0}^T B_t (1 + i)^{-t} - \sum_{t=0}^T C_t (1 + i)^{-t}$$

According to this criterion, an SWM option was considered economically efficient, if the NPV was greater than zero. Discounted nominal prices were used to determine the net present value by assuming an inflation rate of 5% per annum will continue, the time horizon for this study was 3 years under the assumption that at year 3 the benefits or outputs and cost of the management options can easily be tracked like biogas, compost manure, and recycled products. All the calculations which were made on each management option, the prices were for calculations in public investment projects.

3.5.2. Choosing the discount rate

Usually, it is difficult to estimate an exact discount rate, however, both Powers (1981) and Baum and Tolbert (1985) suggest using a real discount rate of 10% to 12% for public investment projects. Gittinger (2001) suggested a common choice to be 12% and World Bank proposed 10% to 12% as an opportunity cost of capital for Nepal. Therefore, the discounting rate used in this study was 12%.

3.5.3. Uncertainty and sensitivity analysis

A sensitivity analysis was carried out to examine the investment NPV outcomes in favorable and unfavorable directions. Since the parameter values and assumptions of any economic analysis/model are subject to change or error, sensitivity analysis was done to investigate these potential changes and errors and their impact, i.e. the difference they make to the conclusions drawn from economic analysis when there is uncertainty about their future values or what would happen to the NPV if the discount rate was increased or decreased to various levels (Msikiza, 2003).

In the case of this study, the most important parameter which is the discount rate was considered before recommending an alternative, given that this most directly impacts how the Municipality views the options. SA was analyzed by varying a discount rate at 5%, 11%, 13%, and 30%.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1.Solid Waste Management in Rampur Municipality

4.1.1. Collection and Transport of Waste

The municipality has been collecting and managing the waste from the roads and households to keep the municipality neat and clean through the municipality office branch named Public Health, Sanitation and Environment branch. The municipality workers collect waste from roads, sewers, and other public places on the daily basis from 5 am to 8 am and from 1 pm to 5 pm and transport it for final disposal. For this purpose, the municipality has mobilized 7 general workers and 2 drivers. The total amount of production of waste is about 3.3 tons per day, of which the municipality collects about 1.5-2 tons per day. The principal generators of the waste in the municipality are households, shops, and institutions respectively. The produced wastes are either stored in a basket in a home before the delivery or emptied into the public container. The street wastes are gathered at a point and collected. Despite regular sweeping, the scattered dirt could be observed in the open area of the market. The number of containers could be seen in the locations but some are found out of condition, fallen from the stand and some are overfilled in some places the containers were empty while the wastes are dumped below the containers. The date municipality is self-involve in the collection and disposal of solid waste in the municipality. Which collects waste based on the door-to-door collection system by taking some service charges as follow:

For households and general stores- NPR 150 per months

For hotels and restaurants – NPR 250 per months

For commercial organizations- NPR 350 per months

Rampur municipality provides services in 4 urban wards ie. 3, 4, 5 and 6 and collects waste in alternate days from 10am to 5pm, earlier it used to provide a dustbin but due to misuse, it does not provide now a days. About 1.5-2 ton waste is collected by municipality.

4.1.2. Disposal of waste and current situation of dumping site

Till now there is no landfill site for the management of solid waste, the waste is dumped at the side of the Kaligandaki River, ward no.6, Bittar. Which is a very sensitive area from an environmental perspective. Human settlement is also growing rapidly in the surrounding dumping site. The municipality collects the waste and dumps near the Kaligandaki Riverside ward no.6, Bittar. Though the sweeping, collection, and transportation seem satisfactory, disposal is not proper. No segregation is done before the disposal. Wastes are dumped indiscriminately, both the bio-degradable and non-bio-degradable are collected together and dumped at once.

4.1.3. Proposed landfill site

Though there is one proposed landfill site of about 1-hectare area at ward no 6, Bittar, 5 km far from the municipality office, it was in operation. A new project is going to implement for 5 years between 2023- 2028 through the fund of Rampur Municipality. This project in Rampur will consist of (i) Solid Waste Management (SWM), (ii) Auto-Village environment improvement, and (iii) community development programs.

Though the sweeping, collection, and transportation seem satisfactory, disposal is not proper. No segregation is done before the disposal. Wastes are dumped indiscriminately, and both the bio- degradable and non-biodegradable are collected together and dumped at once. The different equipments used for solid waste management are shown in the table below:

Table 10: Equipments used for SWM

S.N	Equipment	Total Nos	Remarks
01.	Tipper	01	
02	Tractor Dumper	01	
03	Tractor	01	
04	Garbage Compactor	01	
05	Sanitary Tractor	01	

Source: Rampur municipality

4.2. Results of Households Survey

4.2.1. Composition of solid waste

Organic waste dominated the overall composition of waste which was found to be 65% whereas plastic, paper, glass, rubbers, Hazardous and others were 14%, 5%, 6%, 4%, 2% and 4% respectively.

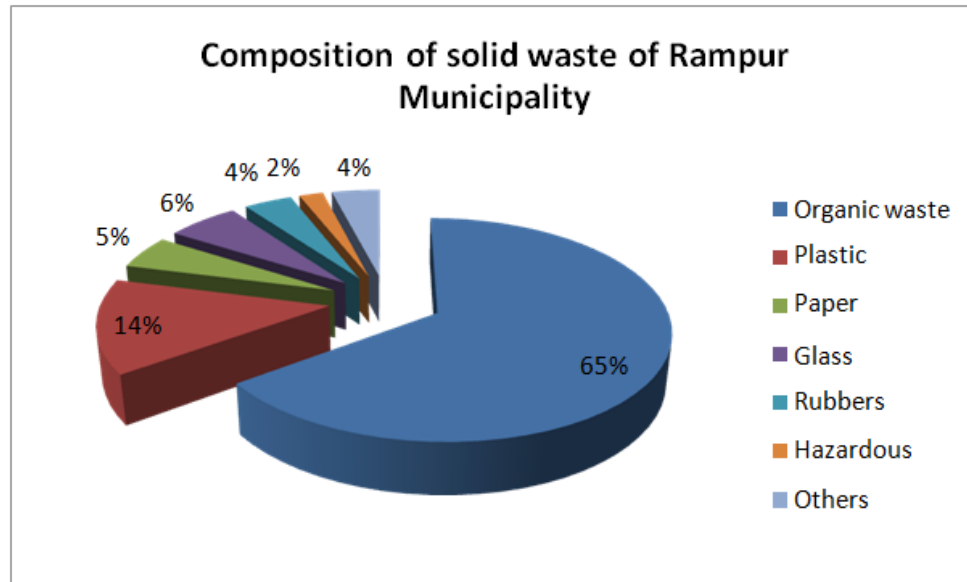


Figure 5: Composition of solid waste

4.2.2. Current SW management practices of households

75% of the respondents were found to be participated in the door to door or collection system. But some respondents which are nearby open public place or streams were not participated in collection system. Instead they throw waste such places to avoid service charge. 5% households dump or burn waste in their yard.

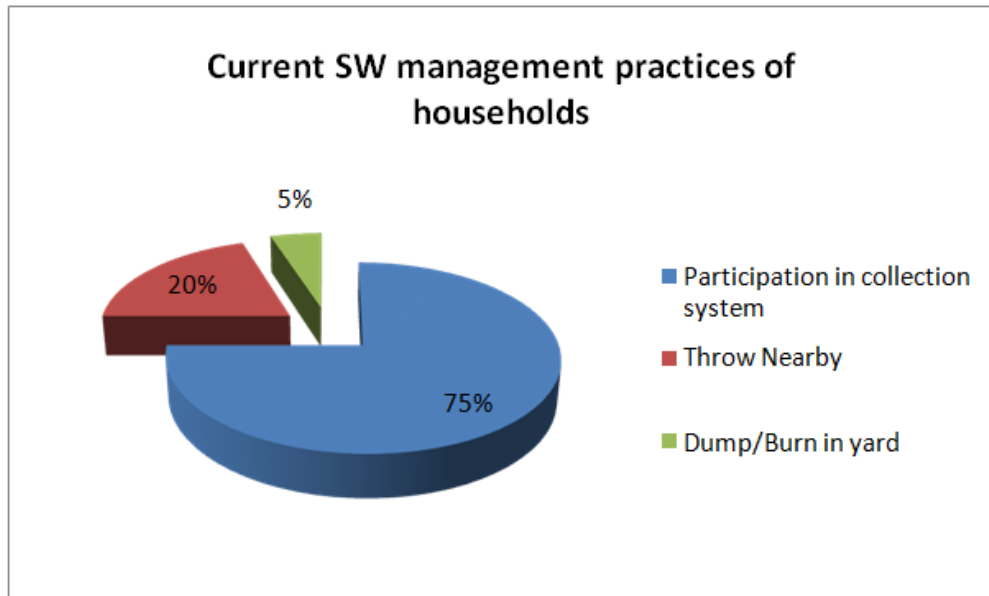


Figure 6: Current waste management practices of households

4.2.3. Public Responses on Solid waste management system

Segregation of waste

As municipality dumps all types of waste together, most of the households do not separate organic and inorganic wastes. Only 6% of the respondents segregate the waste but 94% people do not segregate the waste, they mix up all the waste. The waste from health facility centers are also found mixed with other household waste.

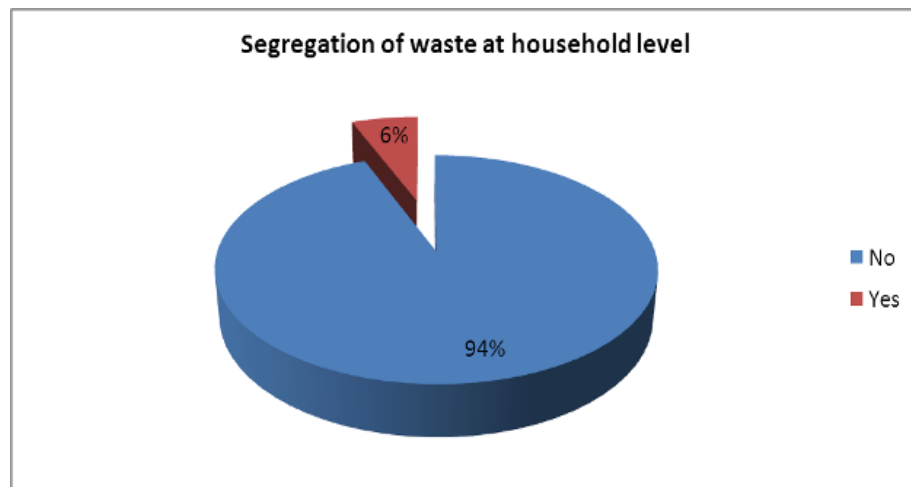


Figure 7: Segregation of waste in households

Willingness to segregate

All respondents showed positive attitude towards segregation of waste, if municipality provides them separate dustbins/containers.

Participation in training to manage the solid waste at their home

The municipality is organizing training about management of waste at household levels frequently such as composting. Only few respondents i.e 18% were found to be participated in such trainings but no one has practiced this at home. Most of the respondent i.e 55% said that they have not been informed yet about such trainings. 27% said that they were informed but did not participate.



Figure 8: No of household involvement in waste management training

Public satisfaction on waste management service of Municipality

Only 14% respondents were found to be satisfied with the current management system of solidwaste. Most of the respondents were not satisfied as they complained that:

- Door to door collectors do not collect regularly
- Waste and dirt from the sewer is not removed so they produce bad smell.
- Container is not placed so they throw waste along road side
- Workers do not collect the scattered things

- Waste should not be dumped near the Kaligandaki River

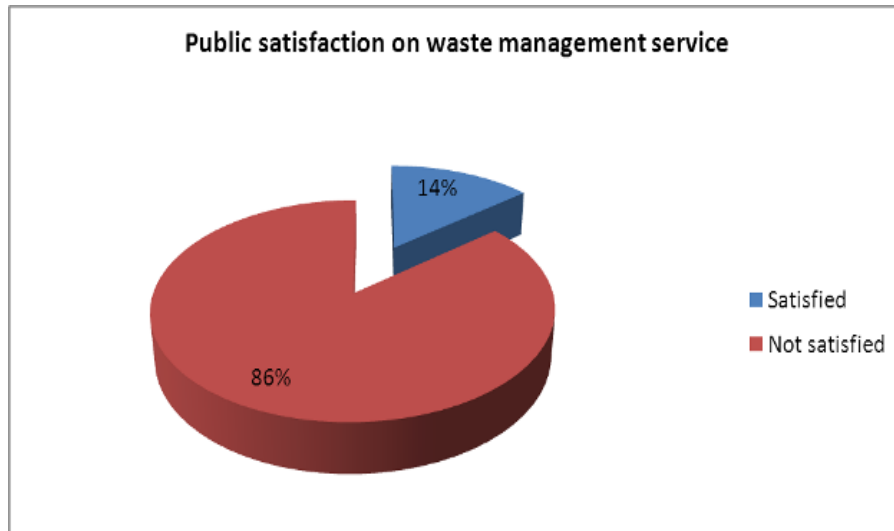


Figure 9: Public satisfaction on waste management service

Willingness to pay for better management

62% of the respondents showed their desire to pay for the better management of waste, but most of them emphasized in improvement in the landscape, such as gardening and greenery of the city. 38% of the respondent thinks it as the sole responsibility of municipality and do not want any more financial burden. Most of the respondents showed their positive attitude towards pay more if municipality collects waste daily.

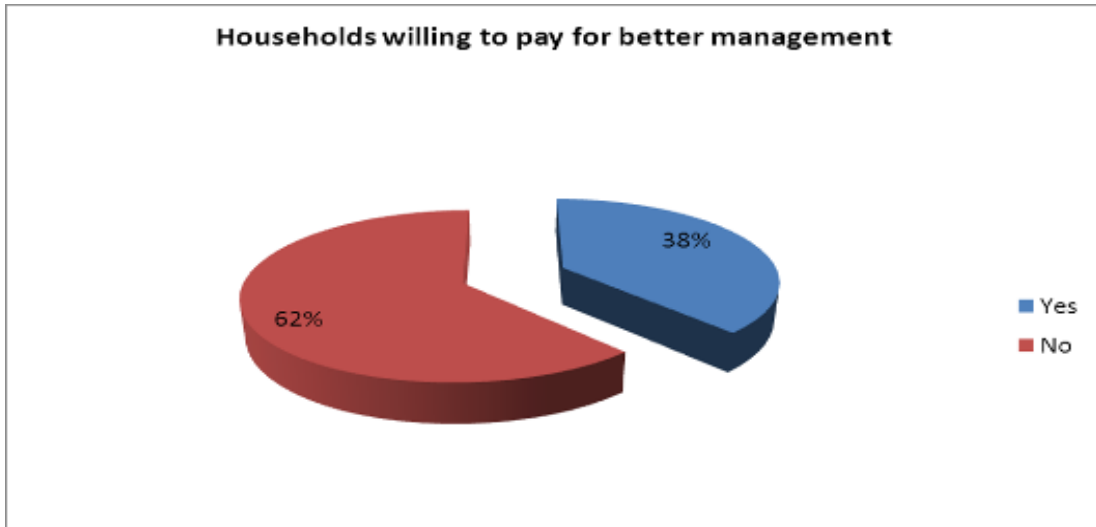


Figure 10: Willingness to pay for better management

4.3.Results of Social Infrastructure Survey

A survey has been conducted with a group of technical team from Rampur Municipality representatives in various social infrastructure sectors like: Educational Centres, Health Centres, Recreational Centres, Commercial Centres, Industries Centres and Bank and Financial Institutes in ward no. 3, 4, 5 & 6. Based on this survey, data are received as below. Where, the total population is 19,353 and households are 4017, these data's are received from the source of Rampur municipality profile, 2076.

