Doctoral Dissertation

Municipal Solid Waste Management in Nepal: A Case Study of Gorkha Municipality

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Summary of Dissertation

Municipal solid waste is a mounting problem for the urban areas of developing countries. The amount of global municipal solid waste generation is increasing faster than the rate of urbanization and it is expected to rise significantly over the years, especially in lower and lower middle-income countries. Although the local governments in developing countries spend up to 50% of municipal budget for waste collection and disposal, its management is far from satisfactory. Nepal is one of the least developed countries in South Asia and municipal solid waste management is the biggest challenge for the local and national government. The average municipal budget allocated for solid waste management is only about 10%, which is spent on solid waste collection, transportation and street-sweeping. Municipalities and community groups in Nepal are mainly characterized by having limited access to information, especially on improving waste management system and using waste in an economically productive way. There is no proper and effective waste collection system and only limited recycling and composting activities are practiced all over Nepal. Haphazard depositing and burning piles of waste along the roads and riversides is a common sight, causing health hazards and environmental problems. The most recent law related with solid waste management in Nepal is the "Solid Waste Management Act, 2011", which gives the local body full authority and responsibility for a proper waste management. It also gives authority to the local body to implement waste segregation at source, impose waste management fees, manage waste by composting and recycling activities, and for proper disposal of waste in sanitary landfill site. However, the law has hardly been implemented by the local governments in Nepal. Although policy implementation is a huge challenge for any government, it is very important to understand the ground issues before any policy is enforced to the public.

Before deciding upon the most effective waste management option, the current status of waste related issues should be identified. It includes how much and what kind of waste is generated, how it is managed, who are the actors involved in its generation and management, what resources do these actors already have to manage the waste, etc. Although the characteristics among urban areas of developing countries are quite common; waste management strategies should be context specific, locally sensitive, critical, creative and owned by the community of concern; as their specific circumstances may be significantly different. This is why there needs to be a comprehensive study on waste, particularly in a country like Nepal where there is hardly any study conducted that has done detailed analysis of waste generation and management practices to suggest for the most effective solution. Therefore, this study was conducted in Gorkha municipality of Nepal for a detailed analysis of solid waste situation and management practices. Gorkha municipality was selected because it is one of the least resource intensive municipalities in Nepal that does not fall under the priority of researchers or implementers, but growing amount of waste nonetheless demands proactive action. It focuses on awareness, behavior and attitude of households; who are the major contributors (75%) of waste generation; toward waste and its management.

The specific objectives of this study are: to analyze factors affecting households' solid waste generation and identify waste composition, factors influencing households' willingness-to-segregate into organic and inorganic waste, factors impacting households' willingness-to-pay for the improved waste collection service, and finally to evaluate compost making practices including its quality at the household level. In order to achieve these objectives, household survey was conducted in two phases. The first phase was conducted from November to December 2015 to gather households' socioeconomic and other waste related data through face-to-face questionnaire survey. Household sample was selected using stratified sampling technique from all the 15 municipal wards to get the best representative sample of the overall population. The total sample considered in this study is 401 households. Second phase was conducted from February to March 2016 to study the compost making practices using the subsidized compost bin distributed by the local government. Out of 300 households, who received the compost bins, 149 households were selected and interviewed. Six compost samples were also randomly selected to conduct chemical analysis to analyze the compost quality made by using household waste.

Waste characterization and composition study was conducted using one-week data of household waste. Each household were given two plastic bags that was numbered and requested to segregate organic and inorganic waste and to store it for a week. After a week, the waste was collected and taken to the municipality's disposal site. Waste was separated into eight categories and its weight was measured. While analyzing waste composition, organic waste (47.25%) formed the highest share of total waste followed by 37.52% recyclable waste that comprised of 10.38% paper and paper products, 9.88% glass, 6.92% metal, 5.39% plastic, 3.57% textile and 1.38% rubber and leather. The rest 15.23% comprised of other waste. From this study, it is estimated that in Gorkha municipality, households generate about 1,621.4 tonnes of organic waste every year, most of which are uncollected, and the rest discarded in an open dumpsite. The recyclable potential of waste is also very high, which is about 1,287.5 tonnes/year. The remaining waste generation that also includes hazardous waste is about 522.6 tonnes/year, which as of now is discarded in an open dumpsite with other wastes but should be managed in the highest possible environmentally and socially acceptable standard. The rate of household waste generation in Gorkha municipality is found to be 0.24 kg/capita/day and estimated total household waste generation of 9.4 tonnes/day. Ordinary Least Square regression model was employed to assess the socioeconomic factors impacting household waste generation. This study found that household size and household income have positive impact on waste generation, both statistically significant at 1% and thus can be important indicators to forecast solid waste generation trend.

Segregation of waste at source and separate collection of waste is the fundamental step to manage waste as the quality of organic waste and recyclable materials can be preserved, which can reduce the total amount of waste that needs to be collected and managed by the concerned stakeholders. Logit regression model was employed to identify the factors that influence households' waste segregation behavior. This study found that environmental awareness, waste collection service, willingness-to-pay, make compost, and segregated waste for a week variable are statistically significant at 1% level of significance. Income variable is significant at 5% level of significance and gender variable is significant at 10% level of significance. It was revealed that 91% of respondents are willing to segregate waste in the future, which can be trustworthy as they just had first-hand experience of waste segregation in the process of taking part in this study.

The waste collection service is provided for free and is restricted only to limited areas in Gorkha municipality. With the assumption that the collected amount from the households would help improve the collection service, this study employed Contingent Valuation method which directly asks the beneficiaries their willingness-to-pay the maximum amount. Logit regression model was used to determine the factors that influence willingness-to-pay for improved waste collection service and tobit regression model was used to determine the factors that influence the maximum amount of money that the households are willing to pay for the improved waste collection service. This study found that the majority of surveyed households (61%) are willing to pay for the improved waste collection service. The mean willingness-to-pay amount is NRs. 73.38 (0.72 US$) per month. The factors that significantly influence households' willingness-to-pay are monthly household income, education of household head, environmental awareness and waste collection service. The significant factors that influence the maximum amount of money households are willing to pay for improved waste collection service are monthly household income, environmental awareness and waste collection service.

Household composting is known to be an effective approach to manage organic waste, which reduces significant burden for the municipality to collect and manage household waste, thus minimizing the amount of waste going to the dumping or landfill site for final disposal. This study found that 56% of the surveyed households are continuing to use compost bin. The reasons for those households who are not using the bin are because of insect invasion, foul smell, leachate production, damaged bins and natural calamity. Kitchen and garden waste are the most common types of waste that were used as an input for household composting. The compost is used for crop production and flowering. Majority of respondents (82%) also perceived to have better production of vegetables in the form of size and quality after applying home-made compost. Chemical analysis of the sampled compost suggests that compost made from household waste does have nutrient content that can definitely add value to the soil when applied. However, higher level of heavy metals such as cadmium shows the importance of compost testing and to take necessary steps to improve its quality.

