

Bhim Prasad Gurung , Rajiv Dhakal

# Municipal Waste Treatment Culture in Nepal

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<p>Nepal is a small landlocked country with unique bio diversity. Due to rapid urbanization in the last decades, lack of concrete government policies on waste management and lack of awareness among general public, Nepal is facing a huge problem of waste management. Waste separation virtually does not exist in Nepal at all. Wastes such as battery, electronic devices are collected in a common container to be dumped in landfill sites. In big municipalities such as Pokhara and Kathmandu sewage and human waste are directly connected to river. Such actions are short-term solution and there is a dire need to find a sustainable solution to these problems. Municipal solid waste is of particular problem among Nepalese municipalities.</p> <p>Solid waste management can be a big opportunity for Nepal as its population is moving towards urban areas and proper strategy on implementing waste management means jobs for thousands of people across the country. Solid waste management is not an easy task and it includes a long-term vision and technology. Integrated Solid Waste Management which considers the existing condition of a certain place and environment to execute a plan to manage waste is necessary. This thesis work examines the situation of municipal waste in one of the rapidly urbanized municipality of Nepal, Nepalgunj. It also compares waste management situation in other municipalities. The data from Asian Development Bank in the year 2011 gives an estimate on waste generation in different municipalities in Nepal and the composition of waste. This data was utilized to form a clear picture on what kind of strategy Nepalese municipalities would have to take for the waste management. The important concepts like reuse, recycle and reduce (3R) are discussed in the context of Nepal in this thesis.</p>	
Keywords	Sustainability, municipal solid waste, waste management

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Appendix 1. Composition of Household Waste

## **1 Introduction**

Nepal is a small landlocked country with a diverse environment and rich biodiversity. Nepal can be divided into three physical regions based on the climate and topography. The northernmost part of Nepal which is covered mostly by the Himalayas is called the Himalayan Region, which is cold around the year with snowfall during winter. It covers nine percent of Nepal. Nepal consists of mostly hilly regions which contains big hills and physically difficult areas. Sixty eight percent of Nepal is hilly region. The plain region of Nepal which consists of fertile land, the agriculture belt of Nepal, covers seventeen percent of Nepal. Nepal's predominant population lives in the middle mountainous region. Due to recent political turmoil that ended the civil war in 2006 with signing of peace accord, urbanization has been rapid in Nepal. Many villages in the hilly areas are empty, and the land is left without cultivation.

This has led to unmanaged and unplanned urbanization giving rise of an unhealthy settlement where pollution is not taken care of. Solid waste management is a major problem for rapidly growing cities. Nepal being one of the poorest countries in the world lacks basic infrastructure such as road, drinking water, and electricity. Waste management has not been in focus in Nepal. After the massive earthquake of 2015, waste management has been completely neglected in Nepal because of lack of budget and proper infrastructure. This thesis concentrates on describing the current waste management situation of Nepal and the current Municipal Solid (MSW) Waste management, and gives recommendations for further improvement and development. The MSW composition and generation in connection to the population concentration among municipalities will be studied.

## **2 Identification of problems**

Solid Waste Management (SWM) is a primary environmental challenge for developing nations like Nepal. Growing Population and economic development are the two primary factors that contribute to the rise in the solid waste in urban areas. The term municipal solid waste can be defined as the waste produced in a community which does not include the waste that is generated from treatment plants, agricultural processes or industrial processes and municipal services [1]. In generalized terms MSW can be termed as domestic waste, garbage or trash. Unmanaged and haphazard urbanization has given birth to unsustainable Municipal Solid Waste. Non-hazardous Municipal Solid Waste (MSW) can be collected by a city, town or village that requires routine collection and transported to a processor or disposed in site. Main sources of MSW are private homes, commercial establishments and institutions, as well as industrial facilities. Moreover, the wastes resulted from the industrial processes, debris during demolition, constructional wastes and wastes from mining, sludge, agriculture, sewerage that generate hazardous waste are not included in MSW. These wastes are not being adequately managed that are resulting in health issues and environmental degradation hazardedly. National agencies also ignore areas such as slums whose residents live below the poverty line and do not have enough capacity to pay for waste management services on their own. Thus, haphazard urban settlements are much affected because of motley dumping and inadequate open space.

At present, with addition of new municipalities in the year 2012, Nepal has total 58 municipalities which vary in size, status of infrastructure, the concentration of educated population and living standard. For example, municipalities like Kathmandu and Pokhara has resources and infrastructure for better management of waste resources while others lag behind. The amount of MSW differs from 1.3 tons/day to 123 tons/day within Nepal and its municipalities, but that overall municipal solid waste generated in Nepal was estimated to be 427 tons/day [2].

Solid waste management is not given due priority in most of the municipalities in Nepal with exception to some big municipalities such as Kathmandu and Pokhara. The short-term vision adopted by most of the municipalities of Nepal on solid waste management seems insufficient for the sustainable solid waste management. A long-term and sustainable vision is necessary for proper solid waste management in Nepalese municipalities. The reliance on foreign donors to manage waste in Nepalese municipalities should be reduced because once the foreign donor stops providing supports the waste

management is literally stopped and the municipality has to wait for another donor. The maximum reliance of foreign aid is a major cause of failed solid waste management in Nepal.

Another problem faced by these municipalities is proper collection areas, transportation and disposal of solid. The accurate data on solid waste production is also lacking which is a serious hindrance in making any kind of decision about solid waste management. Above all the consciousness among Nepalese population on waste management is lacking severely. People are not aware of the result of their little negligence on the environment of their community. During this thesis project community members in Nepalgunj municipality were interviewed and it was found that people did not know the consequence of throwing their household wastes to river and other natural resources. They were convinced that once the waste is thrown in a river it will be taken away and they would not have to think about it. This mind-set is one of the major hindrances in managing solid waste.

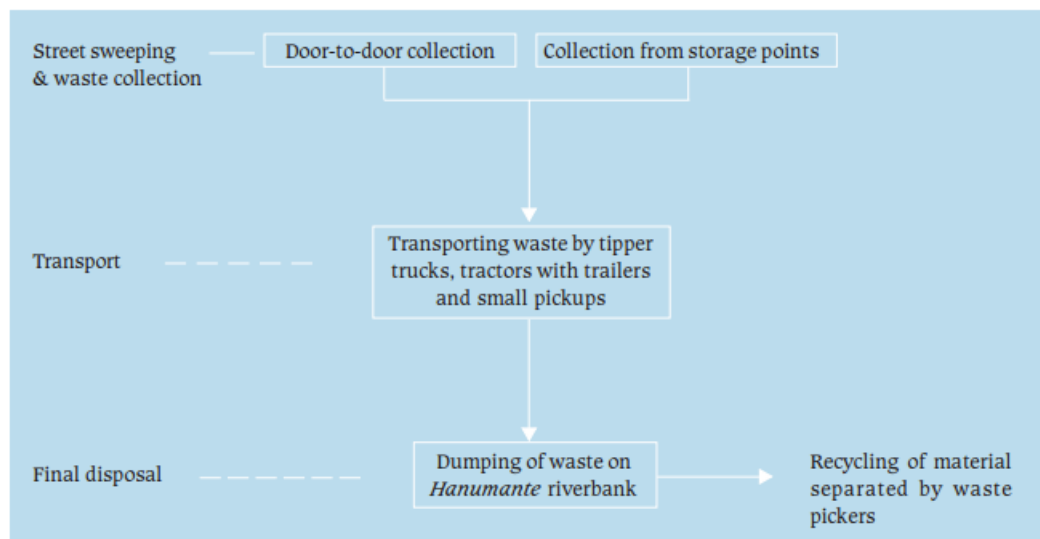
Public and private sector partnership is the key component for sustainable solid waste management in any municipality, but such approach seems lacking in most of the municipalities of Nepal due to slow and inactive bureaucracy.

Moreover, the municipalities do not have any work plans formulated yet to tackle the problems due to lack of proper coordination within municipalities the success stories have always been overshadowed. There is a lack of awareness and less priority is given to educate pupil on waste management. There is lack of skilled human resources and inadequate financial condition in municipalities for achieving goal of sustainable solid waste management.

### 3 Waste management in Nepal

As discussed in the previous chapter of this thesis MSW management in Nepal has become a major problem affecting both environment and population. MSW is dumped in landfill sites without separation and regardless of the type of waste. In the long, run such practice will become a problem rather than an easy solution. MSW management in Nepal differs in urban and rural areas. Practices like re-use, re-cycle and energy recovery are more common in urban Nepal.