Educational Centres

While questioning with 19 key persons in educational centres, it is found that 1 tractor is used for waste collection from all educational centres and are dispatched to disposal zone. Where, volume of the tractor is 2.5 cubic meter and weight of waste collection is around 210kg from all educational centres.

Health centres

While questioning with 3 key persons in health centres, it is found that 1 tractor is used for waste collection from all health centres and are dispatched to disposal zone. Where, volume of the tractor is 2.5 cubic meter and weight of waste collection is around 125kg from all health centres.

Recreational Centers

While questioning with 43 key persons in recreational centres, it is found that 2 tractor is used for waste collection from all recreational centres and are dispatch to disposal zone. Where, volume of the tractor is 2.5 cubic meter and weight of waste collection is around 275kg from all recreational centres.

Commercial Centers

While questioning with 67 key persons in commercial centres, it is found that 2 tractor is used for waste collection from all commercial centres and are dispatch to disposal zone. Where, volume of the tractor is 2.5 cubic meter and weight of waste collection is around 295kg from all commercial centres.

Industries

While questioning with 70 key persons in industries, it is found that 2 tractor is used in each dayfor waste collection from all industries and are dispatch to disposal zone. Where, volume of the tractor is 2.5 cubic meter and weight of waste collection is around 315kg in each day from all industries.

Bank/Financial Institutes

While questioning with 25 key persons in Bank/Financial Institutes, it is found that 1 tractor is used for waste collection from all Bank/Financial Institutes and are dispatch to disposal zone. Where, volume of the tractor is 2.5 cubic meter and weight of waste collection is around 55kg from all Bank/Financial Institutes.

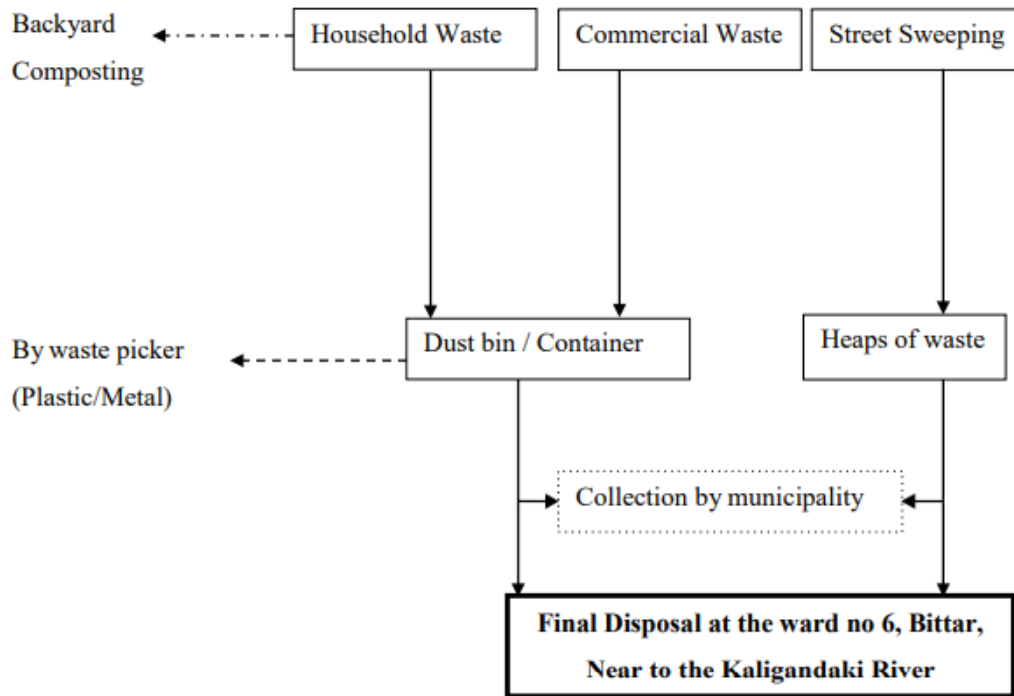
At the end, we find out the solid waste composition by percentage and per capita waste as mentioned below:

Table 11: Results of social infrastructure survey

S.No.	Participants	Methods	No. of participants	Waste composition in %			Per Capita Waste(Kg/ Person/day)
				Organic	In-organic	Hazardious and other	
1	<p>Educational Centers:</p> <p>In ward number 3, 4, 5 & 6, Total Number of Educational Centers(N)=26</p> <p>Waste per day=210kg</p>	Questionnaire (Random Sampling Method)	19	72%	25%	3%	0.011
2	<p>Health Centers;</p> <p>In ward number 3, 4, 5 & 6, Total Number of Health Centers(N)=4</p> <p>Waste per day=125kg</p>	Questionnaire (Random Sampling Method)	3	33%	60%	7%	0.006
3	<p>Recreational Centers:</p> <p>1. In ward number 3, 4, 5 & 6, Total Number of Recreational Centers(N)=105</p> <p>2. Waste per day=275kg</p>	Questionnaire (Random Sampling Method)	43	55%	48%	3%	0.014

4	Commercial Centers: In ward number 3, 4, 5 & 6, Total Number of Commercial Centers(N)=810 Waste per day=295kg	Questionnaire (Random Sampling Method)	67	35%	60%	5%	0.015
5	Industries: In ward number 3, 4, 5 & 6, Total Number of Industries(N)=980 Waste per day=315kg	Questionnaire (Random Sampling Method)	70	30%	62%	8%	0.016
6	Bank/Financial Institutes: In ward number 3, 4, 5 & 6, Total Number of Bank/Financial Institutes(N)=37 Waste per day=55kg	Questionnaire (Random Sampling Method)	25	70%	25%	5%	0.003

Current Waste Management Stream in Rampur Municipality



The waste from the household is collected through door to door collection method and through the containers; other wastes especially from market and roadside are collected through sweeping. All the collected waste is being dumped near to the Kaligandaki River. Scattered settlement can be seen surrounding to the dumping site. No prior segregation of waste is practiced.

4.4.GHG Emission from the Mix MSW Landfilling/open dumping

Total in-organic waste generation in Rampur municipality was around 1500kg per day, where the collected MSW was shifted near to the Kaligandaki river side at Bittar-06, 5Km far from the Rampur municipality office. During the survey, it was found that 65% of organic waste, Plastic 14%, Paper 5%, Rubber 4%, Glass 6%, Hazardous waste 2% and Others around 4% of waste generates in the municipality.

Calculation of GHG Emission

- Total mix waste landfilling= 45 tons/month
- Amount of diesel fuel use for operation of machineries =1100L/month
- Type of landfill = Unmanaged-shallow(<5m waste) Composition of landfilling waste

Table 12: Composition of MSW

Components	Percentage (%)
Organic waste	65
Plastics	14
Paper	5
Rubber	4
Glass	6
Hazardous waste	2
Others	4
Total	100

Result

Emission of Methane (CH₄) from landfilling= 15.67 kg of CH₄/tons

Direct GHG emission from Landfilling= 394.97 kg of CO₂-eq/tons of mix waste

Total GHG emission from landfilling per month= 17773.52 kg of CO₂- eq/month

As a result, Emission of Methane (CH₄) from landfilling is 15.67 kg of CH₄/tons, Direct GHG emission from the mixed waste landfilling/open dumping is found to be 394.97 kg of CO₂-eq/tons of mix waste and the total GHG emission from landfilling per month is 17773.52 kg of CO₂-eq/month using the pre-formulate excel sheet by IGES (Institute for Global Environmental Strategies). Detail calculations can be found in Appendix 5 and 6.

4.4.1. Conceptual Design of Engineered Landfill

Keeping in mind the availability of land and capital cost, the construction scientific landfill is proposed for keeping the waste for the next 10 years. The total volume of inert/non-bio degradable rejects from the processing Plant (assuming 15% maximum of feed) for disposal to landfill, assuming density as 0.85 tons per cubic meter for the duration 2022–2031 is 1376.47 cubic-meter. Considering, 30% volume of soil cover, linear and bund, and 5-meter height of the landfill. Therefore, in the first year, design for the Engineered landfill is done for the first 10 years for the square meter of 275.3, Hence the size of the Engineered landfill is 14-meter x 22-meter. Design can found in Appendix 1.

Table 13: Design parameters of landfill

DESIGN OF LANDFILL			
Waste Volume required for landfill for ten years (2022-2031)	Cum	=	1058.82
Volume of Soil cover, Linear and Bund	30%	=	317.65
Total Landfill Volume	Cum	=	1376.47
Height of the Landfill	M	=	5
Area of Landfill	Sq m	=	275.3

Basic data

- Location: Rampur, Municipality
- Max. Waste Generation: 1.5 tons per day
- Design Life: Active Period = 10 years
- Topography: Flat ground

- Average annual Rainfall: 477.26 mm

Now,

- Average Current Waste Generation Per Day = 1.5 Ton
- Average Current Waste Generation Per Year = 550 Ton
- Estimated Average Waste Generation After 10 Years = $W (1 + x)^n$ Ton
= 900.00 Ton

- Total volume of waste (considered density 0.85 t/cu.m.)

$$V_w = (900.00)/0.85$$

$$= 1058.82 \text{ cu.m.}$$

- Volume of Soil cover, Linear and Bund (assumed 30% of volume of bund)

$$V_t = 1058.82 + 1058.82 \times 30\%$$

$$= 1058.82 + 317.65 \text{ cu.m.}$$

$$= 1376.47 \text{ cu.m.}$$

- Likely Shape of Landfill
- Rectangular in plan (length: width = 1:1.5)
- Primarily above ground level, partly below ground level.
- Area Restrictions: Nil
- Possible Maximum Landfill Height = 5 m
- Area Required = $(1376.47)/5$

$$= 275.3 \text{ square meters}$$

- **Required Dimensions = 14 m x 22 m**

4.4.2. Leachate Evaluation

Considering 477.26 millimeters per year average total precipitation in the City and 80% rainfall in four months, the leachate quantity is 2.39 cubic meters per day. A rainy season for continuous 3 days with no evaporation due to sunlight is assumed. Therefore, the area

required for a leachate tank that can hold the quantity of leachate for 3 days is 7.17 cubic meters. A 2.0-meter depth of leachate tank and 30-centimeter freeboard is provided. Hence the size of the leachate tank is 2 x 2 x 2.3 cubic meters.

4.4.3. Detailed Cost Estimation

The estimated cost of proposed Engineered Landfill of 14-meter x 22 meter and the cost of proposed Leachate collection tank of 2-meter x 2-meter x 2.3-meter is around NRs. 1-1.5 crore Rupees.

Table 14: Location Selection and Characterization Expense

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Data Finding	0.6-0.9
2	Environmental Impact Assessment	0.5-1.0
3	Preliminary Bore Holes	0.15-0.25
4	Geo-technical and Ground Water Investigation	0.8-1.2
5	Topographical Investigation	0.15-0.25
6	Hydrological Investigation	0.25-0.35
7	Geological Investigation	0.25-0.35
8	Traffic Investigation	0.3-0.5
9	Water and Leachate Investigation	0.25-0.5
	Total	3-4.95
	Average	3.97

Table 15: Detailed Engineering Design Expense

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Detailed Engineering Design	1.5-2.50
	Average	2.00

Table 16: Construction expense

S. N.	Parameters	Amount (NRs 10 ⁵)	Amount (NRs 10 ⁵)
1	Land Purchase*	100.00	
2	Expense on infrastructures		15.00
3	Landfill Construction and Operation Equipment **	50.00	
4	Drainage System		3.50
5	Leachate Management system		3.00
6	Environmental Monitoring		1.00
7	Gas Collection system		4.00
	Total	150.00	26.5

* Land acquisition cost and equipment cost are not considered; because these are vary with respect to market and location.

Table 17: Yearly construction expenses

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Modified design	0.50
2	Initial setups	14.00
3	Short term surface water drain	0.10
4	Below Liner checkup periodically	0.25
5	Liner Setup	9.89
6	Leachate management	2.00
7	Maintenance of accessories	5.00
	Total	31.74

Table 18: Yearly operation expenses

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Solid Waste Filling and Compaction	20.00
2	Daily Compaction and Cover laying	2.00
3	Pollution monitoring	0.50
	Total	22.50

Table 19: Yearly closure expenses

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Cover laying final System	15.00
2	Drainage of surface water system on Cover	1.00
3	Facility of monitoring on Cover	0.15
4	Plantation on Cover	1.00
	Total	17.15

Table 20: Yearly Post closure care expenses

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Plantation for long term	2.00
2	Leachate management system operation	1.00
3	Cover and drainage system maintenance	1.50
4	Environmental Monitoring	0.40
	Total	4.9

Table 21: Preliminary fixed expenses

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Location Selection and Characterization Expense (Table 14) Average	3-4.95 3.97
2	Detailed Engineering Design Expense (Table 15)Average	1.5-2.50 2.00

3	Construction expense (Table 16)	26.5
	Total	32.47

Table 22: Active running expenses (Yearly)

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Yearly construction expenses (Table 17)	51.85
2	Yearly operation expenses (Table 18)	22.50
3	Yearly closure expenses (Table 19)	17.15
	Total	91.5

Table 23: Post Closure running expenses (Yearly)

S. N.	Parameters	Amount (NRs 10 ⁵)
1	Yearly Post closure care expenses (Table 20)	4.9
	Total	4.9

4.5.Comparative analysis of amount of waste generation with some other municipalities

Among the six major municipalities of Nepal namely Kathmandu, Pokhara, Butwal, Tansen, Rampur and Waling, Kathmandu is the highest waste generator i.e 466.14 ton/day whereas others have 117.11, 27.12, 11.84, 3.3 and 5.51 ton/day respectively.