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Acronyms and Abbreviations

ADB	Asian Development Bank
APO	Asian Productivity Organization
CBS	Central Bureau of Statistics
Cd	Cadmium
C:N	Carbon to Nitrogen
CV	Contingent Valuation
df	Degree of Freedom
EM	Effective Micro-organisms
EPA	United States Environmental Protection Agency
et al.	And others
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GTZ	German Technical Co-operation
HH	Household
HHH	Household Head
i.e.	That is
INGO	International Non-Governmental Organization
JICA	Japan International Cooperation Agency
K	Potassium
Kg	Kilogram
Km	Kilometer
KMC	Kathmandu Metropolitan City
LGCDP	Local Governance and Community Development Programme
LMC	Lalitpur Metropolitan City
LR	Likelihood Ratio
Ln	Natural Log
Mm	Millimeter
MoFALD	Ministry of Foreign Affairs and Local Development
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
N	Nitrogen
NESS	Nepal Environment and Scientific Services (P.) Ltd.
NGO	Non-Governmental Organization
NRs.	Nepalese Rupees
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
OSCE	Organization for Security and Co-operation in Europe
P	Phosphorous
Pb	Lead
SD	Standard Deviation
SEED Nepal	Society for Environment and Economic Development Nepal
SMC	Sub-Metropolitan City
STATA	Data Analysis and Statistical Software
SWM	Solid Waste Management
SWMRMC	Solid Waste Management and Resource Mobilization Center
SWMTSC	Solid Waste Management Technical Support Center

UNEP	United Nations Environment Programme
US$	United States Dollar
VIF	Variation Inflation Factor
WTP	Willingness-to-Pay

Chapter 1. Introduction

1.1 Background of Study

Municipal solid waste (MSW) is a growing problem in the urban areas around the world that is increasing faster than the rate of urbanization. In 2002, 2.9 billion urban residents generated 0.64 kilogram (kg) of waste per capita per day, which increased to 3.45% in population and a whopping 87.5% in waste generation in 2012 (3 billion urban residents generated 1.2 kg of waste per capita per day). By 2025, it is projected that 4.3 billion urban residents will generate 1.42 kg of waste per capita per day. Furthermore, MSW generated by lower income countries are expected to increase significantly over the years than other income group countries (Figure 1.1) (Hoornweg & Bhada-Tata, 2012). It will intensify the waste management problem as this particular group of countries are the ones which lack the most in terms of technological advancement and socio-political setting favorable to overcome such condition. About 20-50% of municipal budget in developing countries is spent on managing MSW but still 30-60% of the waste is uncollected and less than 50% of its population is served (The World Bank, 2016).

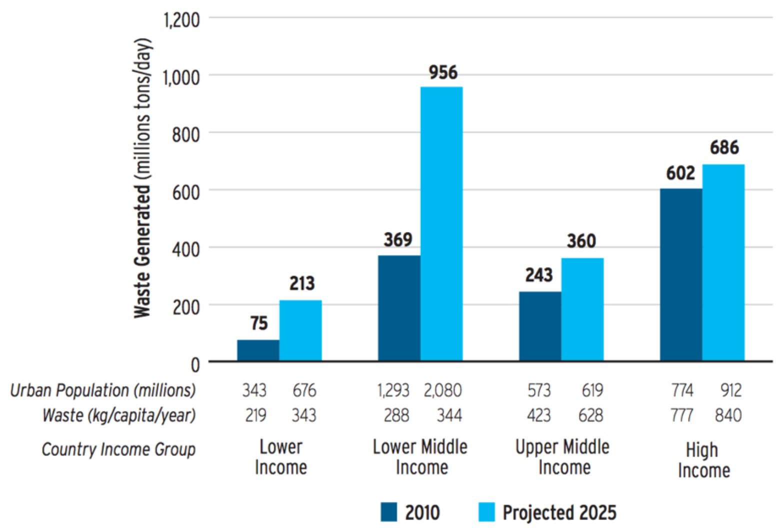

Figure 1.1 Urban waste generation by income level and year
Source: Hoornweg & Bhada-Tata (2012)

The uncollected waste is dumped indiscriminately on streets, banks of river and in drains; gets mixed with human and animal excreta; thus, contributing to flooding, breeding of insects and rodent vectors, and spreading of diseases. Even the limited amount of waste that gets collected is often disposed in uncontrolled dumpsites and/or burnt; thus, polluting water resources, air and the environment (Zurbrugg, 2002). Environmental degradation caused by inadequate disposal of waste can be expressed by contamination of surface and ground water through leachate, soil contamination through direct waste contact or leachate, air pollution by burning of waste, spreading of diseases by vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste. This has jeopardized health of humans and animals alike and is causing significant economic and other welfare losses. Needless to say, risk is more severe where waste collection and treatment is insufficient or absent (Asian Productivity Organization [APO], 2007; Hoornweg & Bhada-Tata, 2012; Japan International Cooperation Agency [JICA], 2005a; United Nations Environment Programme [UNEP], 2011).

Nepal, one of the least developed countries in South Asia, is no exception to such situation. It is inhabited by 26.5 million people with an average annual population growth rate of 1.35% from 2001 to 2011 (Central Bureau of Statistics [CBS], 2014b). Not just the rapid population growth in urban areas (Solid Waste Management and Resource Mobilization Center [SWMRMC], 2008) but increase in Gross Domestic Product (GDP) over the years from United States dollar (US$) 9.04 billion in 2006 to US$ 21.14 billion in 2016 (The World Bank, 2017) could have also contributed to growing municipal waste as number of studies have shown positive correlation between the two (Aleluia & Ferrão, 2016; Kawai & Tasaki, 2016; Palanivel & Sulaiman, 2014; Senzige, Makinde, Njau, & Nkansah-Gyeke, 2014). Municipalities and community groups in Nepal are mainly characterized by having limited access to information, especially on improving waste management system and using waste in an economically productive way (Practical Action Nepal, 2008). Within the existing solid waste management (SWM) situation, there is no proper and effective waste collection system and only limited recycling and composting activities are practiced all over Nepal (Padeco Co. Ltd. & Consultants, 2010). Haphazard depositing and burning piles of waste along the roads and riversides is a common sight, causing health hazards and environmental problems in-situ as well as downstream (Pokhrel & Viraraghavan, 2005). Thus, it is only a matter of time that waste generation will be multiplied and will further intensify the problem if not managed effectively well ahead of time. Effective and sustainable municipal solid waste management (MSWM) system can most effectively be achieved only when society itself takes the ownership (Schübeler, Wehrle, & Christen, 1996).

1.2 Problem Statement

SWM is considered to be the most important environmental problem in urban areas of Nepal. Rapid increase in population in urban areas have resulted in increasing amount of waste, making it challenging for the municipalities to manage it effectively (SWMRMC, 2008). Municipalities and community groups are mainly characterized by having limited access to information, especially on improving waste management systems and using waste in an economically productive way (Practical Action Nepal, 2008). With the existing state of SWM, there is no proper and effective waste collection system and only limited recycling and composting activities is practiced all over Nepal

(Padeco Co. Ltd. & Consultants, 2010). Haphazard depositing and burning piles of waste along roads and riversides is a common sight, causing hazardous health and environmental problems in-situ as well as downstream (Pokhrel & Viraraghavan, 2005).

1.3 Study Rationale

Before deciding upon the most effective waste management option, the current status of waste related issues should be identified. It includes how much waste is generated, what kind of waste is mostly produced, how it is managed, who are the actors involved in its management, what resources do these actors already have to manage the waste, etc. Since these are highly context specific issues, determined by a particular location's socioeconomic, political and cultural background; every situation demands a unique solution. This is why there needs to be a comprehensive study on waste, particularly in a country like Nepal where there is barely any study that has done detailed analysis of waste generation and management practices to suggest for the most effective solution.

The most recent law related with SWM in Nepal is the "Solid Waste Management Act, 2011", which gives the local body full authority and responsibility for a proper waste management. It also gives authority to the local body to implement waste segregation at source, impose waste management fees, manage waste by composting and recycling activities, and for proper disposal of waste in sanitary landfill site. However, the law has hardly been implemented by the local governments in Nepal. Although policy implementation is a huge challenge for any government, it is very important to understand the ground issues before any policy is enforced to the public. This study tries to access various factors that can influence the household (HH) behavior and practices so that policies can be implemented successfully.

1.4 Study Objectives

The general objective of this study is to analyze the current HH solid waste situation in Gorkha municipality of Nepal and identify the effective methods for its management. To meet this objective, following specific objectives will be fulfilled:

- To assess socioeconomic factors affecting HHs' waste generation and conduct characterization study of HHs' waste.
- To assess HHs' willingness-to-segregate waste, and socioeconomic factors influencing it.
- To analyze HHs' willingness-to-pay (WTP) for solid waste collection service and socioeconomic factors affecting it.
- To evaluate HHs' compost making practices using organic waste.