Most of the waste content is organic matter. Others are paper, glass bottles, metals, plastic bottles, cloth, and other materials. Recyclable waste i.e. metals and plastics and papers are collected by informal scrap dealer, scavenger. For transportation of all wastes collected from the municipal area only tractor-trailers are being used. Tractor-trailers are used to pick up the waste heaps accumulated on roadsides. The waste collected from various parts is collected depending upon the necessity. Collection is carried out from street and drainage only. So-called door-to-door collection is also practiced to collect waste disposed by shops and hotels in street as small heaps and clean the street. Only some rag pickers and informal workers collect recyclable waste like, whole unbroken glass bottles, some plastic bottles and materials which can be recovered or recycled easily. The inhabitants also sell some metals and recyclable plastics and the shopkeepers sell cardboard boxes. Most government offices and institutions do sell newspapers and books to scrap collectors.



*Figure 1. Overview of solid waste management in Bhaktapur Municipality [3]*

Figure 1 above depicts the solid waste management in one of the major municipalities in Nepal but this also represents a common trend in the waste disposal in Nepal.

The practice of incineration of waste in municipal as well as in rural areas has become of no obvious value as there are no energy recovery purposes. Unnecessary deposition of waste is seen near water resources like river banks, roads. As a result it contributes water pollution along with water logging and blockage in drainage system causing hazardous health and environmental problems.



*Figure 2. Collection methods for municipal waste: (a) tractor collection and (b) scavenging*

As shown in Figure 2 above, a very primitive and conservative method is being utilized for waste collection. The picture (a) depicts a tractor from municipal area collecting garbage that is collected on the street side while in the second picture (b) a scavenger, so-called garbage pickers is separating the waste that has economical value such as metal and plastics.

### 3.1 Sources of waste production

Municipal solid waste is characterised depending upon the various factors such as pattern of consumption, eating habits, lifestyle and cultural practice of inhabitants, climate and economic status.

A report published by Asian Development Bank in 2015, is based on a sample size of 3,233 households among 58 municipalities. There was an average household waste of 170 g/capita/day in Nepalese municipalities. It states that household waste generation rates have constraints on economic status and climatic conditions. On average, institutional waste produced was 4 kg per school while offices produced 1.4 kg of waste every day. Similarly, hotels and restaurants produced 5.7 kg per day and while shops produced 1.4 kg of waste every day. Household waste accounted about fifty to seventy



five percent of the total municipal MSW produced. Total MSW calculated on the basis of population in the year 2011 and the MSW produced, it was estimated that 58 municipalities in Nepal produced about 1,435 tons/day and 524,000 tons/year waste. [4]

*Table 1. Waste management statics of Nepalgunj Municipality*

Main Features	Description
Location	Nepalgunj Municipality
Area of Municipality	12.51Sq.Km
Total Population	72,503 (CBS, 2011)
Households	15,180(CBS, 2011)
Average Household Size	6 (CBS, 2011)
Average Population Growth Rate	1.89%
Waste Characteristics of Municipal Waste	Organic Waste-69.55%, Paper-7.14%, Plastic-10.14%, Metal-0.12 Glass-3.12%, Inert-6.63, and Textiles-3.30%
Service Coverage Area	<p>Zone 1 (Daily door-to-door collection and daily street sweeping)-Core city area along the highway and major city area with commercial establishments</p> <p>Zone 2 (Daily door-to-door collection and twice a week street sweeping):Semi core area around the core city area, most of residential area with few commercial establishment but higher density of population</p> <p>Zone 3 (Weekly collection of recyclable wastes and sweeping on request): Boundary of the municipality adjoining to the village development committee and away from city core area</p>
Segregation and Storage of Waste at Source	Organic Waste: Green Bin, Recyclable Waste and Inert Waste :Red Bin
Waste Collection Schedule	<p>Organic Wastes collection Route –</p> <p>Route 1: Daily; Area covered: Ward no-1, 2, 5, 16</p> <p>Route 2: Daily; Area covered: Ward no-2, 3, 14, 15, 16</p> <p>Route 3: Twice a week; Area covered -Ward no-12, 13, 17</p> <p>Other than Organic wastes collection Route-</p> <p>Route 1: Alternate day; Area covered: Ward no-1,2,5,16</p> <p>Route 2: Alternate day; Area covered: Ward no-2,3, 14, 15, 16</p> <p>Route 3: Twice a week; Area covered: Ward no-12, 13, 14, 17</p> <p>Route 4: Twice a month; Area covered: Ward no-16</p>
Collection and transportation vehicles	5 m3 4 Mini trucks 3 tractors and 34 Tricycles
Per capita waste generation Per Day (2016)	0.287 Kg

For this thesis, Nepalgunj Municipality, which is located in the southern Nepal, was chosen. Salient features related to waste management in Nepalgunj are shown in the table 1 above. Nepalgunj is the major centre of industrial activity in the mid-western region of Nepal with 32 currently running industries within Nepalgunj Industrial Estate, out of 37 registered plus 726 commercial businesses, 74 hotels and 40 educational institutions as other defined waste generators (Nepalgunj Municipality Brochure, 2009). Different sources of waste production are discussed below in briefly.

Household waste consists of waste produced by individual household in a municipal area. Such wastes differ in composition to the waste collected by municipal system from areas such as roads, garden or institutions. Household waste can be categorized broadly into paper and cardboard which can be actively recycled, glass, plastics, decomposable waste for example outdated food items such as vegetable peeling, hazardous waste such as battery and bulky waste such as old furniture. Table 2 below shows the institutional waste composition. Similarly Figure 3 shows the same information in pie chart as Table 2.

Table 2. Residential Waste Production per month

Totalwaste (gm)	Organic	Paper	Plastic	Metal	Inert	Glass	Textile
63520.00	47,818	2,714	5,988	92	4,874	1,687	349
100%	75.28%	4.27%	9.43%	0.14%	7.67%	2.66%	0.55%

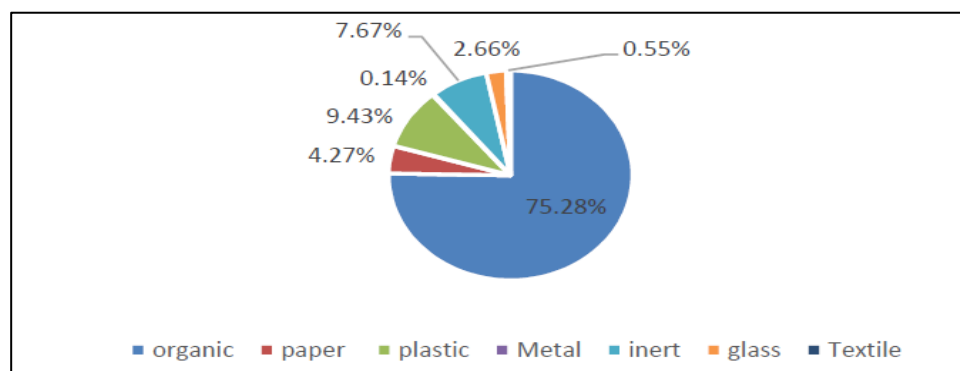


Figure 3. Residential waste composition in Nepalgunj Municipality in figure [4]

The waste generated by shops and other entities that provide services such as restaurants and hotels. This group of wastes consist mainly packaging items are decomposable wastes from restaurants.

*Table 3. Composition of waste from Commercial Establishments*

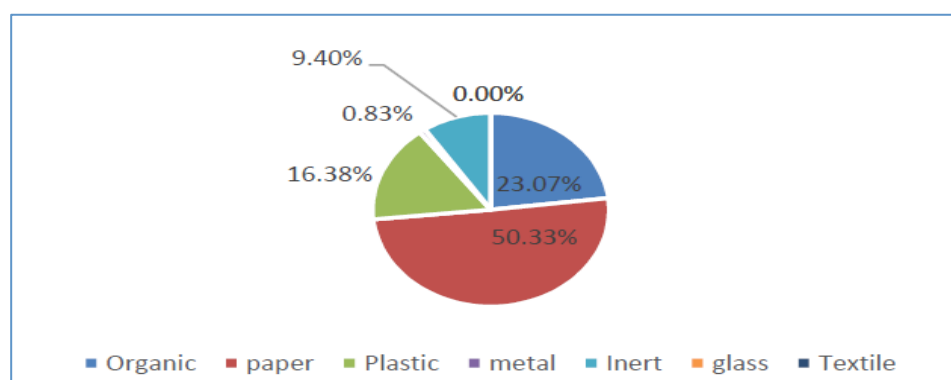
Total waste (gm)	Decomposable	Paper	Plastic	Bottle	Cloth/Textiles	Metal	Inert
1,045.60	878.50	48.70	39.50	0.40	42.00	2.50	34.00
100%	70%	5%	4%	7%	4%	7%	3%

Table 3 above shows the commercial waste production per commercial establishment in a month.