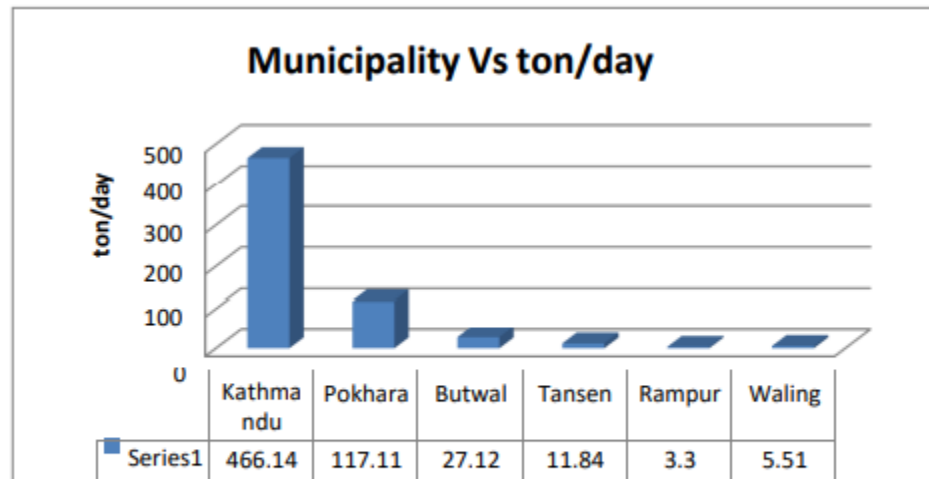


Figure 11:Comparison of solid waste generation of Rampur with other major Municipalities Source: Asian Development Bank Report, 2012

Similarly Kathmandu has highest per capita waste generation i.e 0.46kg/person/day. Whereas, Pokhara, Butwal, Tansen, Rampur and Waling have 0.44, 0.22, 0.38, 0.078 and 0.23kg/person/day respectively.

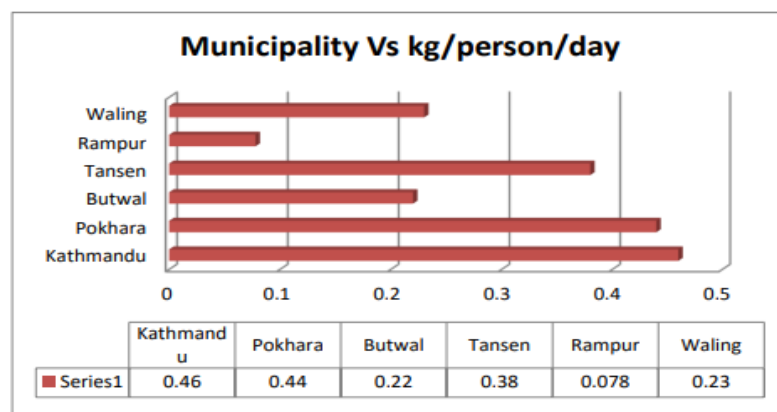


Figure 12: Comparison of per capita solid waste generation of Rampur with other major Municipalities, Source:Asian Development Bank Report, 2012

4.6. Policy Intervention at Rampur municipality

Though Nepal Government has given authority to manage the waste to the local government, Rampur municipality has no specific plan or policy to manage the waste properly. The waste is collected and buried without segregating it. By doing so it is not only burying the waste but the valuable resource too in the form of waste. The municipality increases the budget as the volume of waste increases but has not still invested to educate or train the public for its reduction. Instead of increasing the budget along with the volume of waste, the policy must shift towards 3Rs. Proper training for segregation, reduction at source, and utilization should be delivered to the public. The organic portion of waste claims 65% i.e 2.1 tons, that can be composted and used as manure. Paper occupies 5% which becomes 1.5 quintals, plastics, glass, and rubbers reserve 14%, 6%, and 4%, i.e. 4.5q, 2q, and 1.5q respectively (Based on 2078/79 data from Rampur Municipality). A huge portion of organic waste can serve as a good source of manure for agriculture. A certain portion of paper and metals can be recycled. The paper can be used for the replacement of cooking fuel to some extent by making Paper Briquettes. By providing training to the public on composting, Rampur municipality not only reduces the volume of waste but the management cost for SW and the cost of chemical fertilizer for a farmer as well. If segregation at source, composting and resource recovery is practiced, Rampur municipality can reduce the waste by more than 65% of today. It also generates employment opportunities for the locals.

The policy should be directed towards the Clean Development Mechanism, and short-term and long-term policies should be made. In long run, instead of making separate landfill, an integrated waste management system should be developed along with other neighboring municipalities and other commercial centers. For this Rampur, a municipality can cooperate with Tansen municipality which is about 55 km far from Rampur and also faces the same problems of waste management. Most of the developed part of the world has already shifted to this policy.

4.7. Challenges, Problems and Issues

The major challenge of Rampur municipality is to keep providing sanitation services including solid waste management, for the rapidly growing population by maximizing the utilization of limited resources. The amount of hazardous waste is also increasing with the establishment of new hospitals and other health care centers. Proper management of increasing hazardous waste is another emerging challenge. The major problems linked with waste management are categorized as follow:

Financial Problems: According to the municipality, it spends about 15 million on waste management which is about 1.81% of its total annual budget. This amount is too low for the overall management of waste. Moreover, Rampur municipality has to depend more on local resources for its income so the municipality able to manage the solid waste properly.

Equip-mental problems: Equipment such as rickshaws and containers are not in adequate number and condition.

Lack of landfill location: Although construction of landfill location is proposed in Rampur municipality, nobody can say how long it will take to come into operation. The current dumping site, situated near the bank of Kaligandaki River, is almost filled up so the municipality is seeking another dumping site which is a very sensitive issue.

Lack of adequate human resources: Nobody wants to involve in waste management-related work as it is a dirty job. So the municipality has to provide more salaries to the workers, although the municipality is lacking adequate no of workers.

Lack of awareness: The current waste management problem can be solved to some extent by conducting awareness programs in the municipality. But due to a lack of funds and other technical problems, the municipality is not able to organize awareness programs frequently.

4.8. Effectiveness of municipality in waste collection

The municipality has been collecting and managing the waste from the roads and households to keep the municipality neat and clean through the municipality office branch named Public Health, Sanitation and Environment branch. The municipality workers collect waste from roads, sewers, and other public places on the daily basis from 5 am to 8 am and from 1 pm to 5 pm and transport it for final disposal. For this purpose, the municipality has mobilized 7 general workers and 2 drivers.

The total amount of production of waste is about 3-3.5 tons per day, of which the municipality collects about 1-1.5 tons/day. The principal generators of waste are households, shops, and institutions respectively. The produced wastes are either stored in a basket in the home before the delivery or emptied into a public container. The street wastes are gathered at a point and collected.

The municipality is self-involved in the collection and disposal of solid waste in the municipality. Which collects waste on the basis of the door to door collection system by taking some service charges?

Frame-work of sustainable SWM Plan for Rampur municipality

This suggested SWM plan gives in details of MSW management from sources to the end of disposal for a sustainable SWM plan in Rampur Municipality

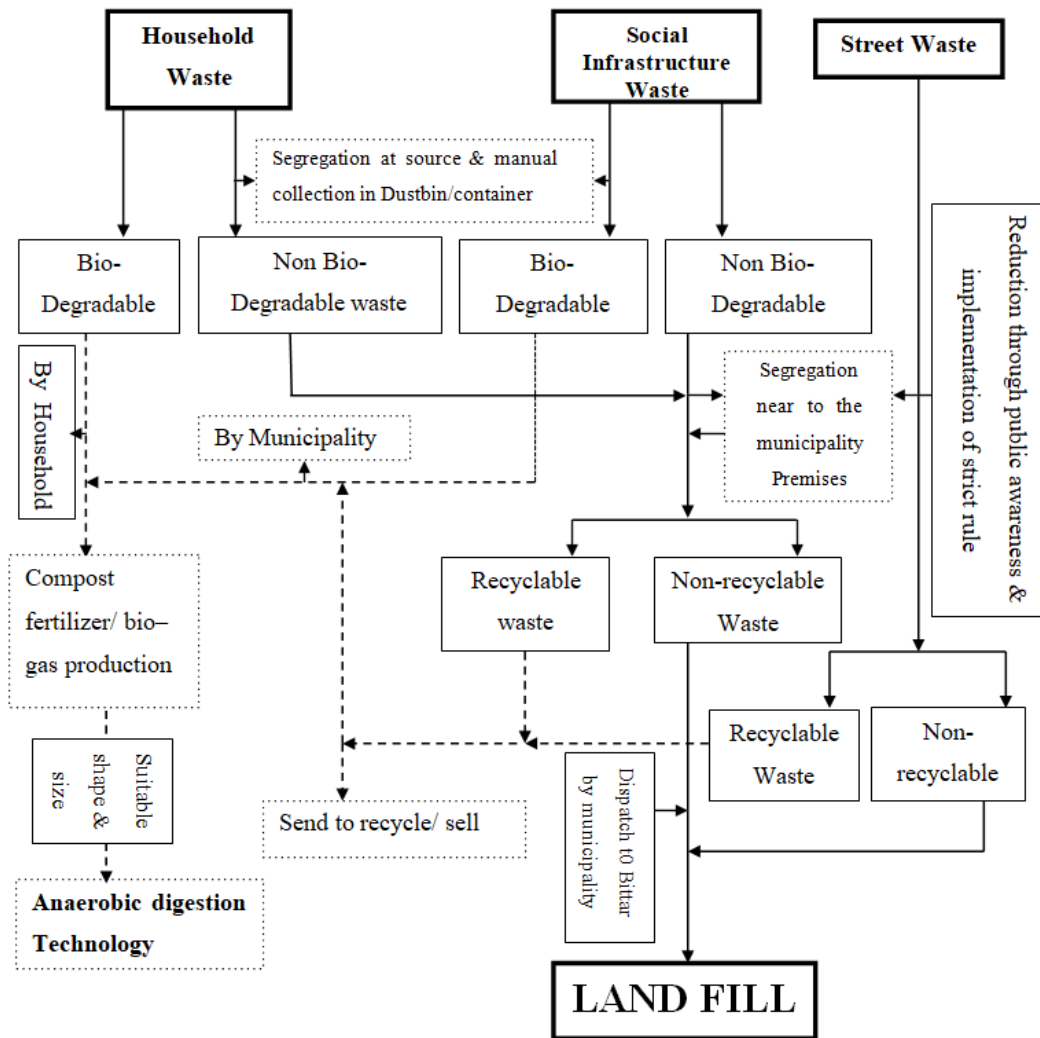


Figure 13: Suggested sustainable SWM Plan for Rampur municipality

Note: Social Infrastructure waste consists of Educational waste, Health waste, Recreational waste, Commercial waste, Industries waste and Bank/Financial Institutions waste.

4.9.Factors of municipal wastes generation

Population growth, rural and concrete development, style modifications and therefore the resulting change in unit consumption patterns have created issues in trendy societies. The modification of unit consumption pattern has modified the waste volume and therefore the waste characteristics or composition.

Following factors affect Municipal Solid Waste Generation Rates

Source reduction

The waste reduction might occur through the planning, manufacture, and packaging of merchandise with minimum deadly content, the minimum volume of fabric, and longer helpful life. Example: Improve product style to use less material. Supply reduction is that the most popular approach.

Reuse

Reusing product over and once more reduces the waste generation. Example: mistreatment reversible batteries, reusable food containers, reusable glass rather than throwaway water bottles, etc.

Recycling

Recycling is collection materials which will be weakened and reprocessed to manufacture new things. Example: unit employment merchandise area unit - Paper merchandise, Glass, Aluminium, Steel and a few plastics.

Effect of public attitudes and legislation on waste generation

Public Attitudes - vital reduction within the quantities of solid wastes generated occur once and if folks area unit willing to alter of their own volition- their habits and lifestyles to conserve natural resources and to scale back the economic burdens related to the management of solid wastes.

Legislation maybe the foremost vital issue touching the generation of an exact sort of wastes is that the existence of native, state, and federal laws regarding the employment of specific materials.

Effect of Geographic and physical factors on waste generation

Geographic and physical factors that affect the quantities of waste generated and collected include:

- Geographical location: related primarily to the different climate that can influence both the amount generated and collection operation
- Season of the year
- Frequency of collection
- Characteristics of population
- Extent of salvage and recycling
- Legislation
- Public attitude

4.9.1. Socio Economic Characteristics of the Respondents

Socio economic and cultural status of the respondents play significant role to produce solid waste and its management. So, in this sub section it analyses the socio economic status of the respondents such as sex, caste, education etc.

Respondents by Caste/Ethnicity

In Rampur municipality there are diverse caste and ethnic people. The following table shows the caste/ethnicity details. (Source: Rampur Municipality Profile, 2076)

Table: 24 Respondents by Caste/Ethnicity

Castes/ethnicity	No.	Percentage
Magar	17	22.67
Brahmin	14	18.67
Kami	5	6.67
Damai	4	5.33
Newar	5	6.67
Sharki	6	8.00
Chhetri	4	5.33
Thakuri	9	12.00
Kumal	8	10.67
Other	3	4.00
Total	75	100

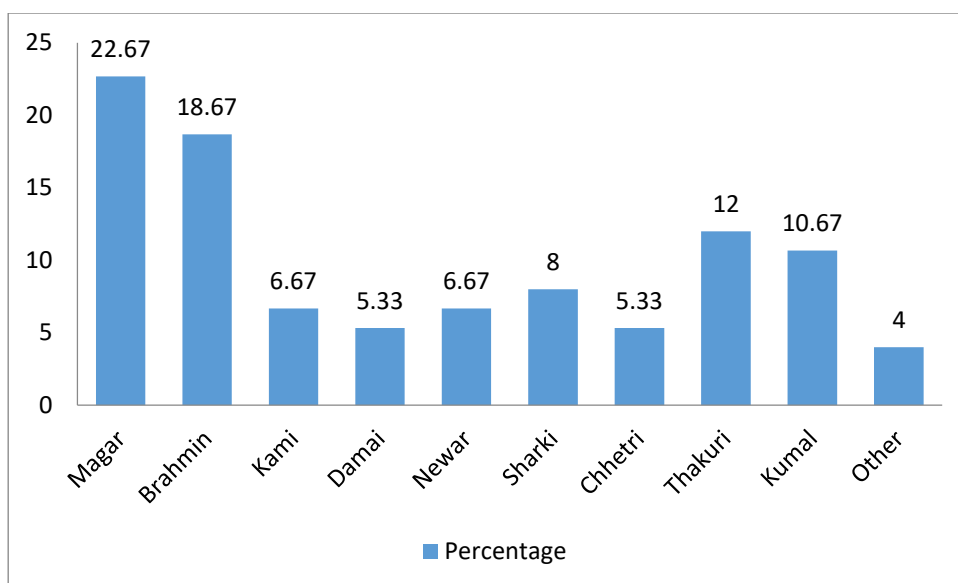


Figure 14: Respondents by Caste\ Ethnicity

Above table and figure show 22.67 % of total are Magar, 18.67% Brahmin, 6.67% Kami, 5.33% Damai, 6.67% Newar, 8% Sharki, 5.33% Chhetri, 12% Thakuri, 10.67% Kumal and next 4% others.