1.5 Justification of Study

There are some studies (ADB, 2013; SWMRMC, 2004, 2008) conducted in all the then 58 municipalities of Nepal and these studies considered only one day waste generation data and did not cover all the municipal wards. Most of the SWM related studies in Nepal are concentrated in Kathmandu valley but these studies have not covered the socio-economic aspects that can influence waste generation and management practices. Furthermore, due to lack of consistent scientific methods and different assumptions made to quantify waste generated from different sources, the findings of these studies are inconsistent. As such, there is no consistent trend of increase in per capita waste generation, and total municipal waste generation and collection. This is a common problem for many developing countries where either statistic is lacking or are inconsistent because of data sources that cannot be validated and are sometimes based on assumptions rather than scientific measurements (Miezah, Obiri-Danso, Kádár, Fei-Baffoe, & Mensah, 2015). Therefore, this leads us to question about the very authenticity of such findings and whether the concerned stakeholders should rely on it for making decisions.

Gorkha municipality was selected because of the familiarity of the author with the study area so that it will be easier to get cooperation and support from the local government and local people to conduct field work for this study. And also, given the limited budget and time-frame to conduct the field work, only one municipality was considered as a case study. Gorkha municipality represents majority of the other municipalities in Nepal in terms of waste generation, management practices, socioeconomic aspects and geographical location. It has many wards which are still under rural setting and is one of the least resource intensive municipalities in Nepal. Therefore, this study can be considered to conduct similar studies in other municipalities, particularly the newly formed ones (154 new municipalities) to understand the SWM situation and come up with the most effective solution.

This study considered weekly waste generation data of the household for the analyses and included all the municipal wards in the sample, so the findings are expected to be more accurate which can contribute in decision-making by the stakeholders, especially at the local municipality level.

This study is one of the first study in the study area and in Nepal to conduct willingness-to-segregate waste study, WTP for improved waste collection service study and assess compost making practices using the compost bin distributed by the government. The findings from this study will help the local government and concerned stakeholders to understand the relevant characteristics of households and come up with a suitable fee for waste collection service, which shall help to improve the current overall SWM scenario. This study can also be a guiding tool to conduct WTP studies in other municipalities of Nepal and other developing countries where there is no waste collection fee imposed.

1.6 Study Limitations

This study is confined within Gorkha municipality and thus may not be generalized for other municipalities of Nepal. However, similar approach can be applied to conduct similar studies. Like any other studies, this study also had financial and time limitation. Though that is the reason why sample survey is prevalent, the most important limitation of this study is the lack of information on commercial establishments. In the absence of reliable data with the local government, it was difficult to generate the minimum required sample size or quantify the representation of the sample size for this category. Hence only HH waste is considered in this study. Because of the geographical location, road infrastructure (accessibility) and lack of information about the HHs with the local government, the samples were selected purposively. Nevertheless, considering these limitations, efforts were made by the researcher to include as much sample as possible to make the best representation of the study area.

1.7 Dissertation Outline and Organization

This dissertation is divided into eight chapters. The main findings from this study is presented in Chapter 4, 5, 6 and 7. A brief highlight of each chapter is as follows:

Chapter 1. Introduction

This chapter presents the background of the study, problem statement for the study, study rationale, study objectives, justification of study and study limitations.

Chapter 2. Literature Review

This chapter presents the various solid waste management related policies that has been formulated in Nepal, various solid waste management related studies conducted in Nepal, and description and status of functional elements and strategic aspects of waste management in Nepal.

Chapter 3. Research Design

The conceptual framework for this study, description of study area, data collection and sample selection methodology, and data analysis methodology is presented in this chapter.

Chapter 4. Determinants of Household Waste Generation and its Composition Study

This chapter deals with the waste characterization and composition analysis, and factors that can influence household waste generation in Gorkha municipality.

Chapter 5. Households' Willingness-to-Segregate Waste

This chapter analyses the willingness of the households to segregate waste if the government enforces the law in near future and factors that can affect the waste segregation behavior of the households.

Chapter 6. Households' Willingness-to-Pay for Improved Waste Collection Service

A detailed analysis of households' willingness-to-pay for the improved waste collection service and factors that can influence their willingness-to-pay amount and decision is presented in this chapter.

Chapter 7. Compost making practices at household level

This chapter covers the study on compost making practices at the household level using the government subsidized compost bin and detailed analyses of the compost quality made from the compost bin.

Chapter 8. Overall Conclusion and Recommendations

This chapter again highlights the importance of this study and summarizes the major findings from this study with discussions and relevant policy recommendations. Recommendations for future research is also presented at the end of this chapter.

Chapter 2. Literature Review

2.1 Solid Waste Management Policies in Nepal

SWM law in Asian developing countries is not comprehensive and well established. The major issues are lack of awareness, technical knowledge, legislation, policies, and long-term strategy (Hwa, 2007). Similar connotation can be implied for the SWM related policies in Nepal. Before the 1980s, MSW did not pose a serious threat as it was managed jointly by the city residents and municipalities who deployed labor force known as '*kuchikars*' to collect and dispose the remaining waste (Pokhrel & Viraraghavan, 2005). With the increasing urbanization of Kathmandu valley, the problem of SWM started to occur only after 1980s and then the government started to formulate and implement SWM polices to address the growing problem.

2.1.1 Solid Waste Management and Resource Mobilization Act, 1987

Solid Waste Management and Resource Mobilization Center (SWMRMC) was the first authorized body to be established under the provision of Solid Waste Management and Resource Mobilization Act, 1987 to provide solid waste collection, transportation, storage, resource recovery and disposal activities within the three municipal areas of Kathmandu Valley [Kathmandu Metropolitan City (KMC) - the capital city of Nepal, Lalitpur Metropolitan City (LMC) and Bhaktapur municipality] that can be considered as the most urbanized area in Nepal. In other areas, there was no serious MSWM related problems, so intervention was to be done only as needed and as prescribed by the government. The act provided definition of various terminologies such as solid waste and disposal sites, defined roles and responsibilities of SWMRMC to provide guidelines to carry out SWM works effectively. According to Section 1.2.1.8, "solid waste means materials which are in a state of disuse, or which have been disposed of, or such other materials which are declared as solid waste by the center from time to time" (p. 2). According to Section 1.2.1.10, "sites for dumping solid wastes means the place of area prescribed by the center for throwing, keeping or dumping solid wastes" (p. 2). According to Section 1.2.1.9, "harmful solid wastes mean solid wastes which are harmful to health through infectious or contaminative disease or otherwise" (p. 2). SWMRMC was also responsible to formulate and implement these policies, to provide SWM services including recycling of the collected waste by producing briquettes, compost fertilizer or bio-gas (Solid Waste Management Technical Support Center [SWMTSC], 1992).

2.1.2 Solid Waste Management and Resource Mobilization Rules (1989)

Solid Waste Management and Resource Mobilization Rules was enacted in 1989 by the then Government of Nepal exercising the power conferred by Section 7.6 of Solid Waste Management and Resource Mobilization Act, 1987 to fulfill the objectives of the act. The Rules provided detailed guidelines for SWMRMC to implement the act. Although the Rules stated that SWMRMC will be responsible to provide SWM related services, but no guidelines and responsibilities were given to the local government for this purpose. It was also entitled to prescribe dumping site that does not provide any inconvenience to the public (His Majesty's Government of Nepal, 1989).

2.1.3 German Technical Co-operation Project (1980 – 1993)

German Technical Co-operation (GTZ) project was the first comprehensive SWM related activities in Nepal which took place from 1980-1993. It was divided into 4 phases (JICA, 2005a):

- Phase 1: 1980 – 1983
  - Creation of Solid Waste Management Board to carry out all SWM related activities in Kathmandu, Lalitpur and Bhaktapur.
  - Established and operated waste collection system in 16 wards of Kathmandu and Lalitpur.
- Phase 2: 1983 – 1986
  - Establishment of Teku compost plan in Kathmandu.
  - Construction and operation of Gokarna sanitary landfill site.
- Phase 3: 1986 – 1990
  - Solid Waste Management Act (1987) which transformed Solid Waste Management Board into an autonomous unit and SWMRMC was established.
  - Passing of SWMRMC by-laws.
  - Attempted to make SWMRMC financially self-reliant through the sale of compost and the collection of service charges from various sources.
- Phase 4: 1990 – 1993
  - GTZ advocated transfer of SWM responsibilities (collection and transfer) to municipalities. It also promoted joint ownership of SWMRMC by Kathmandu, Lalitpur and Bhaktapur while maintaining the center's legal identity.
  - Such decentralization of SWM responsibilities were not implemented, and GTZ terminated support to SWMRMC on July 1993.