The wastes generated by offices premises and institutions that are categorized as the service sector belongs to institutional waste. There is a lack of data on the amount of waste produced by such sectors as well as the composition because there is not a clear mechanism to document waste production from such premises in Nepal. In terms of composition, such wastes are similar to household waste; this waste contains some extra amount of paper, glass and plastics. Medical hazardous waste produced by hospitals that consist of for examples, chemicals, syringes, which require special treatments before disposal also qualifies for consideration, but it will not be considered in this thesis because the thesis was conducted MSW. Table 4 below and Figure 4 shows waste produced from schools, colleges and government offices.

*Table 4. Waste produced from schools, colleges and government offices*

Total waste (gm)	Organic	Paper	Plastic	Metal	Inert	Glass	Textile
18831	4344	9477	3084	156	1770	0	0
100%	23.07%	50.33%	16.38%	0.83%	9.40%	0.00%	0.00%

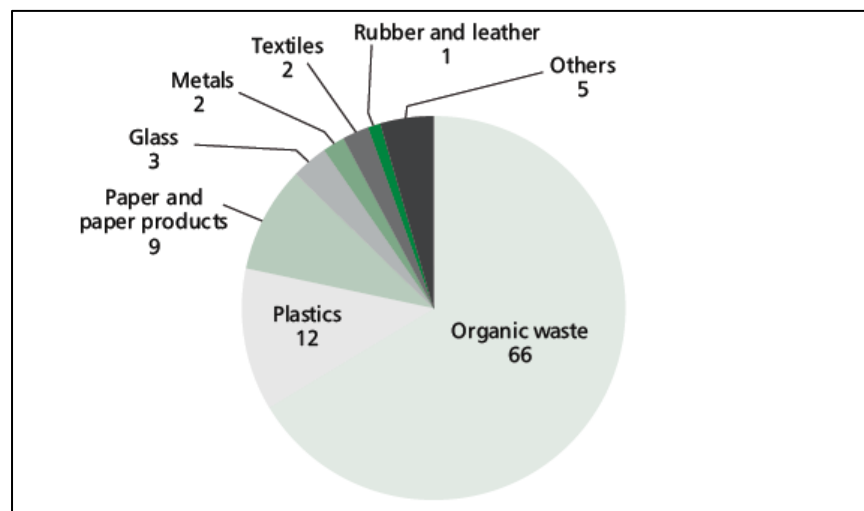


*Figure 4. Waste produced from schools, colleges and government offices [4]*

The waste generation rates based on field survey are 0.276kg/capita/day. This rate has been used in projecting waste volumes for the Municipality over a planning period of 20 years initially. A total population of 73503 based on census 2011 has been projected to a 20-year planning period at rate of increment of 1.89%. This average generation rate includes only the wastes arising from households, commercial and institutional establishments, and street sweepings. Bulk density of 400Kg/m<sup>3</sup>, 300 Kg/m<sup>3</sup> and 450 Kg/m<sup>3</sup> is used for projecting the volume of organic, recyclable and inert wastes respectively. The waste quantities have been verified with the collection system based on field survey. Calculations of waste volumes were performed to estimate the indicative quantities of municipal solid waste that need to be collected and disposed of. These quantities are calculated from the point of generation.

### 3.2 Statistics on municipal waste production

This section present statistics from different sources about the current situation of waste management in Nepal and the vulnerabilities it brings to natural resources and environment.



*Figure 5. Household waste composition in the 58 Municipalities in Nepal*

Figure 5 above shows the household wastes produced in Nepal's 58 municipalities. As shown in the pie chart the majority of the municipal waste is organic and could be easily decomposed by the producer of the waste. Such decomposed waste can be used in farms or could be sold for economic gain.

Figure 6 below compares the composition of different type of wastes produced in municipalities of mountain, hill and terai regions.

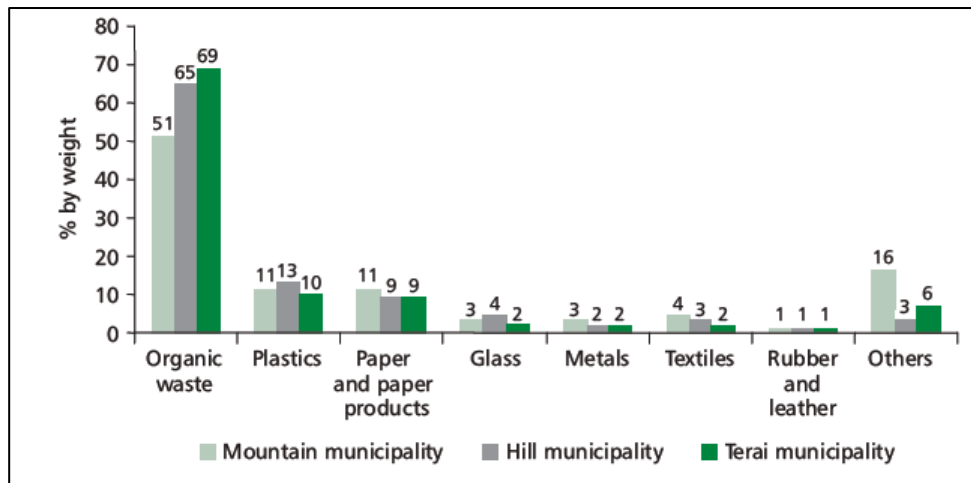


Figure 6. Composition of household wastes in different ecological regions in Nepal [4]

Similarly, Figure 7 below shows the types of wastes produced from commercial institutions from the municipalities of whole country.

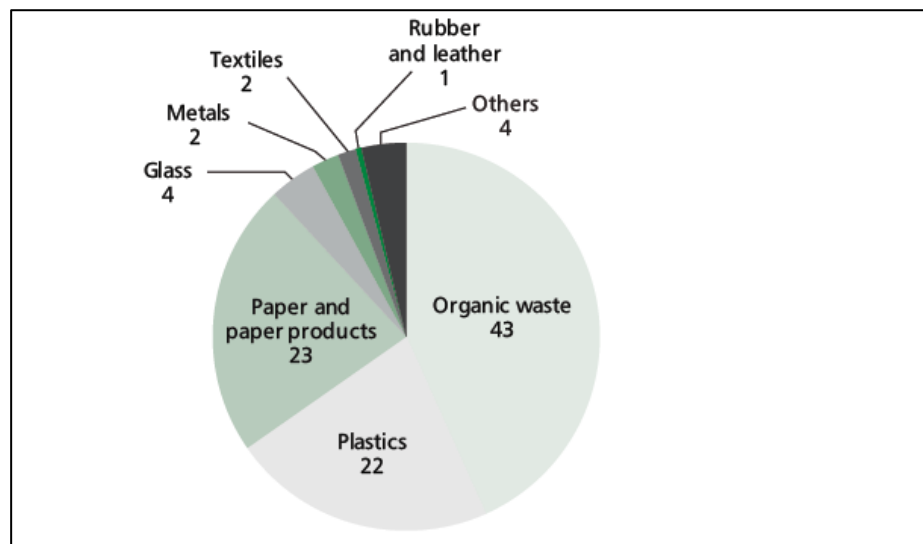
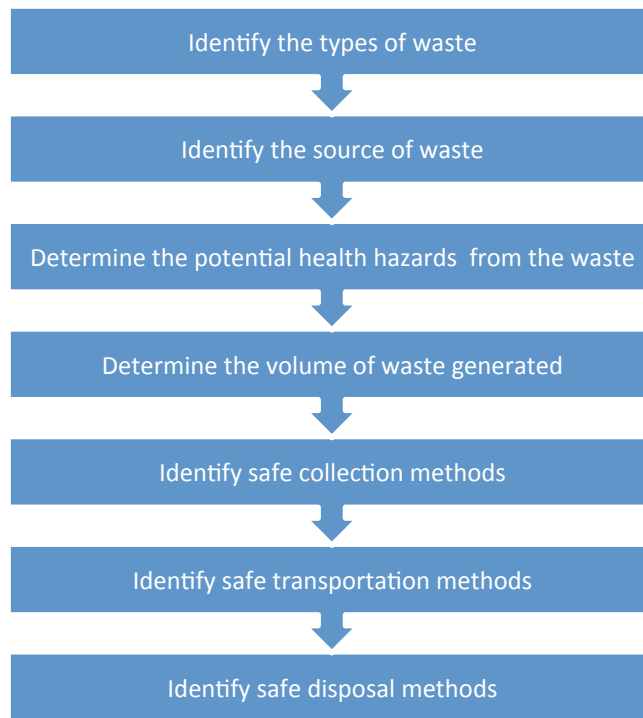


Figure 7. Composition of commercial waste in 58 municipalities [4]

### 3.3 Existing waste management systems

The waste management system is a recent topic in Nepal. Waste management was not considered of any importance in Nepal until the recent sudden urbanization in Nepal.