Age Distribution

The age structure over the total respondents of the study area is analyzed in the below table. (Source: Rampur Municipality Profile, 2076)

Table 25: Distribution of Respondents by Age

Age Group	No of Respondents	Percentage
15-20	4	5.33
21-25	14	18.67
26-30	15	20.00
31-35	15	20.00
36-40	9	12.00
41-45	8	10.67
46-50	5	6.67
51-55	5	6.67
Total	75	100

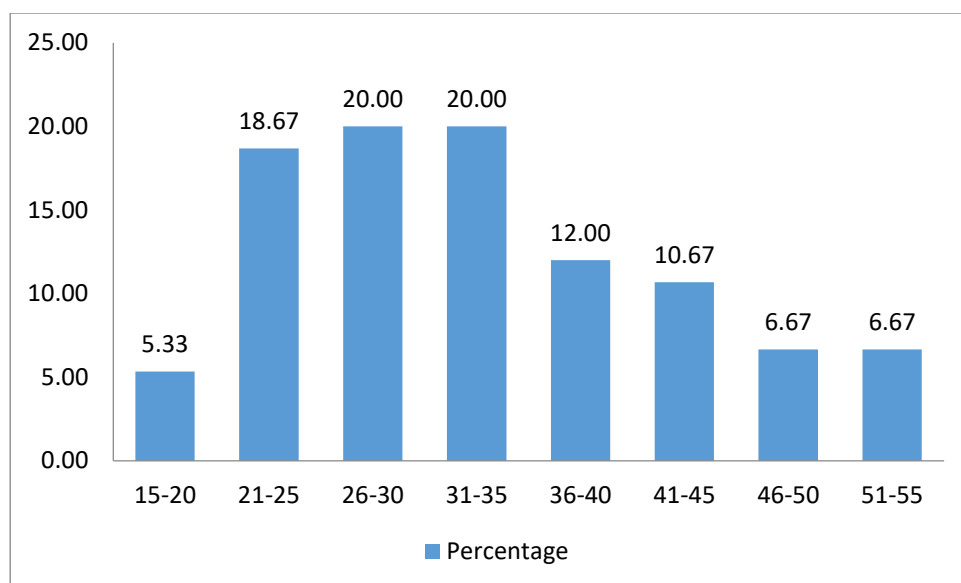


Figure 15: Distribution of Respondents by Age

The table and figure show that most of the members are adult. Out of the total there are 58 percentages is 21-35 age group. More than 50 years are only 6 percentages of the total. It is found that the of age 21-35 are more active in income generating activities, because they are more responsible to their family's economic betterment.

Respondents by gender

Both genders (male and female) are participated in the personal interview. The following table shows the sex composition of response.

Table 26: Distribution of the Response by Gender

Sex	No of Respondents	Percentage
Males	39	52
Females	36	48
Total	75	100

Source: Field Survey, 2022

Above table and figure indicate the sex composition of the respondents. Data shows that 52% respondents are males and 48% respondents are females.

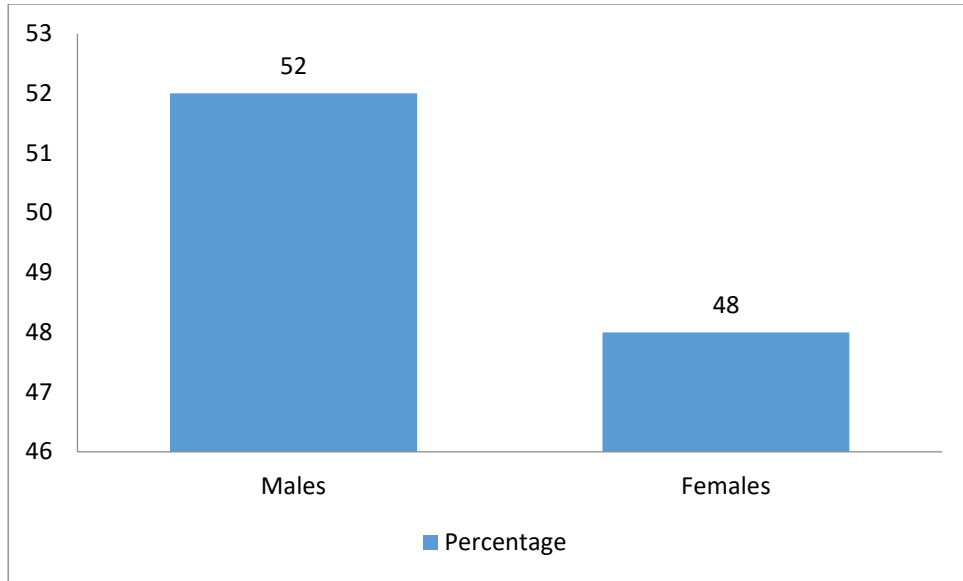


Figure 16: Distribution of the Response by Gender

Marital Status

The marital status over the sample respondents in the study area is analyzed in the table.

Table 27: Distributions of Respondents by Marital Status

Marital Status	No of Respondents	Percentage
Married	53	70.67
Unmarried	14	18.67
Widow	8	10.66
Total	75	100

Source: Field Survey, 2022

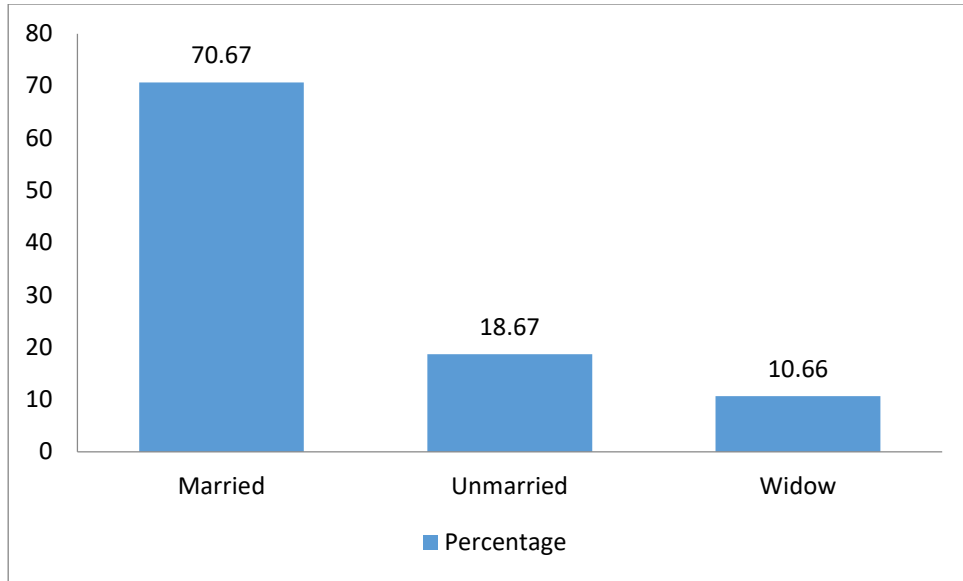


Figure 17: Distributions of Respondents by Marital Status

The table and figure show that most of the members are married. Of the total sample member there are 70.67 percentage are married among them 10.66 percentage are widow. Only 18.67 percentage of are unmarried.

Distribution of Respondents Religion

Respondents' have different social composition of various religions. There is diversity of religion, among them Hindu, Buddhist, Christian, and Muslim are available. The percentage of various religions is shown in the table below.

Table 28: Distributions of Respondents by Religion

Religion	No of Respondents	Percentage
Hindu	60	80
Buddhist	3	4
Christian	7	9.33
Muslim	5	6.67
Total	75	100

Source: Field Survey, 2022

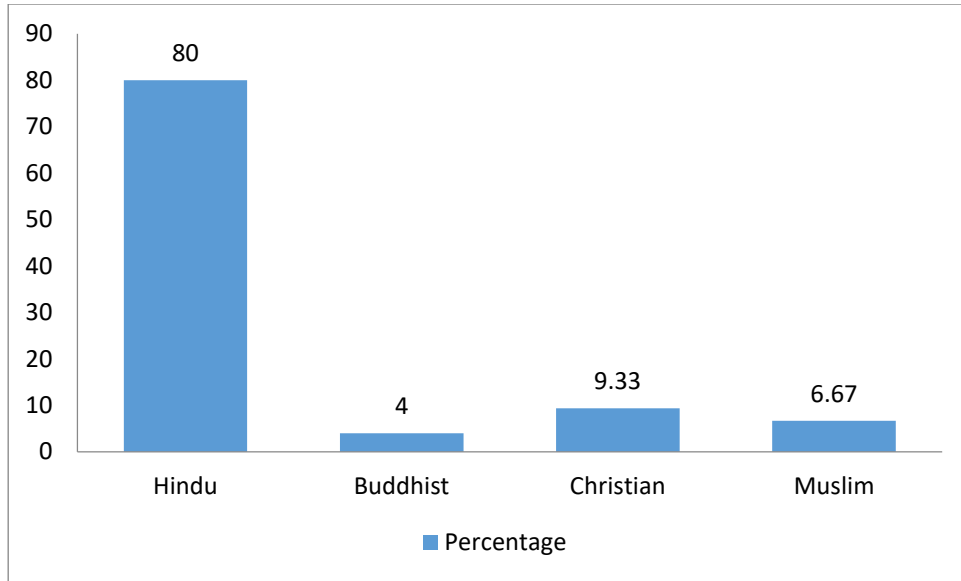


Figure 18: Distribution of Respondents by Religion

The table and figure show that Hindu is the highest among the others which is 80 percentage, similarly, Buddhist are 4 percentage, Christian are 9.33 percentage and Muslims are only 6.67 percentage. This table shows that multi religious people live in the study area.

Distribution of Respondents by Education

Education is one of the major factors for social as well as economic development. It affects all sectors of the society. The educational status of the borrowers is shown table below.

Table 29: Distributions of Respondents by Education

Educational Status	No of Respondents	Percentage
Literate	30	40
Secondary	20	26.67
+2 and Above	25	33.33
Total	75	100

Source: Field Survey, 2022

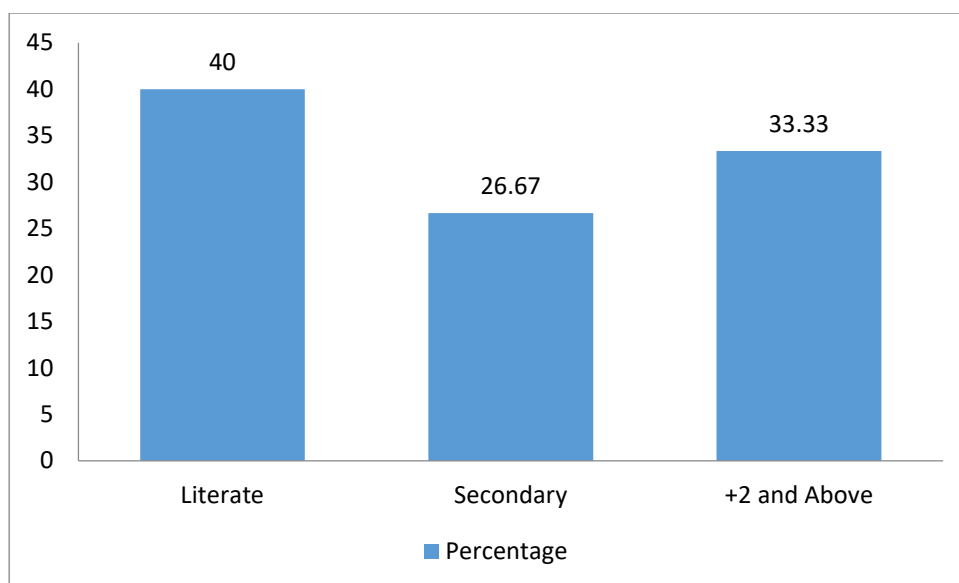


Figure 19: Distributions of Respondents by Education

Above table and figure shows the education status of the respondents'. It is found that 40% are literate and 26.67% passed secondary level and 33.33% passed +2 above.

Respondents by Family Size

The size of a family is determined by the number of the family members in the household. This shows that the size of a family determines the women's awareness about having children. The following table shows the family size of the borrowers.

Table 30: Respondents by Family Size

Family Size	No of Household	Percentage
Small (up to 4)	21	28
Medium (5 & 6)	45	62
Large (above 6)	9	10
Total	75	100

Source: Field Survey, 2022

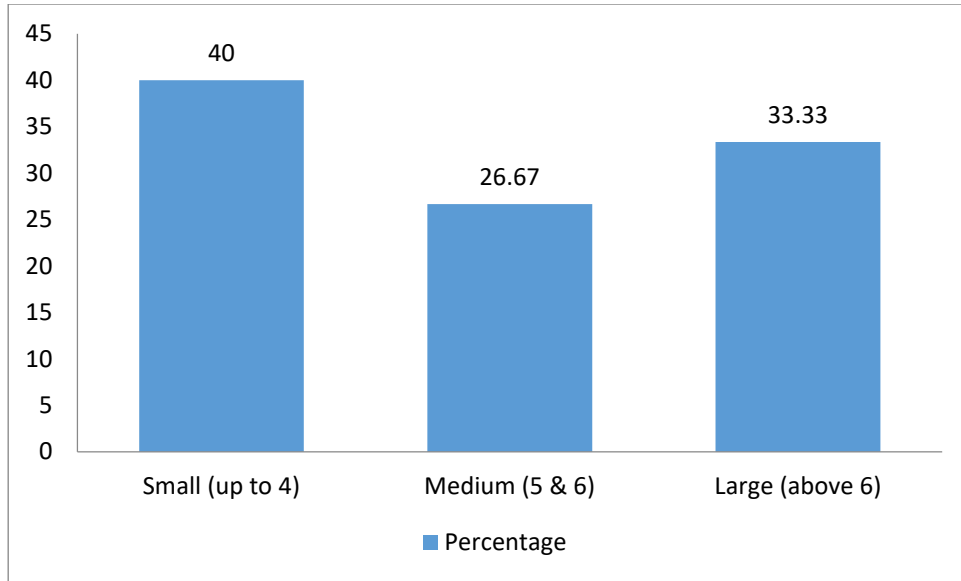


Figure 20: Respondents by Family Size

Out of the total survey, 60 percentages has medium size of family (5 & 6) and 28 percentages of has small size family (up to 4). It has been noted that there is only 12 percentage who have large size (above 6) family.

Occupation of the Respondents

In my study are there have been living people with different occupation. The following table highlights the caste composition of the respondents.