2.1.4 Solid Waste Management National Policy 1996

Solid Waste Management National Policy focused on the following areas:

- Minimize environmental pollution.
- Solid waste as a resource.
- Raise public awareness and public participation.
- Involve Non-Governmental Organizations (NGOs) in sanitation.
- Recycling.
- Minimize generation of solid waste.
- Privatize SWM work for effective operation.
- Authority to local government for SWM in its jurisdiction, collect service charge, punishment/imposing fine for the violators.
- Separate unit concerning sanitation work in each municipal corporation, sub municipal corporations, municipality and town-oriented village development committees (Ministry of Local Development, 1996).

2.1.5 Environment Protection Act, 1997

Environment Protection Act re-defined the following terms:

- "Wastes means the liquid, solid, gas, slurry, smoke, dust, radiated element or substance, or similar other materials disposed in a manner to degrade the environment." (Section 2 (h))
- "Disposal means the act of emission, storage, or disposal of sound, heat or wastes." (Section 2 (i))

(His Majesty's Government of Nepal, 1997)

It also emphasized on the following areas:

- Prevention and control of pollution
- Environment inspector
- Compensation
- Punishment

2.1.6 Environment Protection Rules, 1997

Environment Protection Rules further defined the following areas:

- Qualification and duties/responsibilities of inspector.
- Waste management – prescribed areas for storage and disposal.
- Provision for hazardous waste and lethal waste (radioactive, biological lethal substance).
- Provision to lodge complaints.

  (His Majesty's Government of Nepal, 1999)

2.1.7 Local Self-Government Act, 1999

Local Self-Government Act emphasized on the following issues:

- Municipalities with substantial urban population have the core operational responsibilities in managing solid waste within their jurisdictions.
- Ward Committee needs to:
  - Keep clean roads, ways, bridges, drainage, ponds, lakes, wells, temples, public places, etc. within the ward.

- Arrange for disposal of waste, dirt and rotten materials; keeping streets and corners within the ward clean and make arrangements to encourage the inhabitants of the ward for maintaining sanitation.

- Municipality needs to:
  - Assist in environment protection acts by controlling water, air and noise pollution generated within the municipality.
  - Carry out sanitation program in the municipality.
  - Carry out and manage the acts of collection, transportation and disposal of garbage and solid waste.

  (Ministry of Foreign Affairs and Local Development [MoFALD], 1999)

2.1.8 Solid Waste Management Act, 2011

Solid Waste Management Act, 2011 is the latest and most comprehensive SWM law till date. The salient features of this act are follows:

- SWMTSC was established, which is responsible to provide technical support to local bodies and also conduct studies, research and development in SWM sector.
- Full responsibilities to the local government for SWM related services.
- Comprehensive definitions of terminologies related with SWM, one among which is the definition of solid waste that has been defined as follows:

> Solid waste means the domestic waste, industrial waste, chemical waste, medical waste or hazardous waste. This term shall also include substances including solid, liquid, gas, semisolid, smoke, dust, and materials used by the electronic and information technology, which are not in a position to be used forthwith, thrown or rotten, or disposed causing degradation of the environment; or other similar types of objects

or posters or pamphlets posted in public places in an unauthorized manner, and other objects which have been declared as waste by the Government of Nepal through the publication of notices in the Nepal Gazette from time to time. (p. 3)

- Similarly, recognition of different types of waste (industrial, chemical, medical and hazardous waste). Guidelines about how and who should manage the waste has also been defined.
- Waste should be segregated at source into organic and inorganic waste and the waste producer should bring the segregated waste to the collection center.
- The local government may designate a suitable collection center in each street or colony.
- Sanitary landfill site should be prescribed by the local body for final disposal of waste.
- Waste should be minimized at source and further reduced by reusing and recycling.
- There should be an involvement of the private sector and community for effective SWM.
- Service fee may be realized by the local body to manage waste.
- Pollution control and the monitoring of SWM activities should be done as much as possible by the local body.
- SWM Council shall be formed to determine the policy to be adopted with regard to SWM.
- Detailed functions, duties and power of SWMTSC has been defined.
- Provisions for offences and punishment to the violators.

(Government of Nepal, 2011)

Although the latest act is more comprehensive than any other preceding acts, there are still some loopholes. Although the local government are given full responsibility for SWM related services, they are not mandated to prepare SWM plan as there is no clear deadline set for it. There is no mandatory waste diversion activities and target set to divert waste from going to the landfill site, door-to-door waste collection system, establishment of material recovery facility and community service for the violators remains optional. Similarly, there is no binding obligation to convert open dumpsites into controlled dumpsites, plan to close controlled dumpsites in later phase and establish sanitary landfill for final disposal. It also includes important provisions to ensure the protection of public health and environment, to follow the principles of 3Rs (reduce, reuse and recycle), involve private sectors and community, increase public awareness, and punish violators. But these provisions are not defined properly and non-mandatory in nature which can easily lead to the ineffective implementation of the policies by the government.

2.2 Status of Solid Waste Management Practices in Nepal

Table 2.1 provides comparison of three major SWM studies conducted in 2003-2004, 2008 and 2011-2012 in all the then 58 municipalities of Nepal and shows the status of SWM related practices and how it has changed and developed over the years.

Table 2.1 Status of SWM practices in Nepal

Variables	Study period		
	2003 – 2004	2008	2011 – 2012
SWM services by municipality (in no. of municipalities):			
Street & public place cleaning	57	57	N/A
Waste collection & transportation	55	55	56
Door-to-door collection	19	20	24
Share of HH waste to total municipal waste	75%	N/A	50-75%
Disposal practices in municipalities (in no. of municipalities):			
River banks	21	23	13
Roadside piling	-	-	1
Temporary open piles	19	27 (Open dumping)	6 (River banks and open dumping)
Dumping site	10	-	-
Landfill site	-	8	6 (sanitary)
Controlled dumping	-	-	5
Not available	8	-	2
Composting, mostly in rural areas (in no. of municipalities):			
At HH level	25	30	30% (17)
Municipality	4	6	6
Local club/NGOs	3	-	-
Community	5	4	8
Planned	3	-	-
Not available	-	22	-
Waste segregation	**-**	**-**	▪ 30% of surveyed HHs ▪ Some promotional activities for waste segregation at source by 21 municipalities ▪ Waste minimization programs in 32 municipalities

Medical waste	Managed by most hospitals by burning, except in some municipalities where it is mixed with municipal waste.		
Other major issues	▪ No separate section to look after SWM in 7 municipalities	-	▪ No separate section to look after SWM in 17 municipalities
	▪ Lack of equipment and technical manpower, lack of capacity building of manpower, no environmental specialist in 33 municipalities	▪ Lack of equipment and technical manpower, capacity building of manpower, no environmental specialist in 72% of municipalities	▪ Lack of technical and human resources, statistical records, proper planning, insufficient budget and political leadership
	▪ Lack of data, statistical records, research, awareness and information, proper planning in 17 municipalities	▪ Lack of data, statistical records, research, awareness and information, proper planning	▪ Awareness programs for SWM staff in only 37 municipalities ▪ 65% HHs not aware of SWM program implemented by their municipality ▪ 45% municipalities lack annual plan, 67% have not formulated short-term plan and 62% lack midterm or periodic plan
	▪ Insufficient budget in 26 municipalities	▪ Insufficient budget in almost 50% of municipalities	-
	▪ No public private participation		-
	▪ Political issues		-
Recommendations	▪ Segregation of waste at source into compostable and reusable/recyclables		▪ Develop clear policy objectives, guiding principles and implementation strategy with timeline, and monitoring and evaluation mechanism to provide clear strategic direction to local bodies
	▪ Composting could be the best way to manage municipal waste as almost 62% are organic waste (institutional rather than HH in urban areas)		
	▪ Awareness program on waste and its impact on health and environment		
	▪ Paper and plastics should be reused or recycled		
	▪ There is a need of technical and financial assistance to develop an efficient SWM system		