Most of Nepal's population was living in the mountainous region in Nepal while only a very limited population inhabited the cities in the past. Now Nepal is caused facing a tremendous pressure to manage its sudden urbanization, which has given a severe problem of municipal waste management. The existing infrastructure is not sufficient and allocation of new resources depends upon numerous factors for example the willingness of political parties, availability of road, electricity. Figure 8 shows the steps that should be taken for implementing solid waste management system.



*Figure 8. Initial steps on SWM [7]*

Some waste management that exist in the Nepalgunj municipality and represent a common trend in this field are discussed below.

### 3.2.1 Existing collection and transportation

The Nepalgunj municipality provides no other but waste collection service. The municipality does not have any primary collection service. The waste generators, mainly commercial establishments and institutions, dump their waste at edge of the road, and the inhabitants to throw away in the waste in drains or at an open space nearby. The disposed waste is collected by sweeping to make it easy to collect by a tractor. Those waste heaps made by the sweepers are collected by assistants in tractor as cleaning using primitive tools. The municipality has three tractor-trailers, each having an aver-

age capacity of 2.5 m<sup>3</sup> which makes two collection trips per day with. Most of the waste that is not being collected is waste from rural areas within the municipality. The Nepalgunj Municipality has 81 sweepers. According to the municipality these sweepers sweep city's streets on a daily basis. Sweeping is done using ordinary brooms with long handles and the waste is collected in carts. The municipality has about 100 picks and shovels, 50 baskets, 8 handcarts. Once the carts are filled, the waste is loaded on to a tractor-trailer. Highway and the other main roads are daily swept in the morning around 6:00AM. Accumulated waste heaps on roadsides (from households and shops) are picked up by tractor-trailers. Littering of streets and public spaces from shops and households starts and converts the road to the same littered condition even just one hour after the municipal cleaning services have been completed.

To transport all wastes collected from the municipal area only tractor-trailers are being used. Tractor-trailers are used to pick up the waste heaps accumulated on roadsides. The waste collected from various wards is collected depending upon the necessity between 1 to 5pm, 6 days a week. The ugly aesthetics and water logging in the Nepalgunj is one of the major problems because of waste disposed in drains and in the open space. The municipality sweepers clean drains on request and dump the waste in road edge to collect on the next day. But the large drains seem to not have been cleaned since a long time. For the integrated urban development and environmental improvement, behaviour change and commitment to clean is a must.

### 3.2.2 Existing situation of sorting, treatment and recovery

The Nepalgunj Municipality does not have any mechanism on sorting and recovery of any material. Collection is carried out from street and drainage only. The so-called door-to-door collection is also practiced to collect waste disposed by shops and hotels in the street as small heaps and cleaning of the street. Only some rag pickers and informal workers collect recyclable waste for example, whole unbroken glass bottles, some plastic bottles and materials which can be recovered or recycled easily. The inhabitants also do sale some metals and recyclable plastics and the shopkeepers do sale cardboard boxes. Most of government offices and institutions sell newspapers and books to scrap collectors.

Thus, most of the directly saleable and reusable, recyclable materials those collect by scrape dealers do not enter the waste stream as municipal waste.



According to the municipality, there are about forty two scrap dealers in the municipality. They deal for example with metal, plastics, paper, and glass. Scrapers purchase recyclable materials such as plastic, paper, and metal wastes from houses. These plastics are recycled and used to produce 200-300 kg/day recycled plastic pipe. According to Nepalgunj municipality, once the Swiss Red Cross has trained local people in different wards for household composting. At the moment, there is no composting at the household, community or the municipality level, but the training has been conducted for household composting. The community is expected to compost the household food waste after this training is completed.

### 3.2.3 Existing situation of solid waste disposal

The usual mode of disposal of solid waste in municipality is that about 31% of households dispose the household waste along the road corridor and 13% dispose of their waste in nearby dustbins. About 28% of the households surveyed dispose of the waste/garbage in open area, 13% practiced waste /garbage burning frequently to dispose certain portions of the total household waste generated and 10% of households surveyed dispose of waste within their own premises, which is an indication of the space availability for disposal. Only 2% dispose of waste at locations identified by the municipality or identified place in the locality. About 3% of the households dispose of the solid waste in the drains. The municipality does collect waste from the street, drainage and open spaces and transport it to the open dump landfill. The Nepalgunj municipality is using a private low land area formed because of brick kiln as open dumpsite. All the waste collected by the tractor- trailers is dumped in a large area located in ward 17 which is 3 km east from the municipality office. This area has been used as an uncontrolled dumping site for 25 years, simply by filling the natural depression. As the depressions are full, the area is now being used for crude dumping. The landfill site is as open dump without any control and treatment facility. There are no any structures constructed and neither any management rules. The municipality trend seems to be disposal of waste at the nearest space available. Some rag pickers do collect some valuable items from the waste.

### 3.4 Shortcoming of current systems

Solid waste is a primary unavoidable serious problem for the environment, public health and above all it requires a high cost to handle properly, but if it is reused and recycled as valuable raw material, most of the natural resources and waste generation

can be saved. In a country like Nepal, the proper understanding of issues of solid waste can be converted into viable resources if it can be properly recycled. Thus it is important to understand the current level of knowledge and understanding on recycling, reuse, land filling. Many studies on MSW have focussed on the existing physical environment problems. Only a few studies have been conducted which are basically related to current knowledge and understanding as well as relevant technologies.

Due to various factors like population growth, financial constraints, lack of environmental education, lack of public awareness, changing consumption pattern and social behaviour, the problem of solid waste management has become more crucial during recent years. In contexts of the Nepalgunj and the neighbouring Siddharthanagar municipality many uncontrolled waste dumps can be seen on streets, courtyards and other common public places with large proportion of uncontrolled waste. Existing solid waste management services, in particular, the collection and transportation facilities are not able to cope with the increasing amount of waste generated every year. The problem of MSW management in these municipalities demands immediate solution for the improvement of environment. For the management of solid waste, there is an institutional set up in Nepalgunj municipality, but due to lack of proper infrastructures and equipment municipality is not able to provide a satisfactory level of service. Hence, the municipality is only providing street sweeping, solid waste collection and transportation service to limited areas.

In the context of Nepalgunj municipality, all the wastes are collected and dumped into an open dumping area in Ward No. 17, 3km east from the Municipality Office. This area has been used as an uncontrolled dumping site for the past 25 years simply by filling the low-lands (depressions) formed by a Brick Factory (and Kiln) for long time in the past. Since the lowlands seem to have been saturated, the waste filling occurs at presently Bulbulaiya, which is practically a crude dumping site. Even hazardous and infectious hospital wastes are disposed at the site. Most of the metal and plastic scraps generated by the industries are recycled /reused by the industries. The municipality does not have any separate system to manage special hazardous wastes (such as industrial wastes, dead animals, medical wastes etc.) except for collecting them with the municipal waste and disposing of finally at the currently operated uncontrolled dumping site. Firstly the current bad practices should be demolished. For example, collecting waste from open piles on roadside is unhygienic and so inefficient. It creates many health risks and public nuisance, open dumping sites on riverbanks and roadsides and

in low lying areas, is a major cause for polluting the surrounding environment. The waste can contaminate soil as well as drinking water sources (both surface and ground water). Lack of public awareness and collection efficiency leads to disposing of garbage in the roadside drains, it clogs drainage system. Open burning of garbage emits hazardous gases including dioxin. MSW mainly consist of large an amount of methane, a powerful green house gas which is mainly responsible for causing of climate change.

## **4 Environmental impact**

### **4.1 Agricultural**

The changing life styles of people and communities have increased the consumption rate of the present day people in Nepal. Besides, the production of packed and junk food has increased tremendously increasing the variety of wastes, a bulk of which is in the form of solid waste. In many cities, solid waste generation rate has left civic agencies into a situation where they are not able to handle the disposal of waste on everyday basis. As a result, a major part of the waste remains uncollected and accumulates in the form of heaps at various locations within the inhabited areas [5]. Inefficient and improper methods of disposal result in scenic blights and create serious hazards to human health. These include pollution of air and water resources, accident hazards and an increase in rodent and insect vectors of disease.

The SMW when dispersed due to lack of better collection mechanism impacts agricultural land which in turns affects soil and water that comes in contact with the land. This in turn affects the whole ecosystem that is related to the cultivable land. One example of this is throwing of plastic waste in the areas near road. The farmer often has to deal with plastic waste during harvesting season and this also has effect in the crop they produce. The agricultural land gets degraded which results in crop loss if the hazardous solid waste is mixed with water resources that are used for agriculture.