Table 31: Distribution of the Respondents by Occupation

Occupations	No of Respondents	Percentage
Business	25	33.33
Farming	35	46.67
Service	10	13.33
Others	5	6.67
Total	75	100

Source: Field Survey 2022

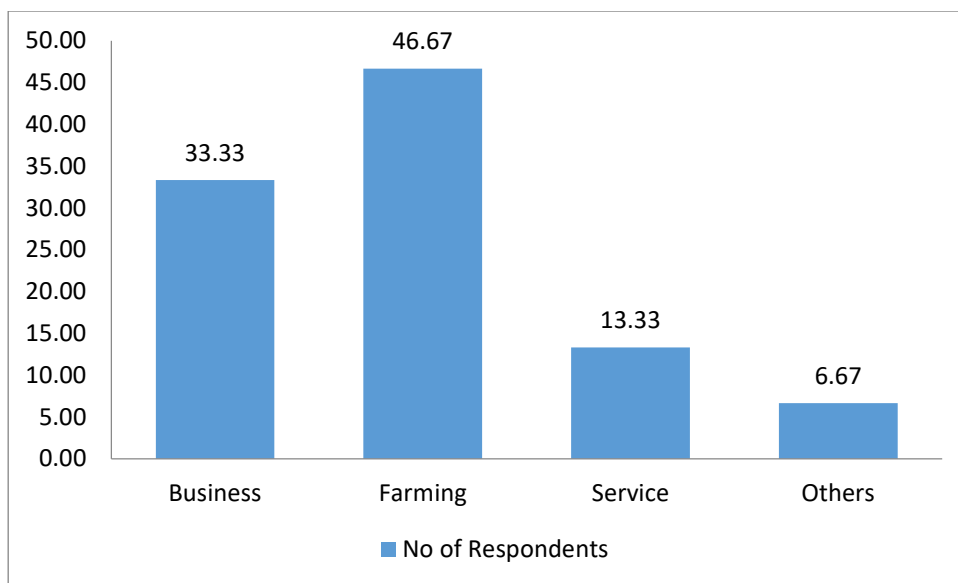


Figure 21: Distribution of the Respondents by Occupation

Above table and figure show the occupation status of the respondents. Data shows that 33.33% of the respondents are involving in business and 46.67% are farmer. In the same way, 13.33% involved in service and 6.67% follow the other occupations like foreign job, labor etc.

Respondents having Knowledge about Solid Waste Management

In the study area different types of people have been living. Some people have not concrete idea about the solid waste. The following table indicates the situation of respondents by having knowledge about solid waste.

Table 32: Respondents' Having Knowledge about Solid Waste Management

Knowledge	No of Respondents	Percentage
Yes	66	88
No	9	12
Total	75	100

Source: Field Survey, 2022

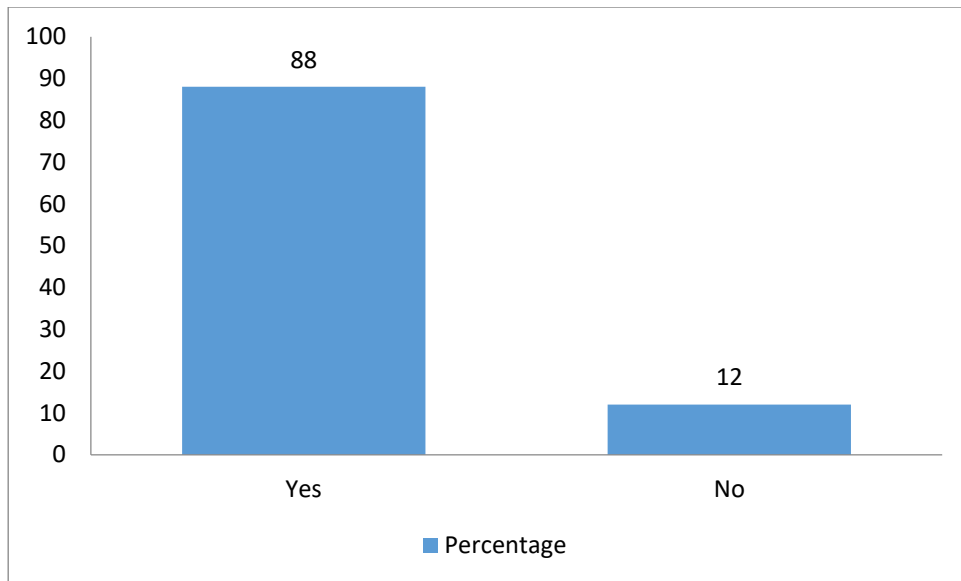


Figure 22: Respondents' having Knowledge about Solid Waste Management

Above table and figure show the situation of the respondents by having knowledge about sold waste management. Data shows that only 88% respondents have knowledge about solid waste management and rest of 12% have no idea about sold waste management. So, it needs to give training about solid waste management.

4.9.2. Solid waste Management in Rampur Municipality

In Rampur Municipality, people have individual dumping setup in their household/commercial waste within the evening and morning into permanent community bins or mobile garbage provided by the municipality. Garbage untidy outside area unit collected by Municipality and deposited into these bins. In bazaar space, the municipality has distributed 2 varieties of bins and is given below: -

(a) Green Color Dustbin

The green color dustbin is for the wet waste such as organic waste.

(b) Blue Color Dustbin

The blue color dustbin is for dry waste like paper, plastic, rags, metal and other inorganic waste.

Every day within the morning the waste assortment vehicles come back for waste assortment with bell system or ringing bell. The collected wastes area unit loaded on the vehicle by Municipality workplace. The wastes assortment vehicles build a spherical of all the streets for waste assortment. Waste assortment from core space

may be a difficult and hard job. There's no door to door assortment system in Study space. Therefore, household's area unit requested to dump solid waste on margin community bins.

Place of Dumping Household Waste by the Respondents

In this study space folks dump solid waste in several places. The subsequent table shows the place wherever folks sometimes dump the solid waste that turn out from their home.

Table 33: Place of Dumping Household Waste by the Respondents

Places	No of Respondents	Percentage
Container	18	24
Open space	12	16
Backyard	15	20
Roadway	25	33
Others	5	7
Total	75	100

Source: Field Survey, 2022

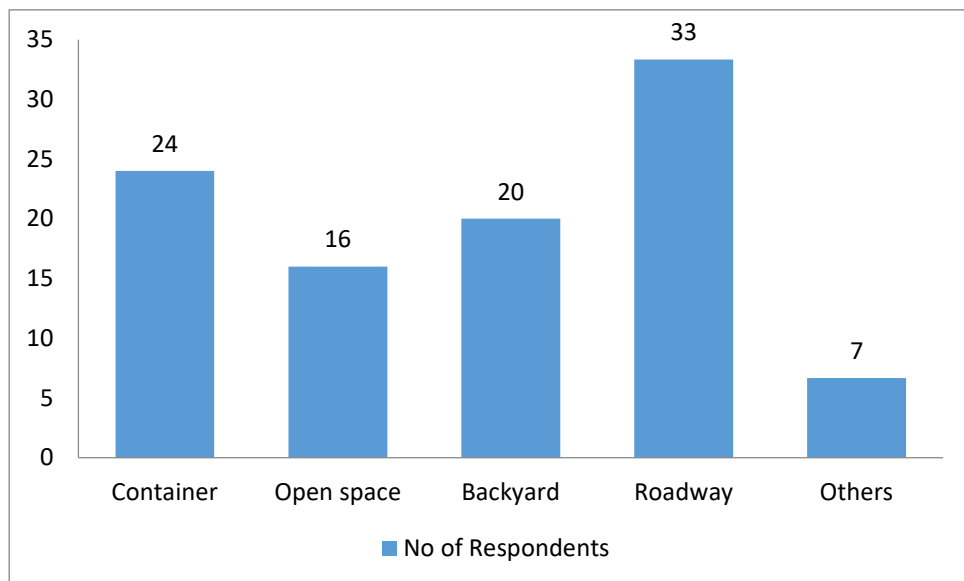


Figure 23: Place of Dumping Household waste by the Respondents

Above table and figures shows the case of dumping household waste. Information shows that 24% place in instrumentation and 16% open area. Within the same approach, 20% collect in backward of the house and 33% add road approach and different 7% throw no matter they like.

Response concerning the Increasing of Solid Wastes in Municipality

All the respondents' are argued that the amount of solid waste is increasing day by day in municipality. They need given varied reasons. The subsequent table indicates the respondents' opinion concerning the causes of skyrocketing solid waste in municipality.

Table 34: Response concerning the Increasing of Solid Wastes in Municipality

How do you think the solid waste in increasing day by day?	No of Respondents	Percentage
Due to population increase	25	33
Change in food habit	25	33
Not taking care of it	15	20
Other	10	13
Total	75	100

Source: Field Survey, 2022

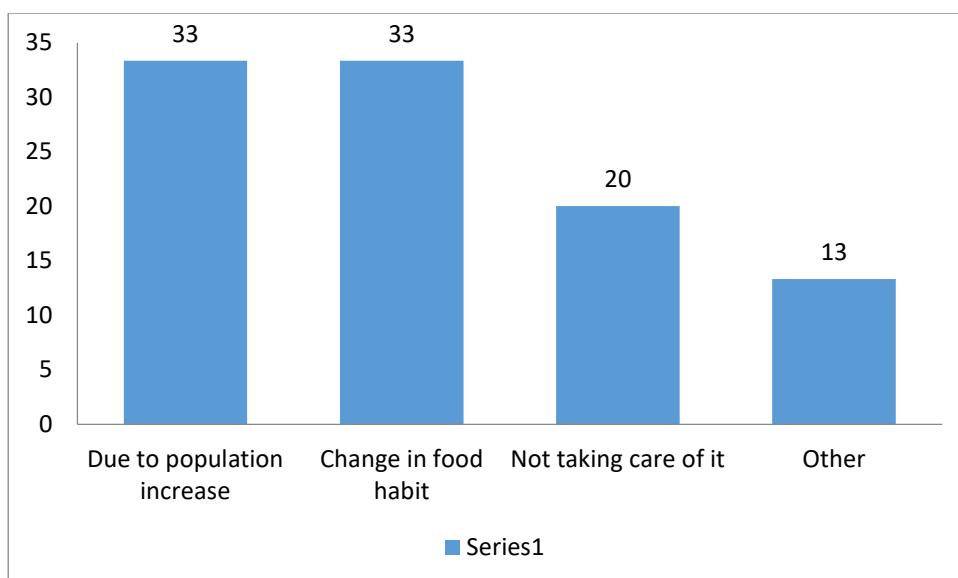


Figure 24: Response concerning the Increasing of Solid Wastes in Municipality

Above details show the opinions of the respondents to increasing solid waste in municipality. Information shows that 33% specialize in increment and 33% indicate that dynamical food habit. Within the same line 20% urged that individuals not care concerning the waste and 13% provide different answers.

Frequency of Waste assortment in Study space

In my study, there's no fastened time of collection waste. The subsequent table shows the frequency of waste assortment above all respondents' house.

Table 35: Frequency of Waste assortment in Study space

What is the frequency of the waste collection?	No of Respondents	Percentage
Once a week	25	33
Daily	10	14
Alternative day	25	33
Other	15	20
Total	75	100

Source: Field Survey, 2022

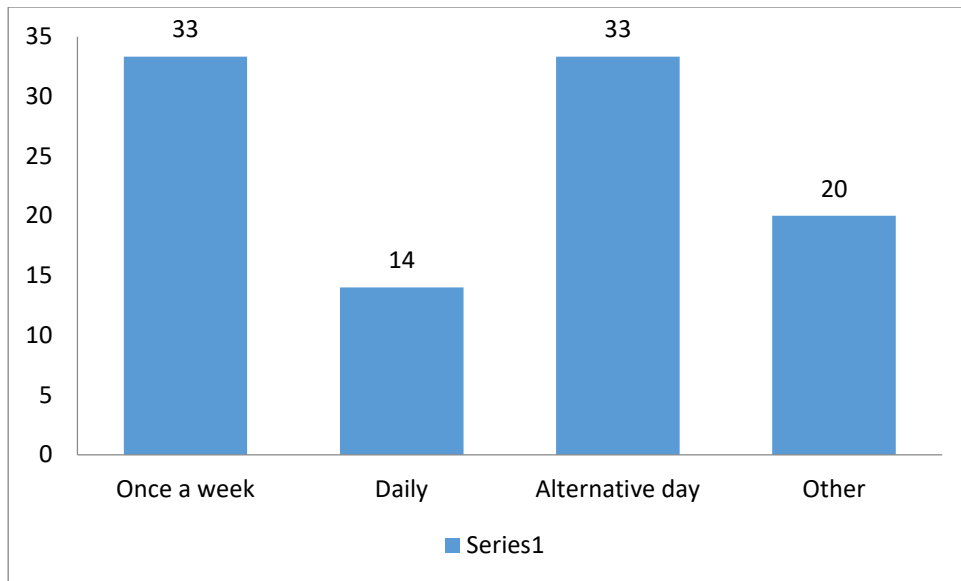


Figure 25: Frequency of Waste assortment in Study space

The table shows higher than indicates the frequency of waste assortment within the study space. Information shows that 33% argued there has collected once every week and 14% answer there has daily assortment. Within the same line 33% detected that there has collected various day and 20% provide different answers like municipality hardly collect the waste from house.

Time of the Day of Waste assortment

Municipality collects waste in different time that highlights in the following table.

Table 36: Time of the Day of Waste assortment

In which time of the day waste collection does?	No of Respondents	Percentage
Morning	40	53
Day	25	33
Evening	10	14
Total	75	100

Source: Field Survey, 2022

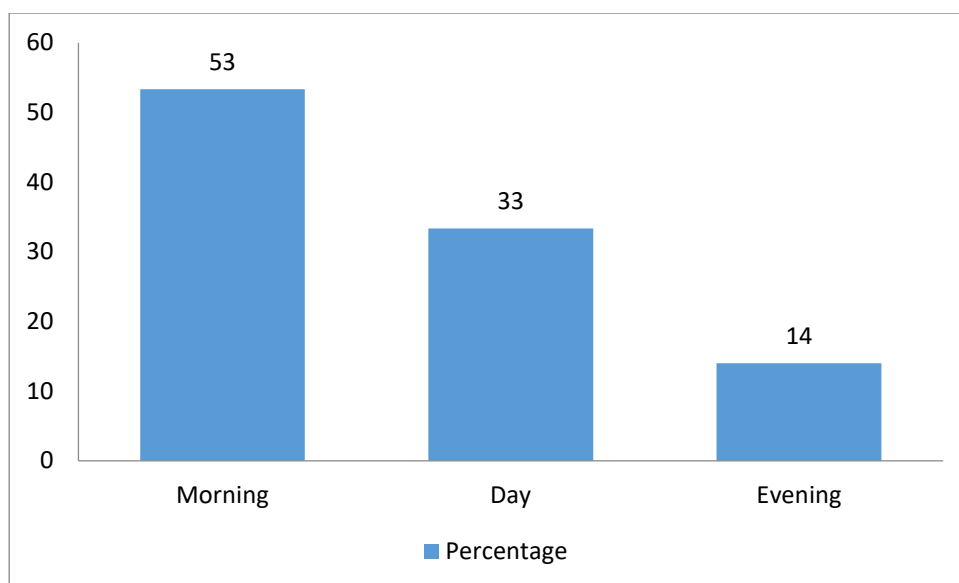


Figure 26: Time of the Day of Waste assortment

Above table and figure shows the time of waste assortment in day by municipality. Information shows that 53% respondents answer at daybreak and 33% detected that municipality collect waste at day time and 14% offers answer your time municipality collect waste at getting dark.