	▪ Municipalities should have SWM by-laws and guidelines		▪ Promotion of 3Rs, mainly composting to reduce waste significantly for final disposal ▪ Public awareness on benefits of waste segregation and encourage public participation ▪ Increase coverage of fee collection and level of service to recover SWM cost, as 82% of HHs are willing to pay fee for better service
Source	Diagnostic Report on State of Solid Waste Management in Municipalities of Nepal (SWMRMC, 2004)	Baseline Study on Solid Waste Management in Municipalities of Nepal (SWMRMC, 2008)	Solid Waste Management in Nepal: Current Status and Policy Recommendations (Asian Development Bank [ADB], 2013)

2.3 Importance of Organic Waste Management

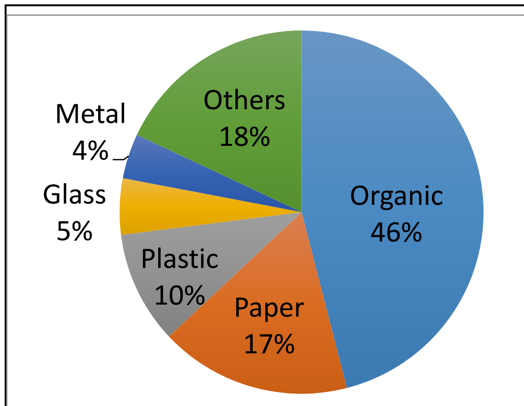

Figure 2.1 Global MSW composition
Source: Hoornweg & Bhada-Tata (2012)

Among various types of waste, organic waste has the largest share on the global average MSW generation (Figure 2.1) and largest share for lower income group countries as well (Figure 2.2). Organic waste when decomposed in landfill or dumpsite produces methane, a major greenhouse gas (GHG) that traps 21 times more heat than carbon dioxide (United States Environmental Protection Agency [EPA], 2002). Methane emission from landfill is also the largest source of GHG emission from the waste sector (UNEP, 2010). Besides contributing to GHG emission, organic waste is the major source of leachate production from landfill or dumpsite as well (Allen & Taylor, 2006), which can contaminate ground and surface water if not managed properly, thus resulting in severe health and environmental impacts (EPA, 2002; Cointreau, 2006). Leachate is a fluid infiltrating through the waste from landfill or dumpsite as a result of liquid already available in the waste that gets mixed with either rainfall or nearby water sources. It contains various contaminants at concentration levels which when comes in contact with ground or surface water will make it poisonous for human consumption. Unfortunately, leachate may be highly toxic for several decades or even centuries before it can reach to a level where it is considered no longer a threat to the environment (Johannessen, 1999).

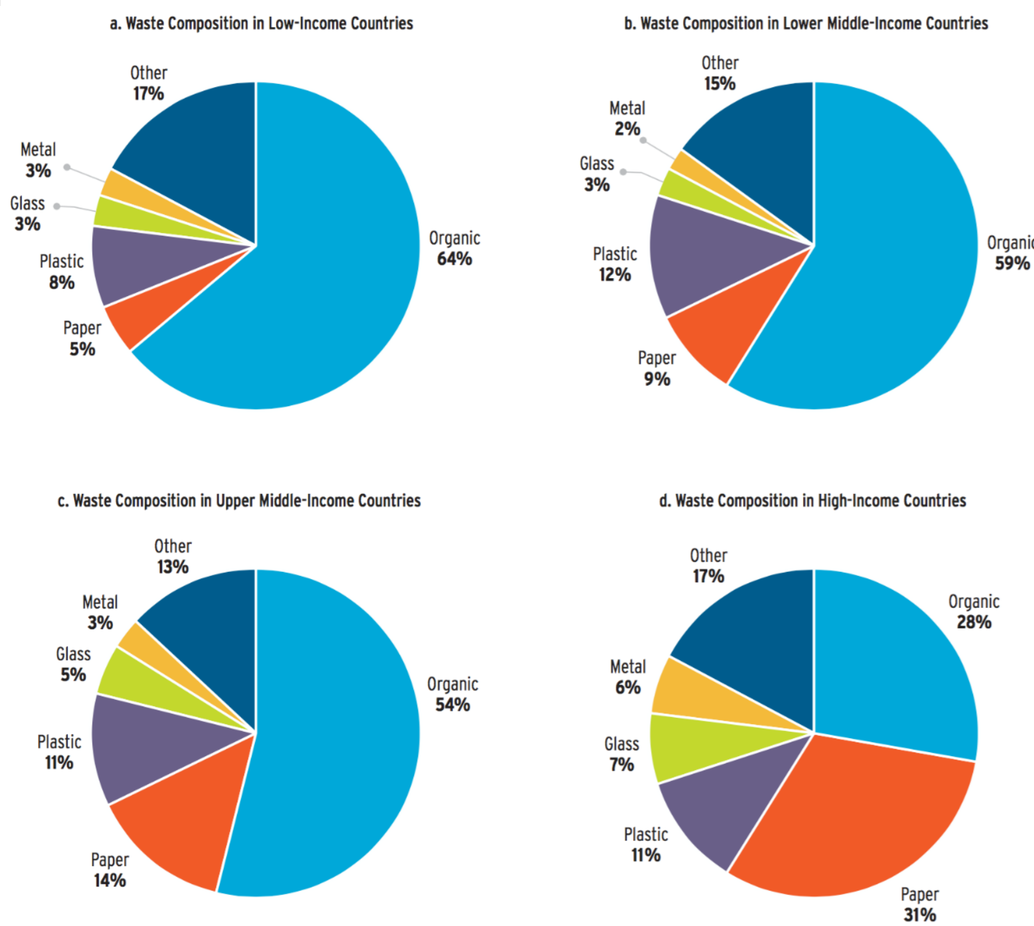

Figure 2.2 Global MSW composition by income group
Source: Hoornweg & Bhada-Tata (2012)

Among various ways of managing organic waste, incineration is one option that uses combustible fraction of waste as a fuel either in a dedicated combustion facility (incineration) with or without energy recovery or as Refuse-Derive Fuel in a solid fuel boiler (Hoornweg & Bhada-Tata, 2012). But organic waste is difficult to combust as it has less calorific value, thus making combustion technology uneconomical (Mutz, Hengevoss, Hugi, & Gross, 2017). Therefore, it is difficult or not advisable for developing countries to adopt this technology mainly because of its high capital requirement and operating cost. Other opportunities for organic waste management for developing countries are to be used as animal feed either directly or after processing, input for biogas for generating energy, or input for making compost. Compost is a humus-like material that takes place through the natural biological degradation of organic matter/materials, which are mixed and piled together, with the help of microorganisms. Unfortunately, it is often neglected within integrated MSWM programs when it is actually a basis of sustainable development (Hoornweg, Thomas, & Otten, 2000). Composting can be done in two ways: aerobically (with oxygen) or anaerobically (without oxygen). Aerobic composting is the most efficient form of decomposition as it produces finished compost in the shortest time. Aerobic organisms will dominate the compost pile and decompose the raw organic materials most efficiently when proper amount of food (carbon), nutrients, water and air are duly provided (Cooperband, 2002).

2.4 Municipal Solid Waste Management and its Functional Elements

MSWM is the control of generation, segregation, storage, collection, transfer and transportation, resource recovery and processing, treatment and disposal of the solid waste by using the most efficient technique in an environmentally friendly, socially acceptable and economical means without compromising the health hazards of the people. Inadequate collection and transportation system, improper treatment and dumping of the solid waste lead to serious health hazards and environmental pollution. Every process of the MSWM plays a vital role in effective implementation of policies related with SWM.