### **4.2 Impact on ecological and biodiversity**

Unmanaged Solid waste makes the environment for plant and animal difficult. For example the chemical contained in the solid waste when eaten by birds affects their population. Algae developed in the ponds and lakes changes the ecological environment of aquatic animals and the land wild life animals that depends on it. When there is

no appropriate collection container of solid waste in the area where hiking is popular and which is frequently visited by tourists. The waste is thrown everywhere which introduces the new chemical and plastics to the biodiversity in those areas. Many rare plants are under threat because of the unmanaged solid waste in the trekking route such as the Annapurna region.

The impacts in physical environment during the construction of a landfill site are for example water and land pollution, impact due to stock piling/spoil disposal, air quality deterioration. Similarly, there are no impacts on the biological environment as the area is barren land and there is absence of flora and fauna. Also, in the socio-economic environment, the impacts are conflicts among stakeholders, the municipality and the contractor, the nuisance to the surroundings due to the operation of hot mixed plants and lying of road surface, noise and vibration due to the construction. Beside these, impacts are also seen in physical, biological and socio-economic environment during the operation and maintenance stage, some of which are leachate generation, water/air/sound/land pollution, harms to the health of public and the labors, spreading of diseases haphazardly and deterioration of the aesthetic beauty of the surroundings.

#### 4.3 Impact on water resources

The drainage network of the Nepalgunj municipality is complex due to the flat topography and not having enough capacity (under design) to drain out the storm water during peak flow, annual monsoon flooding, particularly during mid July to August. One of the major constraints in the development of this municipality is the poor drainage system although it has the potential to grow rapidly.

Only 42% of the population has effective access to the drainage system. As a result, parts of the municipality mainly Ganeshpur (Bus Park), BankeGaun in Ward No. 12, Bilashpur in Ward No. 16 and Bulbulaiya in Ward No. 17 get flooded in monsoons. About 35% of the municipal population (26,800 in 2011) are stranded inside their homes for weeks, hampering normal life and bound to live without safe drinking water. The total length of the main existing drains is 16 km including natural watercourses. In addition, there are a large number of smaller local road drains which are not functioning due to under design and obstructed by the disposal of solid waste in the existing drainage.

#### 4.4 Impact on population

Solid waste composition has changed in the municipal areas due to rapid urbanization and increasing economic prosperity. Biodegradable waste which is more than 70% is gradually reducing and replaced by non biodegradable materials. The proportion of wastes is shown in the waste generation table of the Nepalgunj Municipality. This type of waste can only be recycled or disposed of through special processes. Due to these reasons, the task of handling solid waste has become a highly specialized managerial task.

In most of the cities, waste comprises non-combustible vegetable and meat wastes, because easily combustible wastes such as cardboard, paper, cloth, and plastics which have an economical value after selling it are already eliminated at source or by rag pickers. Once waste reduction is performed the next step is recycling and transformation technologies, the disposal of solid waste in landfills remains a significant component of an integrated waste management strategy.

Land filling is the practice that has been in operation in some municipalities of Nepal but in an unsanitary manner. Besides, the consideration of the environmental parameters in designing and developing these projects has been neglected. Municipalities have thus started to address the MSW issue, for a number of reasons, including citizen concern and as per Environment Protection Act and Regulation and SWM Act and Regulation.

The questionnaires collected for this thesis project has shown that workers who are indulged in handling, placing and lives near disposal sites which are often contaminated with gastrointestinal parasites, worms and related organism. Contamination of this kind is likely at all aspects where waste is handled where the wastes are handled there is a probability of contamination. Various diseases like amoebic and bacillary dysenteries due to the pollution can occur among the population.

Public health, the quality of environment both are benefited substantially and directly by implementation of modern solid waste management practice modifications in the existing system, with the focus being on increasing system efficiencies.

Examples of such improvements includes making changes to the collection routes so that the routes are efficient, certain modifications must be made in the collection vehi-

cles so that they are suitable for such purpose , and reductions are necessary in the equipment downtime, and public education. Public education involves an action that produces materials using mass media that encourage people to reduce litters. [6]

#### 4.5 Health and sanitation

Diarrhoea and respiratory infection are commonly found diseases in the area of the Nepalgunj municipality where waste management not conducted well. Irregular staff along with insufficient medicine in the health institution is further deteriorating the situation. It is seen that there is one sub health centre in each of the affected VDC.

Most of the people use field and open places for defecation, whereas only few people use proper toilets. Moreover, there is no proper waste management system. People dispose of waste materials for example in public places, road, and field.

An on-site system is one that treats and disposes wastewater on the site that the wastewater is generated. However, the system in operation in the Nepalgunj town is nearly a hybrid off-site system as it relies on disposal off- site haphazardly.

The typical sanitation system consists of a sealed septic tank which discharges direct to a drain. Private suppliers provide septic tank emptying facilities. There is no effective control on the dumping of the contents. The main constituent of MSW is organic fraction; its potentially adverse effect impact is upon environment quality as well as health of public. Organic source provides food and shelter for rodents and vector insects. The unusual form of foul odours and unsightliness are the outcome of degraded environment by MSW. These effects are not confined to only disposal sites, they pervade the surrounding sites as well as the wastes which are generated, spread, or accumulated until an organic matter is properly managed, its adverse effect will continue unless it is fully stabilised and turned into decomposed form.

Improper management of the intermediate decomposed product can be the main source for contamination for air, water and soil resources.

## 5 Sustainability analysis

The SWM is a long running process which involves a great deal of public participation and raising consciousness and awareness among general public. But it also involves understanding the ability of a nation to tackle the problem and its readiness to manage the waste. Data on waste production, waste production per capita, composition of waste are necessary for a better analysis of plans to manage the waste. However, in the case of Nepalese municipalities these data are lacking. Thus, this thesis focuses on sustainability analysis discussing the readiness of Nepalese municipalities to tackle waste management and making suggestions on the available and possible solution in the context of Nepal.

### 5.1 Economical, environmental and technical feasibility analysis

The waste management hierarchy and the broader principles and concepts of sustainable analysis are well exemplified if the generation of waste is prevented and the developed waste is well managed. For the proper framework and implementation of waste management, five important pillars of waste management should be considered:

- Improvement of economic efficiency
- Reduction of budget needed for solid waste collection services
- Reduction or elimination of adverse impacts on health and general environment
- Implementation of more attractive and pleasant human settlement
- Creating of employment opportunity and elimination of poverty.

The concept plan developed for the improvement of the solid waste management system in the Nepalgunj and its neighbouring municipality should be based upon the Integrated Solid Waste Management principle covering not only the final disposal facility at the sanitary landfill site but also the equally important aspects of waste reduction and segregation at the source, collection, material recovery and final disposal. All elements should act as a coordinated and integrated whole with the aim of preventing and mitigating environmental pollution, causing minimum environmental impact and protecting public health.

Principle of Integrated Solid Waste Management system (ISWM) is an all round system for reducing the waste, preventing the waste, recycling, and composting if possible and

disposing waste. The effectiveness of ISWM depends upon its consideration on prevention, recycling and management of solid waste so that it can protect human environment and health. A thorough evaluation of local needs and conditions for proper selection and combination of the most appropriate waste management activities for a certain condition is determined. Waste prevention, recycling and composting, combustion and disposal of waste in well designed, managed and constructed landfills are key activities that are involved in ISWM. Successful implementations of each of above activities need proper planning, financing, arrangement of transportation infrastructure and collection methodologies. These key activities are discussed in the following sections. [7]

Figure 9 below shows major activities involved in integrated solid waste management. There is a check-and-balance between management system and proposed activities. Similarly, figure 10 below shows setup for institutional waste management system.