Place of Municipal instrumentation situated

There is no fixed place to locate container in the municipality. The following table highlights the location of putting container by the municipality.

Table 37: Place of Municipal instrumentation situated

Where is the Municipal container located?	No of Respondents	Percentage
Open space	40	53
Beside road	25	33
Other	10	14
Total	75	100

Source: Field Survey, 2022

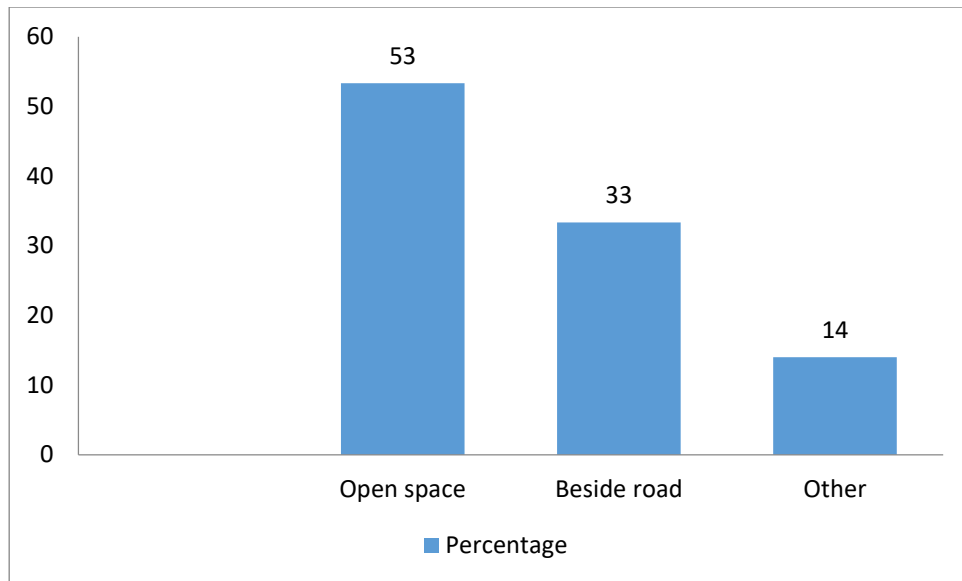


Figure 27: Place of Municipal instrumentation situated

Above table and figure show the place of municipal instrumentation situated space. Information shows that 53% answer as open area and 33% detected that municipality place it as beside road and 14% shows different area like before individual house.

Sorts of Waste assortment System in your Society

There is not fixed waste collection system in the study area. The following table highlight the waste collection system that practice in study area.

Table 38: Sorts of Waste assortment System in your Society

What type of waste collection system do you have in your locality from the concerned agency?	No of Respondents	Percentage
Door to door	30	40
Dumping	25	33
Waste collection by street sweeping	15	20
Other	5	7
Total	75	100

Source: Field Survey, 2022

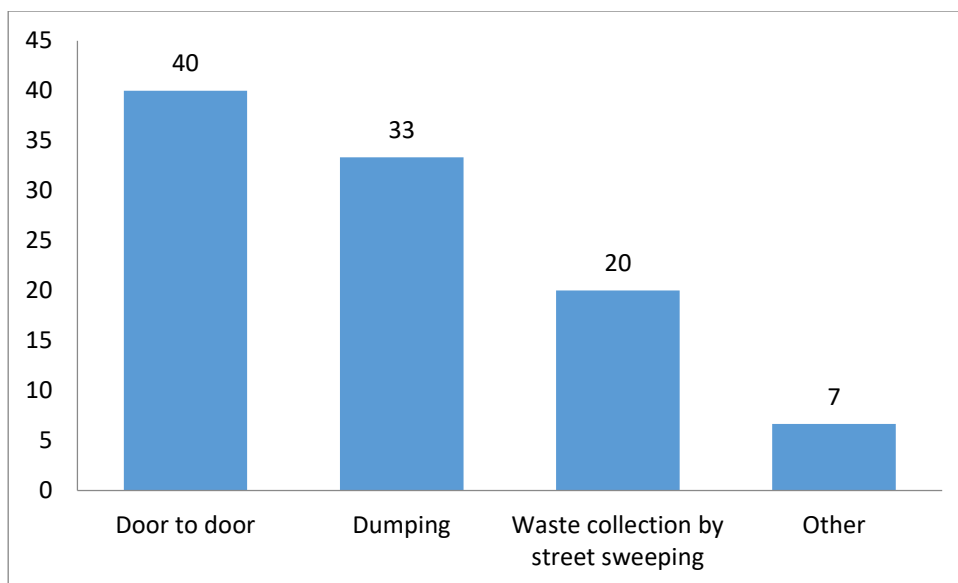


Figure 28: Sorts of Waste assortment System in your Society

The table mentioned higher than show the categories of waste assortment system of the study space. Information shows that 40% argued door to door system and 33% centered on selling system. Within the same approach, 20% indicate that waste has been collected by street sweeping and different 7% offers totally different answers.

Problems face by Respondents because of Waste

Due to the waste respondents face varied issues within the study space. the subsequent table highlights the issues that have facing by the respondents.

Table 39: Problems face by Respondents because of Waste

What type of problem do you face when these waste were not collected?	No of Respondents	Percentage
Land pollution	25	33
Health hazard	20	27
Bad smell	25	33
Other	5	7
Total	75	100

Source: Field Survey, 2022

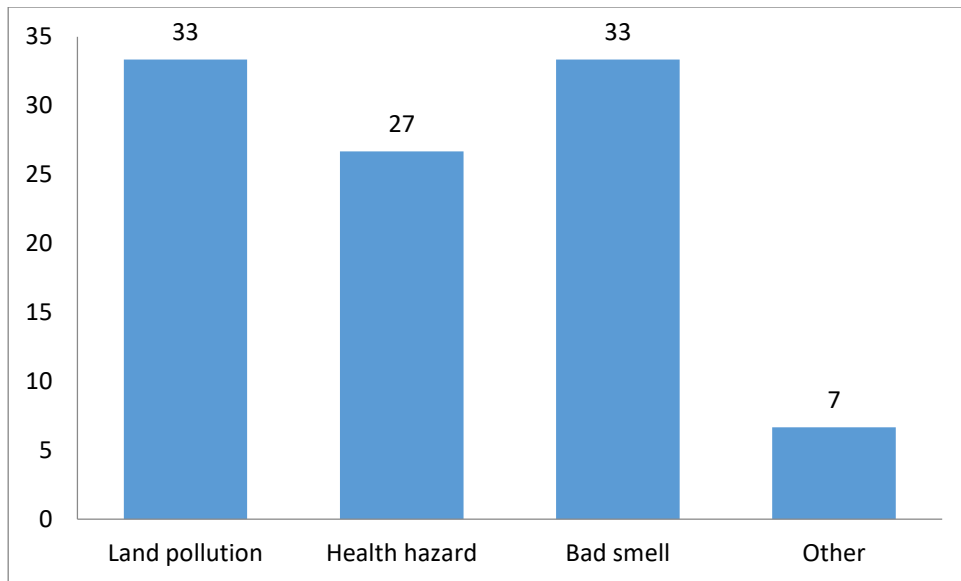


Figure 29: Problems face by Respondents because of Waste

The table and figure mentioned higher than highlight the issues round-faced by the respondent because of waste. Information shows that 33% focuses toward land pollution and 27% argued that effects in peril. Within the same approach, 33% focuses on dangerous smell and 7% provide different answers.

Respondents Manage Waste before Prevailing Waste Management System

Before prevailing waste management system within the study space respondents used totally different methodology that has highlighted within the following table mentioned below.

Table40: Respondents Manage Waste before Prevailing Waste Management System

How had you used to manage the waste before this prevailing waste collection system?	No of Respondents	Percentage
Throwing it in open space	45	60
Road way	20	27
Other	10	13
Total	75	100

Source: Field Survey, 2022

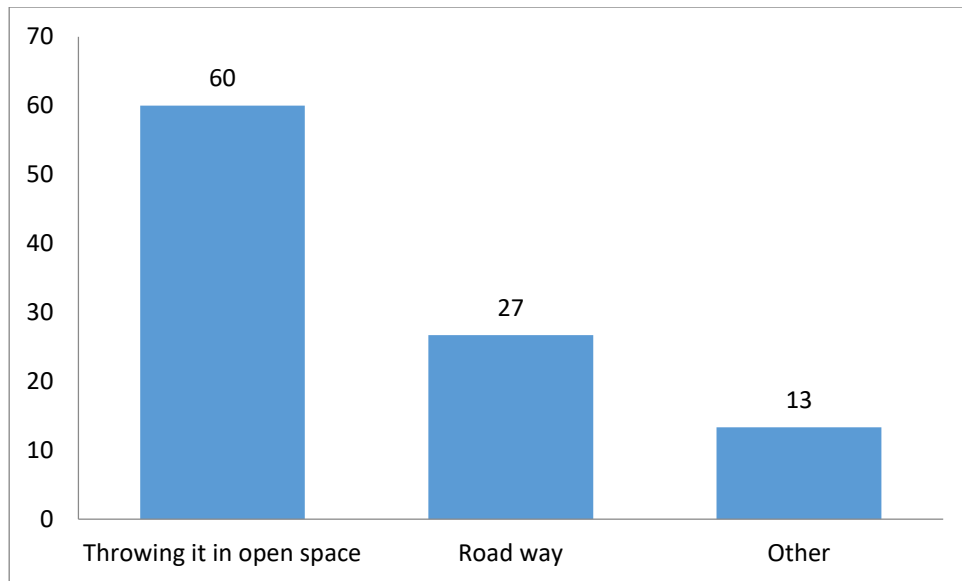


Figure 30: Respondents Manage waste before Prevailing Waste Management System

Above table and figure indicate the case of animal disease waste before beginning waste management system within the study space. Information shows 27% add route and 60% collect in open area. Solely 13% dispose by victimization different methodology.

Respondent’s opinion for sustainable Waste Management

Respondents have given totally different opinions for the property waste management within the study space. The subsequent table provides the standing that are as follows.

Table 41: Respondents' Opinion for Sustainable Waste Management

Which process would be more appropriate for sustainable waste management?	No of Respondents	Percentage
Recycling Method	30	40
Landfill Method	25	33
Composting Method	15	20
Other	5	7
Total	75	100

Source: Field Survey, 2022

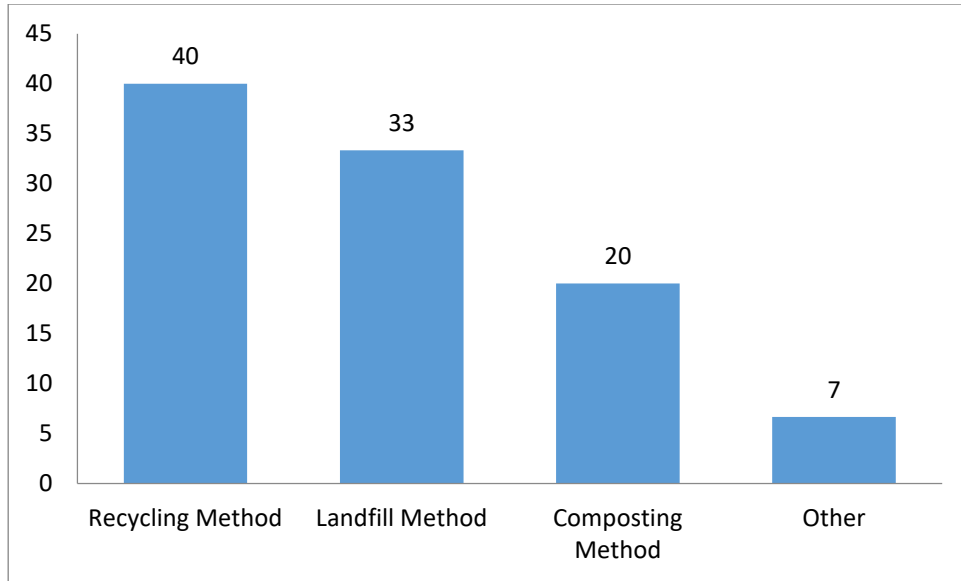


Figure 31: Respondent's opinion for property Waste Management

Above table and figure shows the respondents' opinion for property waste management. Where, 40% specialize in recycle and 33% highlights on landfill methodology. Within the same approach, 20% focuses on composing methodology and 7% focuses on different strategies.

Respondents' Opinion for the Long Term Solution of Solid Waste in the Study Area

Respondents' have given differ opinions about long term solution of solid waste management in the study area that mentioned in the following table.

Table 42: Respondents' Opinion for the Long Term Solution of Solid Waste in the Study Area

How can we have the long term solution of the problems emerging from solid waste?	No of Respondents	Percentage
Public awareness	45	60
Wards responsibility	10	13
Community based efforts	15	20
Others	5	7
Total	75	100

Source: Field Survey, 2022

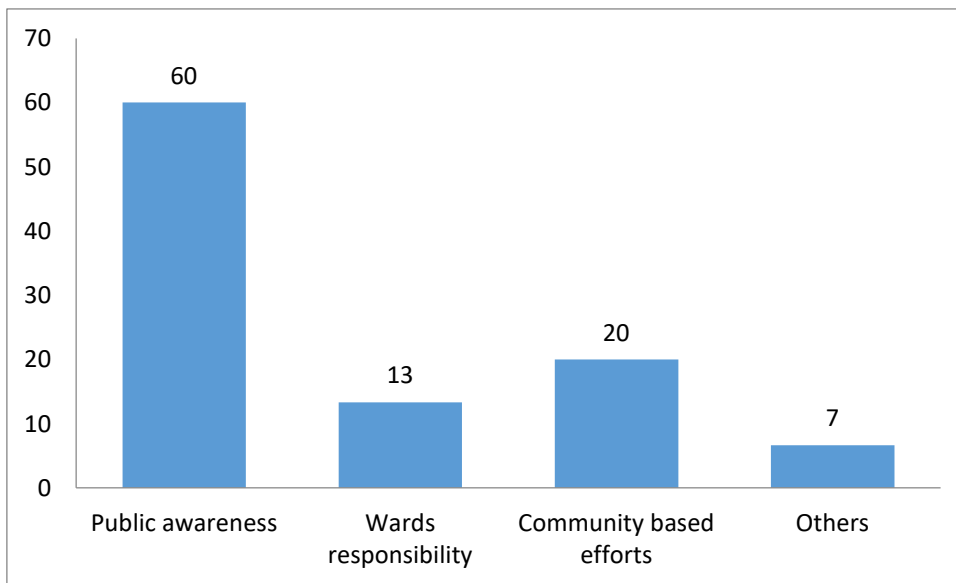


Figure 32: Respondents' Opinion for the Long Term Solution of Solid Waste in the Study Area

Above explained table and figure indicate the respondents' opinion concerning future answer of solid waste management in study space. Information shows that 60% specialize in public awareness and thirteen highlights on wards responsibility, 20% specialize in community primarily based effort and next 7% concentrates on different ways in which.