In Nepal, urbanization is increasing at an alarming rate putting immense pressure on municipal services, particularly to manage the ever-increasing amounts of waste. At present, most of the waste generated in municipalities are not being adequately managed thereby creating a serious health and environmental hazard (WaterAid in Nepal, 2008).

2.4.1 Waste Generation

Waste generation is an act and process of producing waste from human activities which is directly related with the people's consumption pattern and thus, of their socio-economic characteristics. Waste generation is conditioned to an important degree by people's attitudes towards waste, their patterns of material use and waste handling, their interest in waste reduction and minimization, the degree to which they separate waste, and the extent to which they refrain from indiscriminate dumping and littering (Schübeler et al., 1996).

HHs are the main source of municipal waste in Nepal. Other sources include agricultural activities, industries, institutions, commercial areas, construction sites, and medical facilities. Since about 85% of Nepal's population is farmers, agricultural activities probably result in a significant amount of organic waste. However, most of this waste is recycled to produce compost, animal feed, and other products and does not end up as waste that needs to be disposed of. However, organic waste generated in urban areas is often disposed in dumping site or landfill site because of limited agricultural activities. Similarly, the amount of waste generated by industries and other sources is less as compared to other developing or developed countries because of the low level of industrialization in the country. UNEP estimated that about 83% of all waste generated in Nepal is municipal waste, out of which only about 11% is agricultural waste and 6% is industrial waste (APO, 2007).

The average municipal waste generation in Nepal is 24.74 tonnes/day which increased from 19.89 tonnes in 2008 (ADB, 2013; SWMRMC, 2008). The main reasons for the growing quantity of solid waste generation in the municipalities in Nepal are increasing opportunities and activities resulting in urbanisation, growth in non-agricultural sector, and changing consumption pattern. Increasing use of packaged food items, electronic products, plastics and other modern HH appliances are some of the examples indicating the changing consumption pattern.

2.4.2 Onsite Handling, Storage and Processing

Onsite Handling is the first stage of MSWM. It starts from the HH level where the waste is segregated so that they can be dealt with in the most appropriate way. The benefits of appropriate onsite handling include reducing the volume of waste for final disposal by recovering usable and recyclable materials.

Onsite storage means the temporary collection of waste at the HH level or the community level. It is important that waste is stored in a proper container. These could be baskets, preferably made from locally available materials, plastic buckets or metal containers before the solid waste are being collected. In Nepal, the HH normally puts solid waste in plastic bags that are collected by the concerned authorities or put in the containers near the community. Separation of solid waste; organic and inorganic waste is rarely performed by the HHs in Nepal.

2.4.3 Collection, Transfer and Transportation

Collection involves collecting the solid waste and transporting them to transfer stations, processing and recovery stations, or to final disposal sites. Normally, small vehicles are used to collect the waste to be transported to a transfer station before they are transported to the final disposal site by larger vehicles. A properly designed transfer and transport system normally reduces the overall cost of collection and transportation of waste from onsite storage to final disposal sites. But, in most of the developing countries as much as 80% of the collection and transport equipment is out of service, in need of repair or maintenance (The World Bank, 2016).

Cleaning of streets and major public centers has always been the traditional municipal service related to MSWM in Nepal. Collection of waste generated from various sources within the municipalities and transportation to a disposal site (either traditional open sites, e.g. river banks, forests etc. or not properly planned and developed temporary disposal sites) is found to be practiced in almost 95% of the municipalities (i.e. reportedly 55 out of 58 municipalities), however in different operational modes and frequencies. The mode of collection services performed by the municipalities in Nepal is roadside pick-up service, container service and door-to-door collection service. The equipment used for the collection service is the conventional tractor-trailer that is predominant and is found to be in use in most of the municipalities, followed by dump truck/ garbage tipper, waste rickshaw and power tiller (SWMRMC, 2008).

2.4.4 Resource Recovery, Recycling and Composting

Resource recovery means finding a way to use the waste, so it becomes a valuable resource rather than just a disposal problem. This is a very important part of waste management. Resource recovery includes a range of processes for recycling materials or recovering resources from the waste, including composting and energy recovery. In many low-income Asian countries, recycling and recovery is usually conducted by the informal sector on all levels of the waste management stream. Such work is done in a very labor-intensive and unsafe way, and for very low incomes. Scrap dealers buy directly from HHs and businesses, waste pickers or scavengers collect materials from waste bins and dumping sites, and waste collector separate materials that can be sold as they load their trucks. The situation in industrialized countries is very different, since resource recovery is undertaken by the formal sector, driven by law and a general public concern for the environment, and often at considerable expense. Reuse of organic waste material, often contributing to more than 50% of the total waste amount, is still fairly limited but often has great recovery potential. It reduces costs of the disposal facilities, prolongs the sites life span, and also reduces the environmental impact of disposal sites as the organics are largely to blame for the polluting leachate and methane problems (Zurbrugg, 2002).

Composting is another form of recycling which is the controlled aerobic biological decomposition of organic matter, such as food scraps and plant matter, into humus, a soil-like material. Compost acts as a natural fertilizer by providing nutrients to the soil, increasing beneficial soil organisms, and suppressing certain plant diseases, thereby reducing the need for chemical fertilizers and pesticides in landscaping and agricultural activities (EPA, 2002).

In developing countries, organic fraction of solid waste is generally higher; composting is the best solution as far as practicable. It is found that rural areas (15% to 100% HHs) are practicing it but in urban areas where less land is available within HH, it is generally not practiced (less then10% of HHs). However, community or municipal composting exists to some extent and is also in planning phases in some municipalities. Composting provides fertilizer for farmers wherein they need to buy less chemical fertilizer. This will reduce large stream of solid waste to be handled and much less burden in terms of quantity for final disposal into a landfill. Open pile composting is in practice in many rural and peri-urban areas (SWMRMC, 2008).

Recycling is normally done by the informal sector in Nepal. Rag pickers and scavengers pick up recyclable solid waste from dumping sites and scrap dealers collect directly from the HH. The recyclable waste such as paper, plastic, metal, bottle, can, etc. are collected and sold to the recycling dealers or recycling companies. Some municipalities such as Hetauda and Bharatpur have initiated separate plastic waste collection programs. Both Hetauda and Bharatpur municipalities have joined hands with the local community groups and the private sector to start a plastic waste collection program. In these municipalities, a simple metal hook called "*suiro*" is distributed to HHs so that plastic waste can be recovered and stored easily (Practical Action Nepal, 2008).

2.4.5 Disposal (Landfilling and Combustion)

Combustion is the controlled burning of waste in a designated facility to reduce its volume and, in some cases, to generate electricity. Combustion is carried out for waste that cannot be recycled or composted and is sometimes selected by communities where landfill space is limited. While the combustion process can generate toxic air emissions, these can be controlled by installing control equipment such as acid gas scrubbers and fabric filters in combustors. Combustion of solid waste can help reduce amount of waste going to landfills. It also can reduce reliance on coal, one of the fossil fuels that produce greenhouse gases when burned. In Nepal, combustion of solid waste is practiced openly near the banks of river and on the dumping sites. The uncontrolled combustion of solid waste leads to a serious health hazards and environmental pollution.

Uncontrolled dumping of waste can contaminate groundwater and soil, attract disease carrying rats and insects, and even cause fires. Properly designed, constructed, and managed landfills provide a safe alternative to uncontrolled dumping. For example, to protect groundwater from the liquid that collects in landfills (leachate), a properly designed landfill has an earthen or synthetic liner. As waste decomposes, it emits methane, a greenhouse gas that can also cause fires. To prevent fires, a properly designed landfill should have a way to vent, burn, or collect methane. Landfill operators can also recover this methane—thereby reducing emissions—and generate electricity from the captured gas (EPA, 2002).

In Nepal, the disposal practices by most of the municipalities are open dumping and river bank dumping. Usually these sites do not have any precautionary measures such as cover material, a leachate collection mechanism, drainage facilities, and fencing to prevent unauthorized personnel. Only few municipalities dispose the solid waste in landfill sites. In 2008, out of 58 municipalities, only 8 municipalities had a landfill site whereas 23 municipalities practiced river bank dumping and 27 municipalities practiced open dumping (SWMRMC, 2008).