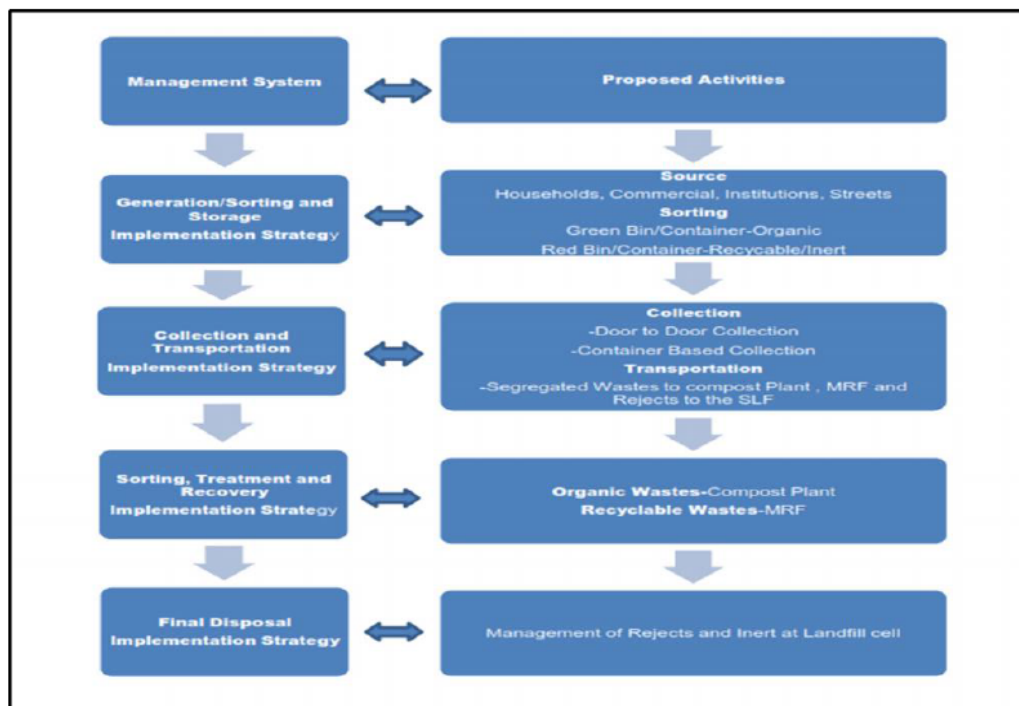
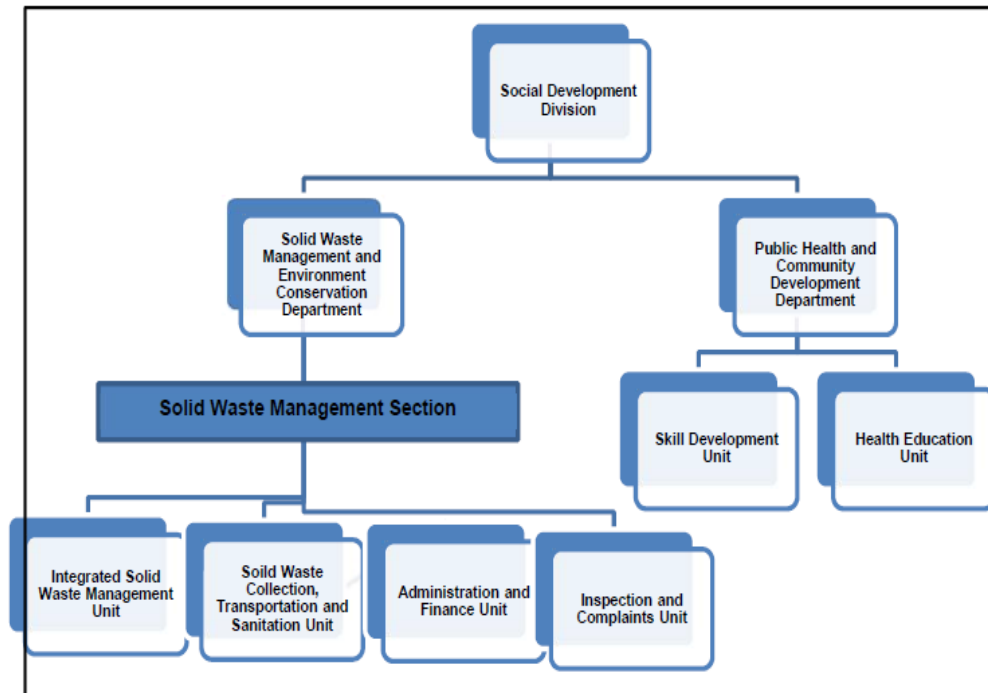


Figure 9. ISWM activities





*Figure 10. Institutional setup for solid waste management*

The processes for ISWM are listed below:

- Waste generation, collection of waste from collection point, transportation and disposal methods should be adopted by a community
- Evaluation of such above mentioned methods so that these can be revised to reduce the impact

To achieve the objective of managing solid waste of the Nepalgunj Municipality, design approaches taken into account are as follows:

- a) Integrated Solid Waste Management should be applied to municipal waste. ISWM. ISWN finds it application in the area where there is a need for waste reduction and management of waste that is left behind after reduction
- b) The 3R Principal (Reduce, Reuse and Recycle) should be actively followed with aiming to create awareness among the people and with principle such as Polluters Pay Principle where someone who pollutes a public place is liable to fines.

The Nepalgunj Municipality is responsible for SWM measures in the entire municipal area. The institutional set up has to ensure both financial sustainability and environmental compliance and responsibility with continuous up-dating. Consequently, the day- to-day operation and maintenance costs should be covered by a service fee which has to be collected from the waste generators. In addition, the Environment and Hy-

giene Section has to take over environmental and legal safeguard issues along with solid waste management with the national standard. [8]

Comprehensive and target-oriented institutional strengthening, HRD and capacity building has to enable the municipality to implement the SWM strategy. The municipality has to provide a proactive SWM related education to the general public in close cooperation with residents and key stakeholders including the local youth club, NGO. There is an urgent need to change the very bad habit of throwing SWs into roadside drains/storm drains, improve source separation with maximum on-plot management depending upon available situation and delivery of source-separated waste fractions to the formal or informal SWM services.

As a strategy, cost-effective and efficient waste minimization at source by all waste generators should be maximized (i.e. reduction of materials to be discarded as waste), through the following steps:

- Source separation in different fractions (compostable, recyclables, landfill waste, and others including hazardous wastes) on HH level;
- Maximum on-plot management, e.g. household composting of organics for private use etc. depending upon available space of individual households
- Delivery of source-separated wastes to the collection services provided instead of discarding
- Appropriate door-to-door collection service (mainly in city core areas) rather than providing container service or even roadside pick-up service as currently practiced combined with routine street sweeping and cleaning of roadside drains

Precondition for the separate treatment of different waste types is the source separation into two different waste fractions. The municipality has to be in position to improve performance continuously. Sufficient transport capacity has to be established for daily transport of collected waste to processing plant and landfill site. Parts or entire service can be contracted out to NGOs, CBOs or private enterprises. The rehabilitation of the existing dump site has to follow environmental responsible standards and has to reduce emissions as an immediate task. The site, construction and operation of a new sanitary landfill have highest the priority.

Health Care Waste Management (HCWM), Hazardous Waste Management and Commercial/Industrial Waste Management has to be operated according to the highest possible environmental and socially acceptable standards. Legal and institutional pre-conditions have to be set and supervised by the Environment & Hygiene Section of the Municipality. Composting will be encouraged at the household level, or by indirect support and supervision. In addition, bio-waste will be composted at a centralized pilot composting plants.

Moreover, the following programs should also be adopted:

- Awareness campaigns, institutional building and capacity building;
- Separation of wastes (bio-wastes for composting, recyclables, remaining waste to be disposed at the landfill site) and primary collection
- Transport
- Recycling and treatment/processing facilities with sorting, shredding and processing including a waste transfer station
- Construction of Sanitary landfill cells at Hirimuniya VDC at Telenpurwa for more than 20 years including liner system, leachate and gas collection, treatment and disposal systems.

## 5.2 Methodologies to reduce waste production

In order to propose a Solid waste management plan and infrastructure / equipment for ISWM systems for Nepalgunj Municipality, the following were considered:

1. Projected populations for the design period based on the census
2. Projected MSW quantification and composition as per field survey data
3. Current and projected per-capita waste

Several maps and other information have been studied to collect data within the search radius. Some of the important maps and data are listed below:

1. Topographic maps
2. Land use
3. Transportation maps
4. Geologic maps
5. Rainfall data, temperature and sunshine

In order to undertake a detailed design, the following surveys and investigation have been carried out:

a. Subsoil / geotechnical investigation of proposed site

- Stratification of subsoil – type of soil and depth
- Depth to ground water table and bedrock
- Permeability of various strata beneath the landfill
- Strength and compressibility properties of subsoil
- Extent of availability of liner material, drainage material, top soil, and protective soil
- Subsoil properties along approach road.

b. Ground water investigations

- Depth to groundwater table and its seasonal variations
- Ground water flow direction
- Baseline ground water quality parameters – all drinking water quality Parameters

c. Topographical survey

A topographical survey of the landfill site and a detail engineering survey of access road have been carried out for detail design of physical infrastructure for proposed ISWM.

d. Geological & seismic investigations

Geological investigations have been carried out to delineate the bedrock profile beneath the landfill base based on geological map of the region.

e. Environmental investigation

A detailed EIA is in process to determine the possible environmental impact and possible mitigation measures. For this a TOR and a scoping document is under process for approval.

f. Traffic investigation

Traffic investigations have been conducted on secondary information to identify peak traffic volume as well as the quality of existing roads for route planning of waste transportation.