4.9.3. Costs Benefit Analysis of SWM for Landfilling Options

Cost profit analysis is to know the price and advantages of solid waste management choices for Rampur Municipality. The aim is to know CBA for landfilling choices. Waste to energy is Associate in choice that remains happening to provide biogas it's a model check thus it's solely the prices that involves establishing of Landfilling choice, design, construction, operation, post closure and environmental aspects. This incorporates a total price of around NRs 1 to 1.5 Crores. So, the results of price profit analysis for landfilling options in Table 43.

Table 43: Details of Costs and Benefits

Solid waste management for Landfilling Options	
Costs and Benefits	Amount(NRs)
COSTS	
Location Selection and Characterization Expense	3,97,000
Detailed Engineering Design Expense	2,00,000
Construction expense	26,50,000
Yearly construction expenses	31,73,500
Yearly operation expenses	22,50,000
Yearly closure expenses	1,71,5,000
Yearly Post closure care expenses	4,90,000
Total Cost	1,08,75,500
BENEFITS	
Methane(CH ₄) generation from landfill waste(kg/ton)	15.67
Quantity of methane to be sold(kg)	8,579.33
Selling price of Methane(NRs/cylinder)	1,800
Total selling recovered amount(NRs)	1,54,42,794
Total benefits	1,54,42,794
Net Benefits/return	45,67,294
Net present value (NPV)	2,58,06,229.74
NPV are for Ten year's period using a discount rate of 12% and their calculations for each option are in Appendix 3.	

The selling price of methane is obtained from Nepal Oil Corporation website. The results from this analysis showed that once discounting all the advantages and prices at 12% system, all the SWM choices earned positive NPV, which suggests that all told situations the assembly prices will be recovered and also the firm can stay with the profit.

4.9.4. Landfilling option's Payback Period

Payback period in capital budgeting refers to the time required to recoup the funds expended in an investment, or to reach the break-even point.

Payback Period = Cost of Investment ÷ Annual Cash Flow

$$= 1,08,75,500 \div 1,54,42,794$$

$$= 0.70 \text{ year}$$

$$= 8.4 \text{ month}$$

Thus, the investment in the landfilling option for Rampur municipality SW management will be recovered within a year ie, 8.4 month of project operation.

4.9.5. Sensitivity analysis

The CBA doesn't think about risks. NPV is extremely linked to the discount rate a little amendment within the discount rate causes an oversized amendment in NPV (Lin et al., 2000). So, consistently the NPV results based on varied tests. Results were product of the earning capability of the 2 processors handling SWM choices, if the discount rate was exaggerated or faded to varied levels. The leads to Table 44 showed that, the NPV varied because the discount rate (r) was varied.

Table 44: Sensitivity of Management choices to options of discount rate

Discount rate	Landfilling Option's NPV values
r=5%	3,52,67,433.61
r=11%	2,68,97,854.03
r=13%	2,47,83,249.27
r=30%	1,41,19,969.80

NPV are for ten year period and their calculations for each option and discount rate are found in appendix 4.

The results showed that, the implementation of landfilling choice in Rampur Municipality is economically even once the discount rate is as higher as 13%. However, the value of the NPV decreases by 60% once the discount rate will increase from 5% to 30%. With an occasional discount rate thus 5%, it's easier to win over the municipality to take a position, to continue funding such a project as a result of the current price of the long run advantages in all fairness high compared to the case once high discount rates are used.

4.9.6. Situation of Solid Waste Generation

Nature of solid waste depends upon, sources from that the wastes are generated. In general, rural areas manufacture a lot of perishable waste, whereas in urban areas perishable and non- perishable waste are found.

Composition of solid wastes is analogous throughout planet, however the proportions vary wide. The generated waste consists of each organic phenomenon and abiotic components. organic phenomenon components contain degradable waste like garbage, fuel like the branches and yard trimmings, dead animals, rags and temple offerings, some industrial waste and biodegradable pollution waste. Abiotic components ar non-biodegradable parts consists of waste like recent machine components, demolition waste and construction waste etc. Over the years, it's doubtless that changes occur within the composition of waste for reasons such as: -

- A rising commonplace of living and changes publicly style that notably influence the proportion of non-biodegradable waste.
- Changes in food technology (food process and packaging) to extend the utilization of materials like plastic, tins, metals and paper and Paving of roads that may cause a decline in inert materials.

Waste could be a part of act from yesteryear and its management is crucial. The fundamental issues of solid waste within the study space are as follows: -

- Lack of selling website
- Improper management of waste from the involved agency
- Lack of technology for managing the waste
- Unable to enforce correct rules and regulation.
- Lack of public awareness.

The vary of key problems that have to be compelled to be tackled once seeking to enhance solid waste management includes: -

- Daily waste assortment service to be provided
- Door to door waste assortment service to be provided
- Correct implementation of rules and laws.
- Public awareness programs to be launched
- Correct location of selling website

- Most numbers of containers to be provided
- Correct management of solid waste from the involved agency
- Each government and personal sector to return forward for correct management of solid waste.

4.9.7. SWOT analysis of waste management system

Safe waste disposal could be a massive and sophisticated method that needs an oversized space, special conditions, finance and different parts. Waste management is extremely necessary for maintaining the health of living beings further as for making a robust atmosphere for future generations. Waste management helps to cut back pollution, and by adapting to effective waste management practices, emissions of gases like greenhouse emission and gas from waste will be considerably reduced. It conjointly helps to forestall infectious diseases.

Strengths

- Established location of the solid waste management Centre
- Regular waste collection
- Establishment of waste purchase centers
- Establishment of recycling centers
- Strong information and training programs to promote waste.

Weaknesses

- Poor jilting operation
- Inefficient sorting of food waste
- Failings in the composting process
- Lack of processing capability for lunch product
- Failures in sludge toxin product openings

Opportunities

- Installation of a biogas factory in a solid waste operation center
- Entering external support from government and assiduity associations
- Five waste separation lockers are presented
- Operation of new technologies for MSW processing Pitfall

Threats

- Inadequate attention to promoting environmental exploration
- Invalidity of compost standardization
- Filtrate poisoning

Solid domestic waste is that the commonest waste stream and is created by a lot of individuals. Major money and logistic resources square measure needed for its assortment, recycling, and final disposal. Industrial waste tends to own a larger tonnage than municipal solid waste however is managed by comparatively tiny and specific sectors of society. Environmentally acceptable waste management practices square measure necessary to stop harmful effects like the results of toxic/hazardous waste, gas emissions, pollution, pollution, and noise/visual impacts (recycling/disposal facilities).

There is a requirement to more develop additional comprehensive tools for property waste property, together with environmental, social, and economic aspects. Ancient usage technologies square measure terribly straightforward, leading to rather heterogeneous merchandise. Even once process pure concrete, the combination created doesn't have identical productivity as primary concrete. Additional subtle usage technologies square measure still required to supply higher-quality secondary aggregates for every fraction of mineral building waste. In several components of the planet, the high value of natural aggregates and therefore the value of lowland will increase the economic viability of such processes.

Some of the proposals to eradicate the matter of unit waste moon-faced by individuals

- The govt. ought to think about all factors to blame for pollution and provides priority to effective compliance with environmental laws and laws.
- There ought to be a united effort by the govt. to boost public awareness of the importance of cleanliness and environmental protection through the media and to prepare data camps at the native level.
- Individuals ought to develop the habit of storing waste at the supply within their own homes and lose such waste solely in the municipal system.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The overall waste management system of Rampur Municipality was not found as environment friendly, no segregation was done prior to disposal. All the wastes were dumped at one place regardless of its nature, near to the bank of Kaligandaki River. As there was controlled dumping but the management of hazardous waste and composting plant as well as land filling facility is still absent.

Municipality has not taken any specific action to reduce the amount of waste and has no specific plan for future, yet. Organic waste dominates the overall composition of waste, which was found to be 65%, whereas plastic, paper, glass, rubbers, Hazardous and other was found as 14%, 5%, 6%, 4%, 2%, and 4% respectively. The study has shown the average capita per day waste of the study area was 0.022 Kg/Person/Day. Average waste generation per household per day was 0.08 kg and total waste generated in study area per day was found to be 435kg. At present budget for SWM is about two percent of the total budget.

From the survey data and various factors consideration in solid waste management in Rampur Municipality. It was concluded that for MSW management in Rampur Municipality, the sustainable solid waste management system ie, landfilling option was suggested and the detail cost estimation for the construction and operation for 10 years was estimated, which is around NRs 1-1.5 Crores per year with running cost and construction cost of the project. And, detail financial analysis for waste management by landfilling option was carried out. Where payback period of the project is around a year i.e. 8.4 months. The project's NPV, IRR and B/C ratios are NRs. 2,58,06,229.74, 12% and 1.42 respectively. Thus, the project is reliable and acceptable for the construction and operation.

In spite of resident's eagerness to participate in the management system, municipality is unable to train or educate them, so the need of provision for training or technology transfer was noticed. The joint effort from public and private sector can help in the waste management process, as it was in practice in many other municipalities of Nepal, under the Public Private Partnership Program. Introduction of 3Rs policy could significantly reduce the volume of waste. Composting has potential to reduce the waste volume by about 65%. Adoption of clean mechanism not only helps to reduce

waste but also generates sources of income and employment. At present the volume of waste is low and can be managed efficiently with simple measures. But the increasing population and urbanization within and in neighboring places could result in the larger amount of waste in future then CDM could be one of the better options in coping with it.

5.2.Recommendations

Sustainable management of solid waste is an emerging task for all urban areas like Rampur in Nepal. People consider waste as burden but it can be resource if some technologies are applied. Composting from organic waste can be the first option. Similarly recycle, reuse etc. help to reduce the waste for final disposal in large extent. Managing authorities are also found to be unaware of this fact. Simply by practicing segregation, waste management could become much easier. Following points are recommended based on the results and discussion for the solid waste management of Rampur municipality:

5.2.1. Policy level Recommendations

- The policy of municipality should shift from post production management of waste to the reduction and alternative management measures at source.
- Plastic bags should be banned.
- There should be the provision of fine for person who throw waste in open places, for this continuous monitoring is required.

5.2.2. Management and Technical Aspect Recommendations

- The municipality should stop dumping waste near at the bank of Kaligandaki River immediately as it is polluting the river, for this municipality should locate another place for dumping waste.
- The proposed landfill site should be construct and bring it into operation as soon as possible.
- Municipality can also implement Private public Partnership program for Waste management
- Other alternative methods such as composting, incorporation of 3R principles, recycling etc. should be adopted gradually in future.
- Equipment's used for waste management should be repair frequently.

5.2.3. General Recommendations

- Municipality should increase the number of containers and the frequency of wastecollection from households.
- Municipality should encourage local communities and clubs to manage their waste at community level
- Awareness programs and trainings about management of waste at household levelsuch as composting should be organize regularly