2.5 Strategic Aspects of Municipal Solid Waste Management

2.5.1 Political and Legislative Aspects

The government should establish the legal and regulatory framework, determine the roles and jurisdiction and formulate the goals and priorities for MSWM. Without transparent bylaws, ordinances and regulations for MSWM, it will be very difficult for the concerned authorities to effectively control and manage MSW. A clear definition of jurisdiction and roles is essential to the political sustainability of MSWM systems. The "strategic plan" for

MSWM provides a basis for putting the defined roles of government authorities and other actors into effect (Schübeler, 1996). The lack of effective legislation for SWM is a norm in most developing countries. Legislation related to SWM in developing countries is usually fragmented, and several laws (e.g., Public Health Act, Local Government Act, Environmental Protection Act, etc.) include some clauses on rules and regulations regarding SWM (Hisashi, n.d.).

In Nepal, the Solid Waste Management and Resource Mobilization Act was formulated in 1987 in order to regulate, collect, recycle and dispose solid waste generated in the three cities of Kathmandu valley and it was the first legislation related to waste management in Nepal. In 1996, the Government took another major step by announcing Solid Waste Management National Policy in order to provide a long-term solution of garbage problems arising from unplanned urbanization (Devkota, Watanabe, & Dangol, 2004). The main legislation governing the activities of municipalities is the Local Self-Governance Act (1999). The act makes municipalities responsible for waste management but does not describe how this is to be done. Some municipalities, such as Dharan and Itahari, have formed their own guidelines on SWM. These guidelines define responsibilities and set the number of fines to be collected from people who litter (Tuladhar, 2007).

Solid Waste Management Act was formulated in 2011 and it outlines the duties of local government to take action against haphazard waste generation, disposal or collection and provision of penalty has also been incorporated in the act.

2.5.2 Institutional Aspects

Effective MSWM depends upon an appropriate distribution of responsibilities, authority and revenues between national, provincial and local governments. In metropolitan areas, where MSWM tasks extend across several local government units, inter-municipal cooperation is essential. Decentralization of responsibility for MSWM requires a corresponding distribution of powers and capacities. It normally calls for revised organizational structures, staffing plans and job descriptions of the local agencies concerned.

In developing countries, several agencies at the national level are usually involved at least partially in SWM. However, there are often no clear roles/functions of the various national agencies defined in relation to SWM and also no single agency or committee designated to coordinate their projects and activities. The lack of coordination among the relevant agencies often results in different agencies becoming the national counterpart to different external support agencies for different SWM collaborative projects without being aware of what other national agencies are doing. This leads to duplication of efforts, wasting of resources, and unsustainability of overall SWM programs (Hisashi, n.d.).

According to the Local Self Governance Act of 1999, municipalities are responsible for SWM within their jurisdictions. The organizational capabilities of municipalities in dealing with waste management, however, vary significantly. While many municipalities have separate SWM units, new municipalities such as Khandbari do not have a waste-management unit within their organizational structure and are not involved in waste-management related activities. Although SWM is a very important service that requires substantial human and financial resources, many municipalities are not able to provide adequate resources due to financial constraints. Furthermore, often due to technical and managerial limitations, the available resources are not efficiently utilized (Tuladhar, 2007).

2.5.3 Socio-cultural Aspects

Public awareness and attitudes to waste can affect the whole SWM system. All steps in SWM starting from HH waste storage, to waste segregation, recycling, collection frequency, the amount of littering, the WTP for waste management services, the opposition to the location of waste treatment and disposal facilities, all depend on public awareness and participation. Thus, this is also a crucial issue which determines the success or failure of a SWM system (Zurbrugg, 2002).

The social status of SWM workers is generally low in both developed and developing countries, but more so in developing countries than developed countries. This owes much to a negative perception of people regarding the work which involves the handling of waste or unwanted material. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and poor quality of their work (Hisashi, n.d.). Traditional values, religious beliefs and the existing caste system are the major factors acting against effective SWM in urban areas of developing countries. For example, it is widely believed in Nepal that work requiring direct contact with solid waste is strictly for the lower classes (Devkota, Watanabe, & Dangol, 2004).

2.5.4 Financial Aspects

Financial aspect of MSWM is related to budgeting, cost accounting, capital investment, cost recovery and cost reduction. MSWM is given a very low priority in developing countries, except perhaps in capital and large cities. As a result, very limited funds are provided to the

SWM sector by the governments, and the levels of services required for protection of public health and the environment are not attained. The local government of developing countries lack good financial management and planning. The problem is acute at the local government level where the local taxation system is inadequately developed and, therefore, the financial basis for public services, including SWM, is weak. This weak financial basis of local governments can be supplemented by the collection of user service charges. However, users' ability to pay for the services is very limited in poorer developing countries and their WTP for the services is unknown, which are often irregular and ineffective.

2.5.5 Economic Aspects

Solid waste generation and the demand for waste collection services generally increase with economic development. The economic effectiveness of MSWM system depends upon the life-cycle costs of facilities and equipment and the long-term economic impact of services provided. Economic evaluation constitutes an important input to strategic planning and investment programming for MSWM. Measures should be introduced which discourage wasteful use of resources and encourage waste minimization. The best way to promote efficient use and conservation of materials is to internalize the costs of waste management as far as possible in the production, distribution and consumption phases (Schübeler, 1996).

Developing countries have weak economic bases and hence, do not have sufficient funds for sustainable development of SWM system. Local governments cannot afford for the latest equipment and facilities for MSWM. Also, in small developing countries, waste recycling activities are affected by the unavailability of industries to receive and process recyclable materials. The level of economic development is an important determinant of the volume and composition of waste generated by residential and other sectors. For example, the effective demand for waste management services, and the willingness and ability to pay for a particular level of service is also influenced by the economic context of a particular city or an area.

2.5.6 Technical Aspects

Technical aspects of MSWM are concerned with the planning and implementation, maintenance of collection and transfer systems, waste recovery, final disposal, and hazardous waste management. In developing countries, the technical systems established for primary collection, storage, transportation, treatment and final disposal are often poorly suited to the operational requirements of the city. In many cases, the provision of imported equipment from international donors leads to the use of inappropriate technology and/or a diversity of equipment types which undermines the efficiency of operations and maintenance functions (Schübeler, 1996).

In developing countries, lack of human resources with technical expertise necessary for SWM planning and operation is quite common. Another technical constraint in developing countries is the lack of overall plans for SWM at the local and national levels. As a result, a solid waste technology is often selected without due consideration to its appropriateness in the overall SWM system.

With regard to the technical system, often the "conventional" collection approach, as developed and used in the industrialized countries, is applied in developing countries. The vehicles used are sophisticated, expensive and difficult to operate and maintain, thereby often inadequate for the conditions in developing countries. After a short time of operations, usually only a small part of the vehicle fleet remains in operation (Zurbrugg, 2002).

Chapter 3. Research Design

3.1 Conceptual Framework

This study highlights two main stakeholders of SWM in Gorkha municipality; HHs and local government. The role of informal sectors also plays a vital role specially to recover recyclable discarded materials by the HHs, which aids to reduce the amount of waste for final disposal. These stakeholders act under various strategic aspects of SWM, i.e., political and legislative, institutional, socio-cultural, economic, and technical aspects. The whole SWM system can function only with such aspects and with the participation of the concerned stakeholders. The national government, under the persisting law, implements waste management strategies at the national level. On the other hand, municipalities take the responsibility of waste management within their jurisdiction. This means that municipality is accountable for grass-root actors including HHs.