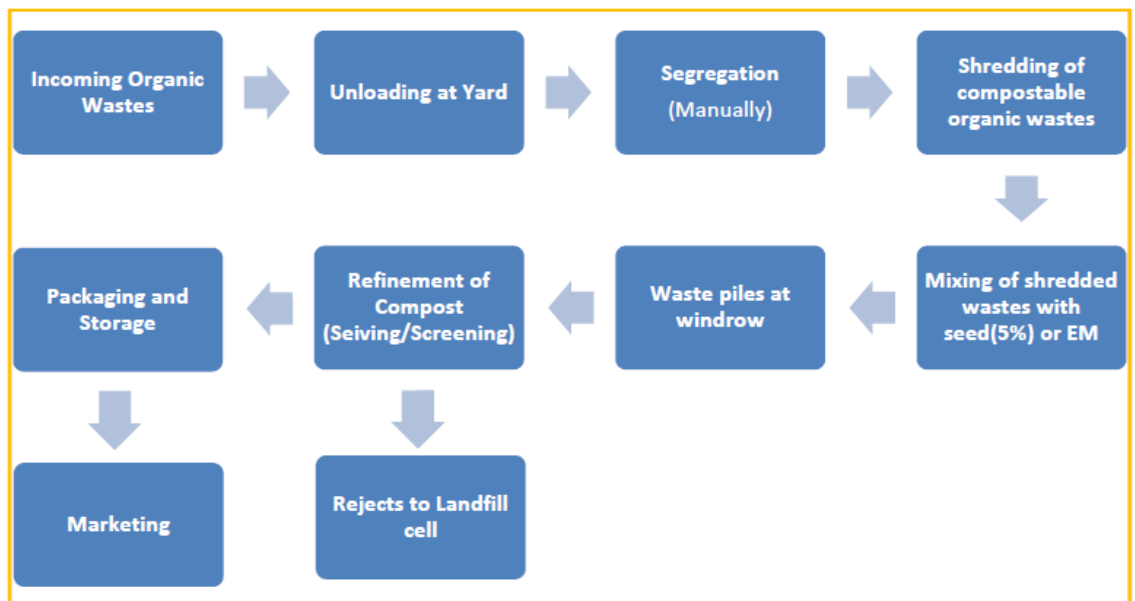
g. Waste characterization

Knowledge of waste characteristics is essential in selecting and designing the waste collection and transportation vehicles as well as waste processing and disposal facilities. Waste characterization was normally conducted as a part of waste management studies. Waste from all sources was studied for the following properties: composition; per capita generation and waste quantity.

The following process should be followed for creating a central composting facility:

1. Organic wastes reception and pre-processing
2. Windrow composting
3. Process flow

Figure 11 below shows a flow chart which shows the process of composting in a compost plant which uses organic waste to produce bio-energy.



*Figure 11. Flow chart showing composting process at compost plant*

Materials Recycling Facility (MRF) is a facility to receive, sort, process and store recyclable materials to be shipped and marketed to end-users. A variety of material categories serve for processing facilities designed to deal with source-separated materials. At MRF the recyclable fraction of the municipal solid waste (MSW) would be separated and temporarily stored for sale in the market or for remanufacturing. MRF would be crit-

ical for reducing the waste going to the landfills, and/or to achieve reduction by maximizing processing as well as recycling.

The nature and design of each unit process accommodate the physical and chemical characteristics of the particular materials or types of materials for which each is intended. Because most discarded materials have certain characteristics in common, basic processing principles can be applied.

In Nepalgunj 17% waste is recyclable waste consisting of the paper plastic glass, cloths and metal portion. The MRF aims to separate those from the rest and collect for sale in market. It is assumed that 10% of total recyclable will be reduced with segregated waste initiation and rest 20% of total transported comes as wastage or non-recyclable. Only 12% of total recyclable will be recycled at this MRF facility. Most part of the waste come in MRF is plastic and paper with the minimum quantity of metal, textile and inert materials.

### 5.3 Expected improvements

Considering the lower quantity of recycles, it is not feasible to use a sophisticated recovery system, a Material Recovery Facility (MRF) is recommended in the case of Nepalese municipalities. Hence, a very simple and cost-effective labour-intensive waste recovery system will be installed. Figure 12 describes the process of MRF in a flowchat.



Figure 12. Flow chart showing Process of Material Recovery at MRF

The separated waste collected in a red vehicle is dumped in the yard. Some large size paper and plastic waste like paper packaging boxes and plastics, some bottles and metal canes will be manually sorted at yard. The residue of small pieces of paper plastic, metal and textile waste are supposed to be abandoned and transported to landfill site for final disposal.

Sanitary land filling is the process of isolating the waste from the surrounding environment until it becomes harmless through biological, chemical and physical processes of nature to minimize exposure of the detrimental effects of solid waste to humans and environment. Municipal sanitary landfill site should be designed to manage organic, inert waste and other wastes that are not suitable either for recycling or for biological process. Table 5 below shows the requirements for sanitary landfill site.

*Table 5. System requirements of final disposal for a sanitary landfill site*

System Requirements	Proposed Activities
Final Disposal	Closure and rehabilitation of existing and old dump sites.
	Only residue waste and inert materials will be disposed at sanitary landfill site
Technology	Final disposal is done in sanitary landfill site with leachate and landfill gas treatment facility.
Policy	Construction of sanitary landfill is costly but safe.
Implementation strategy	Safe closure and rehabilitation of old and existing dump sites.
	Only residue and inert waste will be disposed in ISWMF. Private sector participation is promoted for quality and efficient operation of landfill Site.

As per Solid Waste Management Act 2011, a local body may perform out solid waste management works in partnership for example with private sector, community and NGO. Public and private sector partnership can be beneficial to design a sustainable solid waste management strategy. The ISWM system proposed by this report encourages the gradual promotion of the involvement of the NGOs and Private Sector for the door- to-door collection and transportation of waste to the landfill site, operation of landfill site introducing a fee-based collection service for SWM under the Polluters Pay Principle. [9]

Municipal solid waste management is an essential public service, which benefits all urban residents. Participation of the private sector in solid waste management is a possi-

ble opportunity. In situations in which existing service delivery is either too costly or inadequate, private sector participation should be examined as a means of enhancing efficiency and mobilizing private investment.

Privatization of collection, transportation, treatment and disposal may be evolved. This would require executing contractual agreement with the private contractor, selected through a transparent competitive bidding process. The contractual agreement would have set of regulations so as to facilitate control and monitor the operation of the contracting agency.

Some other development options available for the municipality in this regard are as follows:

- TLO/NGO/private participation may be explored in the areas of door-to-door collection of residential waste, commercial waste, institutional wastes etc.
- TLO/NGO/private participation may be encouraged in the area of awareness creating and public participation.
- Supplying vehicles on rent, supplying vehicles on lease, repairs and maintenance of vehicles at private garages are also some areas where the private sector involved.
- Transportation of waste to the ISWM site may also privatized
- Disposal of waste at the ISWM site may also be given to private sector.

Activities like inspection and recording of the quantity of incoming wastes, unloading of the Recyclable wastes at MRF for material recovery and organic wastes at compost plant for composting and their storage and disposal of septic sludge at Septage drying bed come under the activities to be conducted by contractor. The disposal of residue from compost plant and MRF in landfill cell is also responsibility of contractor. Besides, these activities contractor has to spread and compact the waste disposed of at a landfill cell by the help of chain dozer and the compacted wastes have to be covered by the soil to prevent littering and foul smell.

The leachate collected in the sump well has to be pumped to leachate collection tank as per necessity and the environmental monitoring work also has to be conducted in regular manner along with other daily ISWMF operation and management work. All these activities are performed by the contractor selected after competitive bidding.



## 6 Summary

This thesis has shown that Nepalgunj is responsible for SWM measures in the entire municipal area. The institutional set up has to ensure both financial sustainability and environmental compliance and responsibility with continuous up-dating. Consequently, day-to-day operation and maintenance costs should be covered by a service fee which has to be collected from the waste generators. In addition, the Environment and Hygiene Section has to take over environmental and legal safeguard issues along with solid waste management with national standard.

Comprehensive and target-oriented institutional strengthening, HRD and capacity building has to enable the municipality to implement the SWM strategy. The Municipality has to provide a proactive SWM related education to the general public in close cooperation with residents and key stakeholders including the local youth clubs, NGO. There is an urgent need to change the very bad habit of throwing SWs into roadside drains/storm drains, improve source separation with maximum on-plot management depending upon available situation and delivery of source-separated waste fractions to the formal or informal SWM services.