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APPENDIX-1: PHOTOGRAPHS

Rampur municipality office and vehicles used for waste collection



Dumping site

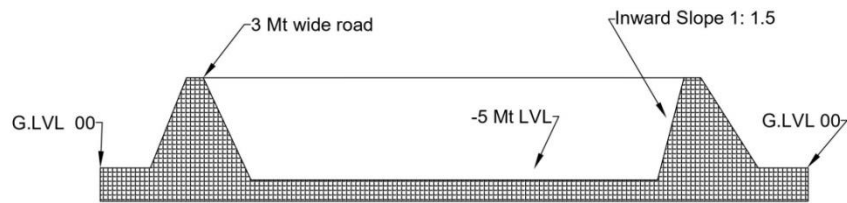


Proposed Landfill site

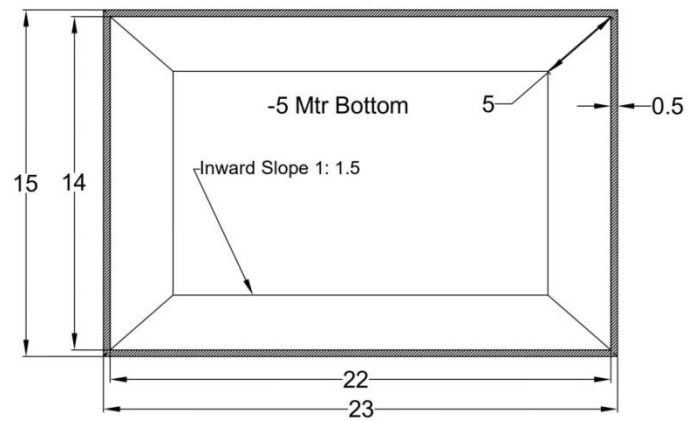


Detailed Drawing of Key Plan for Engineered Landfill

Notes: All dimensions i

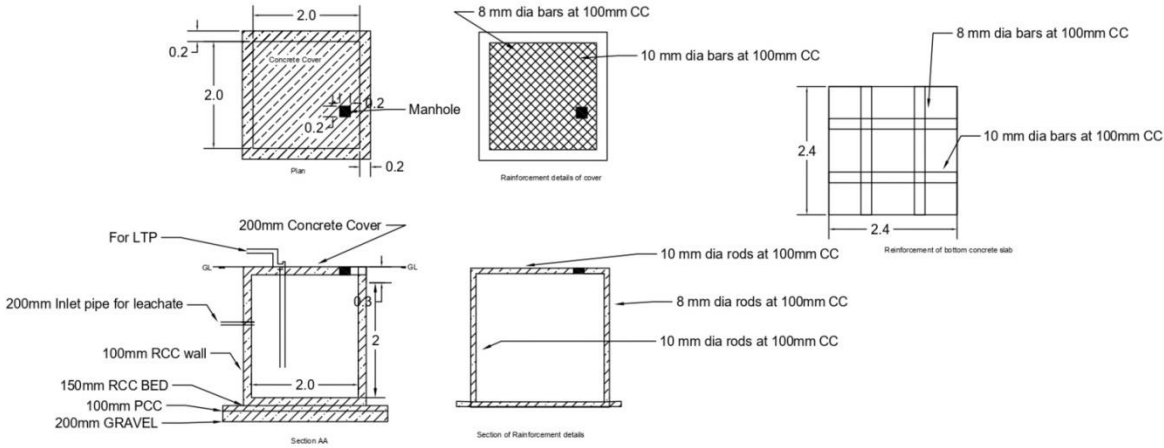


Section AA through Pit



Detailed Layout Plan of Leachate Collection Tank

Notes: All dimensions in meter



Rampur Municipality income sources in FY 2078/2079



रामपुर नगरपालिका
नगर कार्यपालिकाको कार्यालय, पाल्पा
कार्यालयको कोड : ८०५५४०२३००

संक्षिप्त विवरण

आ.व. : २०७८/७९ अवधि : २०७८/०४/०९-२०७९/०३/३२				Estimated	Actual	
सि.नं.	स्रोत समूह	बजेटको स्रोत/तह	प्राप्तिको श्रोत	विधि	वार्षिक अनुमानित आय	आम्दानी
१	संघीय सरकार	नेपाल सरकार	१३३११ - समानिकरण अनुदान	नगद अनुदान	१२,६०,००,०००	१२,६०,००,०००
२	संघीय सरकार	नेपाल सरकार	१३३१२ - शसर्त अनुदान चालु	नगद अनुदान	३०,७१,२९,०००	३०,६७,२९,०००
३	संघीय सरकार	नेपाल सरकार	१३३१३ - शसर्त अनुदान पुँजीगत	नगद अनुदान	३,०४,५०,०००	३,०४,५०,०००
४	संघीय सरकार	नेपाल सरकार	१३३१५ - विशेष अनुदान पुँजीगत	नगद अनुदान	१,२५,००,०००	१,२५,००,०००
५	प्रदेश सरकार	लुम्बिनी प्रदेश	१३३११ - समानिकरण अनुदान	नगद अनुदान	६०,१३,०००	६०,१३,०००
६	प्रदेश सरकार	लुम्बिनी प्रदेश	१३३१२ - शसर्त अनुदान चालु	नगद अनुदान	१,१५,४४,०००	१,१५,४४,०००
७	प्रदेश सरकार	लुम्बिनी प्रदेश	१३३१४ - विशेष अनुदान चालु	नगद अनुदान	७०,००,०००	७०,००,०००
८	प्रदेश सरकार	लुम्बिनी प्रदेश	१३३१६ - समपुरक अनुदान चालु	नगद अनुदान	२,००,००,०००	२,००,००,०००
९	राजस्व बाडफाइ	राजस्व बाँडफाँड - प्रदेश सरकार	११४१५ - घरजग्गा रजिष्ट्रेशन दस्तुर	नगद	२,००,००,०००	१,४९,४७,८८६
१०	राजस्व बाडफाइ	राजस्व बाँडफाँड - प्रदेश सरकार	११४५६ - बाँडफाँटबाट प्राप्त हुने सवारी साधन कर	नगद	१,२८,००,०००	१,१५,५९,६३४.४४
११	राजस्व बाडफाइ	राजस्व बाँडफाँड - संघीय सरकार	११४११ - बाँडफाँट भई प्राप्त हुने मूल्य अभिवृद्धि कर	नगद	४,३९,०२,०००	६,७७,९२,७४७.६०
१२	राजस्व बाडफाइ	राजस्व बाँडफाँड - संघीय सरकार	११४२१ - बाँडफाँट भई प्राप्त हुने अन्तःशुल्क	नगद	४,३९,०२,०००	२,१९,५५,९७२.८५
१३	आन्तरिक श्रोत	सडक बोर्ड	१३४११ - अन्य संस्थागत आन्तरिक अनुदान	नगद	७१,४१,७५७	७१,६०,५३९
१४	आन्तरिक श्रोत	आन्तरिक श्रोत	११३१४ - भुमिकर/मालपोत	नगद	२,००,००,०००	५८,१३,९८०.५९
१५	आन्तरिक श्रोत	आन्तरिक श्रोत	११३२१ - घरवहाल कर	नगद	१२,००,०००	११,५६,२७९.५१
१६	आन्तरिक श्रोत	आन्तरिक श्रोत	११३२२ - वहाल विटोरी कर	नगद	१०,००,०००	०
१७	आन्तरिक श्रोत	आन्तरिक श्रोत	११४५१ - सवारी साधन कर (साना सवारी)	नगद	३,००,०००	०
१८	आन्तरिक श्रोत	आन्तरिक श्रोत	११४५२ - पुर्वाधार सेवाको उपयोगमा लागेको कर	नगद	१५,००,०००	०
१९	आन्तरिक श्रोत	आन्तरिक श्रोत	११६११ - अन्य कर	नगद	४,००,०००	१,५४,७२१.८६
२०	आन्तरिक श्रोत	आन्तरिक श्रोत	१४२११ - अन्य सेवा शुल्क तथा बिक्री	नगद	५,००,०००	९५,५१६.५१
२१	आन्तरिक श्रोत	आन्तरिक श्रोत	१४२२२ - नक्सापास दस्तुर	नगद	३,५०,००,०००	३०,०३,४००.७१
२२	आन्तरिक श्रोत	आन्तरिक श्रोत	१४२४३ - सिफारिश दस्तुर	नगद	६०,००,०००	४५,३५,८८९



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नगर कार्यपालिकाको कार्यालय, पाल्पा
कार्यालयको कोड : ८०५५४०२३००

संक्षिप्त विवरण

आ.व. : २०७८/७९ अवधि : २०७८/०४/०९-२०७९/०३/३२				Estimated	Actual	
सि.नं.	स्रोत समूह	बजेटको स्रोत/तह	प्राप्तिको श्रोत	विधि	वार्षिक अनुमानित आय	आम्दानी
२३	आन्तरिक श्रोत	आन्तरिक श्रोत	१४२४४ - व्यक्तिगत प्रदान दर्ता दस्तुर	नगद	३०,००,०००	६,६०,७२२
२४	आन्तरिक श्रोत	आन्तरिक श्रोत	१४२६३ - जलस्रोत सम्बन्धी अन्य दस्तुर	नगद	२,००,००,०००	४,३००
२५	आन्तरिक श्रोत	आन्तरिक श्रोत	१४२६५ - अन्य क्षेत्रको आय	नगद	४,००,०००	४,३०,५६२
२६	आन्तरिक श्रोत	आन्तरिक श्रोत	१४३११ - प्रशासनिक दफ्तर, जरिवाना र जफत	नगद	१,५०,०००	४,०१,२७८.३९
२७	आन्तरिक श्रोत	आन्तरिक श्रोत	१४५२१ - अन्य राजस्व	नगद	२,००,००,०००	१,१५,२७,०२२.१८
२८	आन्तरिक श्रोत	आन्तरिक श्रोत	१४६११ - व्यवसाय कर	नगद	४०,००,०००	११,७२,०८८
२९	आन्तरिक श्रोत	आन्तरिक श्रोत	१५१११ - वेल्फेयर	नगद	५०,०००	७,३७,२४४.३०
३०	आन्तरिक श्रोत	आन्तरिक श्रोत	३२१२२ - वैक मौज्दात	नगद	१,६५,००,०००	०
जम्मा					७७,८३,८१,७५७	६७,३३,५५,०३४.७४

APPENDIX 2: QUESTIONNAIRE

Status of Solid Waste Management System of Rampur Municipality and Its Challenges

1. Questionnaire for Household Survey

District: _____ Name of the respondent: _____
Municipality: _____ Date: _____
Ward No: _____

1. How do you manage waste?

- a) Taken up by door to door collectors b) Throw nearby
c) Throw in Municipality container d) Manage yourself at house
e) Others

2. What is the name of organization/forum managing solid waste/garbage in your ward?

4. How many times a week does the organization collect the garbage?

Frequency	Regularity in collecting at specified time		
	Yes	No	To some extent
Daily			
Twice a week			
Thrice a week			
Four times a week			
Once a week			

5. Generally, at what time the organization collects the waste?

- a) Early Morning (4 am-6 am)
b) Morning (6 am-10 am)

c) Day Time (10 am-5 pm)

d) Evening (5 pm-7 pm)

e) Night (after 7 pm)

6. Have the Organization provided Dustbin?

a) Yes b) No

7. Are you paying for the waste collection service?

a) Yes b) No

8. Are you satisfied with the amount you paying?

Response	Reason
Yes	
No	
To some extent	

9. Have you given any room/apartment in rent?

a) Yes b) No

10. If yes, please mention the following

a) Total room given for residential purpose:

b) No. of families staying:

c) Total no. of person staying in rent:

d) Total room (Shop) given in rent:

10. Do family in the rent have share in payment for waste collector?

a) Yes b) No

12. How does the organization collect the wastes?

a) Door to door collection

b) Should dispose at container at specific time of collecting the garbage

13. If the organization fails to collect the waste according to schedule time, how do you manage the waste in such specific cases?

- a) Store inside house for certain days
- b) Dispose in the public container
- c) Dump outside house
- d) Store within the premises until they come and collect
- e) Dump in the street
- f) Dump in nearby river
- g) Others, please specify

14. Prior to existence of present organization, where did you use to dispose off the waste?

- a) Dumping outside the house
- b) In the street
- c) In open space as per convenience
- d) In the river
- e) Container
- f) Incarnate
- g) Making compost
- h) Managed through private cleaner
- i) Bury in pit
- j) Other, please specify

15. Do you segregate Decomposable and Non- decomposable waste?

- a) Yes b) No

16. Will you ready to segregate if told to do so?

- a) Yes b) No

17. Have you participated in any trainings of Municipality to manage the waste athousehold level?

a) Yes b) No

18. Do you have any problem in waste management?

a) Yes b) No

If yes, please, highlight those?

19. Are you satisfied with the management of present waste collecting organization?

Response	Reason
Yes	
No	
To some extent	

20. What suggestions you make for the present organization to become effective?

21. What activities do you suggest to make the organization sustainable?

22. In your opinion, what could be the best measures for those families who are not being co-operating the present organization?

a) Creating awareness

b) Boycotting from the community

c) Strong action (Penalty)

d) Convincing them about the importance of managing the waste in the area

e) To co-operating to such families

23. Do you know where the collected waste is being disposed by the organization?

a) Yes b) No

If yes, where?

2. Key Informant Interview

Name:

Position:

Age:

Sex:

Education:

1. What are the current system of collection, transportation and final disposal of MSW?
2. Are the wastes segregated at the final disposal sites? (If not, what are the reasons?)
3. What is the total budget of the municipality for the current fiscal year?
4. How much of it has been allocated for the MSWM?
5. Is the budget enough for the Proper management of MSW?
6. What are other apparent financial hurdles in the waste management system?
7. How many vehicles have been collecting and transporting MSW at the moment?
8. How many dustbins have been placed in the whole municipality?
9. Are those dustbins enough or need to add more?
10. Are those vehicles enough for the whole municipality?
11. Has there been any landfill sites proposed for the final disposal of wastes?
12. Has there been any awareness program/campaign for the MSWM in the community?
13. If yes, how actively have public people participated?
14. What are the proposed future strategies/plans for the overall improvement of MSWM system?
15. Can the municipality possibly provide two separate bins to households for segregation of wastes?

APPENDIX 3: Calculations of NPV of SWM options in Rampur municipality

Time Horizon (n)= 10years

Net Benefits =TB –TC

Interest rate (i) Or Discount Factor=12%

Discount Factor = $(1+I)^n$

V_0 =Discounted Net Benefit

Discounted Net Cash flow = $V_0/(1+I)^n$

$$NPV = \sum_{t=0}^T B_t (1 + i)^{-t} - \sum_{t=0}^T C_t (1 + i)^{-t}$$

LANDFILLING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	10875500	15442794	4567294	12%	1.12	4077941.07
2	10875500	15442794	4567294	12%	1.25	3641018.81
3	10875500	15442794	4567294	12%	1.40	3250909.66
4	10875500	15442794	4567294	12%	1.57	2902597.91
5	10875500	15442794	4567294	12%	1.76	2591605.27
6	10875500	15442794	4567294	12%	1.97	2313933.28
7	10875500	15442794	4567294	12%	2.21	2066011.86
8	10875500	15442794	4567294	12%	2.48	1844653.44
9	10875500	15442794	4567294	12%	2.77	1647012.00
10	10875500	15442794	4567294	12%	3.11	1470546.43
						NPV=25806229.74

APPENDIX 4: Sensitivity analysis

Sensitivity analysis was carried out at 5%, 11%,13% and 30% interest rate/discount rate

LANDFILLING

Year	Cost	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	10875500	15442794	4567294	13%	1.13	4041853.10
2	10875500	15442794	4567294	13%	1.28	3576861.15
3	10875500	15442794	4567294	13%	1.44	3165363.85
4	10875500	15442794	4567294	13%	1.63	2801206.95
5	10875500	15442794	4567294	13%	1.84	2478944.20
6	10875500	15442794	4567294	13%	2.08	2193755.93
7	10875500	15442794	4567294	13%	2.35	1941376.93
8	10875500	15442794	4567294	13%	2.66	1718032.68
9	10875500	15442794	4567294	13%	3.00	1520382.90
10	10875500	15442794	4567294	13%	3.39	1345471.59
						NPV=24783249.27

LANDFILLING

Year	Cost	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	10875500	15442794	4567294	11%	1.11	4114679.28
2	10875500	15442794	4567294	11%	1.23	3706918.27
3	10875500	15442794	4567294	11%	1.37	3339566.01
4	10875500	15442794	4567294	11%	1.52	3008618.03
5	10875500	15442794	4567294	11%	1.69	2710466.69
6	10875500	15442794	4567294	11%	1.87	2441861.88
7	10875500	15442794	4567294	11%	2.08	2199875.57

8	10875500	15442794	4567294	11%	2.30	1981869.88
9	10875500	15442794	4567294	11%	2.56	1785468.36
10	10875500	15442794	4567294	11%	2.84	1608530.06
						NPV=26897854.03

LANDFILLING

Year	Cost	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	10875500	15442794	4567294	5%	1.05	4349803.81
2	10875500	15442794	4567294	5%	1.10	4142670.29
3	10875500	15442794	4567294	5%	1.16	3945400.28
4	10875500	15442794	4567294	5%	1.22	3757524.08
5	10875500	15442794	4567294	5%	1.28	3578594.36
6	10875500	15442794	4567294	5%	1.34	3408185.10
7	10875500	15442794	4567294	5%	1.41	3245890.58
8	10875500	15442794	4567294	5%	1.48	3091324.36
9	10875500	15442794	4567294	5%	1.55	2944118.44
10	10875500	15442794	4567294	5%	1.63	2803922.32
						NPV=35267433.61

LANDFILLING

Year	Cost	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	10875500	15442794	4567294	30%	1.30	3513303.08
2	10875500	15442794	4567294	30%	1.69	2702540.83
3	10875500	15442794	4567294	30%	2.20	2078877.56
4	10875500	15442794	4567294	30%	2.86	1599136.58
5	10875500	15442794	4567294	30%	3.71	1230105.07
6	10875500	15442794	4567294	30%	4.83	946234.67
7	10875500	15442794	4567294	30%	6.27	727872.82
8	10875500	15442794	4567294	30%	8.16	559902.17
9	10875500	15442794	4567294	30%	10.60	430693.98
10	10875500	15442794	4567294	30%	13.79	331303.06
						NPV=14119969.80