As a strategy, cost-effective and efficient waste minimization at source by all waste generators should be maximized (i.e. reduction of materials to be discarded as waste), through source separation in different fractions (compostable, recyclables, landfill waste, and others including hazardous wastes) on HH level. Maximum on-plot management for example, household composting of organic waste depending upon available space of individual households is suggested. Delivery of source-separated wastes to the collection services provided instead of discarding. Appropriate door-to-door collection service (mainly in city core areas) rather than providing container service or even roadside pick-up service as currently practiced combined with routine street sweeping and cleaning of roadside drains.

The following points should be considered for proper management of MSW:

- Awareness campaigns, institutional building and capacity building;
- Separation of wastes (bio-wastes for composting, recyclables, remaining waste to be disposed at the landfill site) and primary collection;
- Transport; recycling and treatment/processing facilities with sorting, shredding and processing
- Construction and operations of wastes for final disposal.

## **7 Conclusion**

The management of municipal solid wastes (MSW) in South Asian cities has many problems. Nepal has equal or graver situation in this field. The regulations practised in Nepal practicing are also not perfect and the existing collection facilities, management systems are not working perfectly to meet the requirements. The municipal solid wastes which are generated in sources are mixed waste system and are being collected without separation. The treatment facilities in most of the municipalities are limited and the collected wastes are mostly dumped haphazardly in open areas. The government, NGOs, CBOs and private sectors are working hard in this field, but the achievements so far are not significant or still much needs to be done.

It is recommended to encourage implementing the waste separation and recycling program at sources: households, commercial centres and institutions. The strategy of separation should fit the appropriate waste collection and disposal practices. There is a need to promote public education, awareness program at local levels, schools and among women's and mothers' groups with an introduction of 3R concept in general SWM, trainings and workshops. The waste hazards should be made known by the society through the different emerging channels such as social media and FM radios so that people will understand the emerging need to manage solid waste.

There should be an initiation for education and training program in fostering technical and administrative capabilities to the local government and the private personnel. The separate collection of hazardous waste will only be possible if there is development of such separation facilities and a safe disposal facility of hazardous waste. Hence, there is a need for the development of such an infrastructure so that the emerging public awareness can take benefit of those existing facilities to solid waste management. It can be concluded that the existing culture of waste management needs improvements, which can be achieved by the combined initiative of citizens and government agencies working together for awareness creation and waste management infrastructure development.

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**Appendix 1. Composition of household waste**  
(Data from Asian Development Bank)

## Composition of Household Waste in the 58 Municipalities (%)

	Municipality	Organic Waste	Plastics	Paper and Paper Products	Glass	Metals	Textiles	Rubber and Leather	Others
1	Amargadhi	71.50	9.13	11.88	1.35	0.21	3.79	1.04	1.09
2	Baglung	40.44	24.18	15.83	8.19	2.36	3.92	2.80	2.28
3	Banepa	68.11	11.19	9.14	1.33	1.83	1.19	0.32	6.90
4	Bhadrapur	72.99	11.58	8.04	0.00	0.00	6.27	0.62	0.50
5	Bhaktapur	77.48	8.52	6.79	0.55	0.79	0.69	0.00	5.19
6	Bharatpur	78.96	4.63	7.84	3.08	1.74	2.32	1.00	0.43
7	Bhimdatta	48.17	8.16	5.99	4.92	1.13	2.30	0.00	29.32
8	Bhimeshwor	56.68	5.56	8.63	0.00	0.00	0.00	2.58	26.55
9	Bidur	70.19	12.04	7.21	3.70	0.15	5.62	0.00	1.09
10	Biratnagar SMPC	85.77	5.05	5.18	1.03	0.22	1.00	0.43	1.32
11	Birendranagar	73.95	11.06	10.15	0.94	1.08	0.76	0.06	2.00
12	Birgunj SMPC	58.48	13.70	7.44	9.99	1.06	0.00	0.00	9.32
13	Butwal	74.60	8.82	5.73	1.99	1.57	1.57	1.42	4.30
14	Byas	70.87	10.89	7.97	2.92	0.59	2.06	1.05	3.66
15	Damak	63.40	5.35	6.51	0.66	1.06	2.12	1.23	19.67
16	Dasharathchanda	35.64	8.19	34.17	2.51	1.41	4.19	1.18	12.70
17	Dhangadhi	68.13	13.11	10.07	2.67	1.08	0.00	2.30	2.65
18	Dhankuta	59.61	17.86	11.90	0.00	1.28	3.05	0.25	6.04
19	Dharan	58.34	15.49	11.30	2.43	6.24	2.96	0.75	2.48
20	Dhulikhel	52.61	17.65	7.11	11.10	0.53	3.88	0.46	6.68
21	Dipayal Silgadhi	43.64	15.14	9.49	19.02	3.83	5.66	2.69	0.52
22	Gaur	76.78	2.51	2.29	0.30	0.31	0.69	0.00	17.12
23	Ghorahi	80.63	8.34	5.44	0.78	0.00	0.63	2.50	1.68
24	Gorkha	48.16	12.33	20.43	2.69	0.83	0.49	0.00	15.06
25	Gulariya	56.33	9.46	5.48	1.18	7.91	0.00	2.08	17.55
26	Hetauda	50.93	18.92	18.39	2.15	0.17	2.79	0.86	5.79
27	Ilam	57.98	9.18	14.22	4.51	3.84	2.38	4.10	3.78
28	Inaruwa	56.27	5.79	6.54	1.28	0.13	0.20	0.26	29.54
29	Itahari	61.23	12.56	19.35	1.49	0.00	2.05	0.00	3.32
30	Jaleshwor	70.13	17.11	9.05	0.00	0.00	1.12	2.59	0.00
31	Janakpur	71.53	17.23	10.51	0.00	0.41	0.00	0.32	0.00
32	Kalaiya	66.60	4.36	5.38	0.93	0.49	3.14	0.41	18.69

*continued on next page*

	Municipality	Organic Waste	Plastics	Paper and Paper Products	Glass	Metals	Textiles	Rubber and Leather	Others
33	Kamalamai	62.72	11.17	7.88	3.04	2.61	1.84	1.73	9.00
34	Kapilvastu	81.72	8.52	6.36	0.48	0.36	2.56	0.00	0.00
35	Kathmandu MPC	64.24	15.96	8.66	3.75	1.72	3.40	1.12	1.15
36	Khandbari	46.82	14.76	13.33	4.90	4.94	6.85	0.40	8.00
37	Kirtipur	74.34	15.06	8.01	0.62	0.23	1.47	0.27	0.00
38	Lahan	84.52	7.93	5.61	0.10	1.04	0.00	0.65	0.14
39	Lalitpur SMPC	77.94	9.81	5.23	1.99	0.66	0.74	0.75	2.86
40	Lekhnath	59.80	9.12	10.63	10.13	1.73	0.00	0.00	8.59
41	Madhyapur Thimi	48.86	12.78	9.83	1.98	0.03	0.00	1.74	24.78
42	Malangawa	60.45	6.63	5.63	4.44	2.61	4.64	2.14	13.46
43	Mechinagar	70.19	12.87	11.93	0.92	1.73	0.00	0.86	1.50
44	Narayan	84.62	6.95	5.83	0.00	0.71	0.76	1.13	0.00
45	Nepalgunj	76.27	12.75	6.94	0.09	0.84	1.91	0.52	0.67
46	Panauti	82.95	7.82	5.06	0.00	0.00	1.78	0.47	1.93
47	Pokhara SMPC	62.65	8.80	11.61	4.54	5.74	2.21	2.82	1.63
48	Putalibazar	71.84	8.69	3.86	11.82	0.00	0.23	0.00	3.57
49	Rajbiraj	80.04	8.02	3.93	1.27	0.95	2.40	0.11	3.29
50	Ramgram	51.06	7.83	15.34	0.10	0.28	3.33	0.52	21.54
51	Ratnanagar	74.00	20.00	2.00	1.00	0.67	1.00	0.33	1.00
52	Siddharthanagar	64.15	16.54	15.22	2.09	1.99	0.00	0.00	0.00
53	Siraha	67.78	3.58	6.01	0.34	1.59	1.48	4.31	14.91
54	Tansen	44.18	10.25	10.11	6.40	5.06	3.86	3.63	16.52
55	Tikapur	61.77	9.10	12.87	3.64	6.26	6.36	0.00	0.00
56	Triyuga	55.55	4.75	18.25	0.50	3.81	2.75	2.13	12.26
57	Tulsipur	85.87	4.77	6.38	2.65	0.33	0.00	0.00	0.00
58	Waling	47.24	11.28	10.53	5.14	2.61	4.33	0.00	18.87
	<b>Average composition</b>	<b>66.37</b>	<b>11.97</b>	<b>8.95</b>	<b>3.07</b>	<b>1.88</b>	<b>2.22</b>	<b>1.07</b>	<b>4.48</b>

MPC = metropolitan city, SMPC = submetropolitan city.

Source: Asian Development Bank.