HHs are the primary source of waste generation. According to law, HHs should segregate their waste into organic and inorganic waste. But the law has not been enforced by the local government. If waste is segregated at source, then high quality of reusable and recyclable materials can be easily recovered. After recovering reusable and recyclable materials, HHs can sell the recyclables to either informal or formal sector. Formal actors are basically junkshops owners or employees and informal actors are those who collect recyclable materials from HHs and dumping site and sell these recyclable materials to formal sectors. The organic waste can be used to make compost, which can be used as an alternate to chemical fertilizer. The remaining waste is collected and transported for disposal to the open dump site. This whole process will help for the reduction of total municipal waste that needs to be disposed at the dumping site. This concept is also related with the waste management hierarchy, which classifies SWM options in order of their environmental desirability. Source reduction and reuse of waste is considered to be the most desirable approach to manage waste, followed by recycling and composting, further recovery at disposal site and lastly treatment and disposal of waste is considered to be the least desirable approach (Schall, 1992).

In order to have a sound SWM system, it is very important to understand the behavior and attitude towards waste, and waste management practices of the HHs. This study analyses waste generation by the HHs and various factors that can influence it. As the waste segregation has not been enforced by the local government, this study assesses the determinants of willingness-to-segregate waste by the HH. The local government had distributed subsidized compost bins to manage organic waste at HH level. However, there has been no follow-ups to check whether it has been used or not, how it has been used and if there is any problem using the bins. This study has tried to study that gap and come up with suitable recommendations to make its usage more effective and efficient. Waste collection is also a major problem in Gorkha municipality where most of the HHs are deprived of such service. This study assesses the possibility for the local government to impose waste collection fee to finance waste collection service so that most of the HHs can have access to the service. It is very important to understand about the willingness of the HHs to pay for the service and various socioeconomic factors that can influence their decision.

Only if there is a favorable condition of various aspects of SWM, the stakeholders can act to have a sound SWM system. This can be achieved by increasing the awareness about SWM policy and importance of proper SWM to the HHs, integration of formal and informal waste sectors to the waste management system and addressing the various aspects of SWM by both the national and local government. This can help for improved waste collection efficiency, reduction of waste for final disposal and improved overall SWM.

The details of the conceptual framework for this study and relationship with different aspects, stakeholders and SWM system is presented in Figure 3.1.

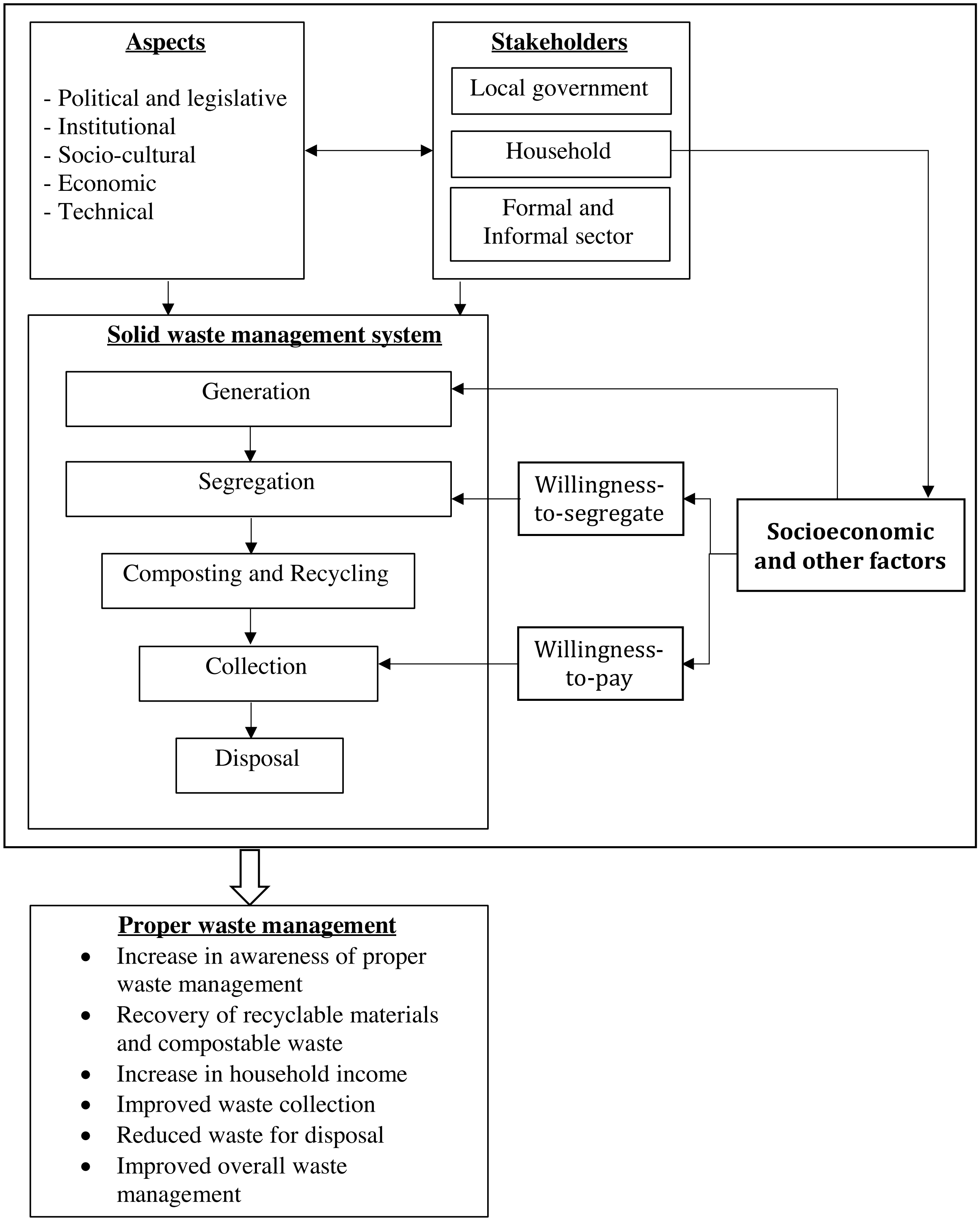

Figure 3.1: Conceptual framework of solid waste management

3.2 Study Area

This study was conducted in Gorkha municipality of Nepal (Figure 3.2 and Figure 3.3). Physio-graphically, Nepal is divided into Tarai, hill and mountain region. Gorkha municipality lies in mid-hills of western development region of Nepal. Its ecological region ranges from tropical to nival (artic) to the trans-himalayan arid zone (lower tropical zone – 0.1%, upper tropical zone – 19.8%, sub-tropical zone 14.6%, temperate zone – 13.3%, sub-alpine zone – 14.9%, alpine zone – 10.6%, trans-himalayan zone 14.8%, nival zone – 11.5% and water body – 0.2%). Therefore, it can be said that it covers all the ecological zones of Nepal (Lillesø, Shrestha, Dhakal, Nayaju, & Shrestha, 2005). It lies between 27° 56' 03" to 28° 13' 07" north latitude and 84.23° to 84.38° east longitude. It occupies an area of 83.55 square kilometers and has an average temperate of 25°Celsius with an average annual rainfall of 149.2 millimeter (mm). There are 10,616 HHs (total population of 2015 divided by HH average of 2011 census) in Gorkha municipality. However, according to the data given by the municipality, the current total HHs are 9,236 and for this study this total HH data is used. There are 39,172 inhabitants with an average HH size of 3.69 living in this municipality, which is lower compared to the national average of 4.21 (CBS, 2014c). It is divided into 15 wards, which is the lowest administrative unit. (CBS, 2014b; Gorkha Municipality Office, 2015). It has a population density of 539 persons per km^2, which is lower compared to national urban population density of 1,345 persons per km^2 (CBS, 2014c).

Out of 15 wards, only 6 wards have regular waste collection services provided by the municipality. The municipality itself is constrained by limited resources and owns only 1 tractor for providing their service of waste collection. It also manages a controlled dumpsite within the municipality for waste disposal. The municipality estimates that about 4 tons of waste is generated per day, but according to the local government's capacity, only 2 tons per day is collected so far (B.B Khatri, personnel communication, December 15, 2015). However, recent study conducted in Gorkha municipality shows that about 6.6 tons of waste is being generated of which 2 tons of waste is being collected and managed by the municipality.

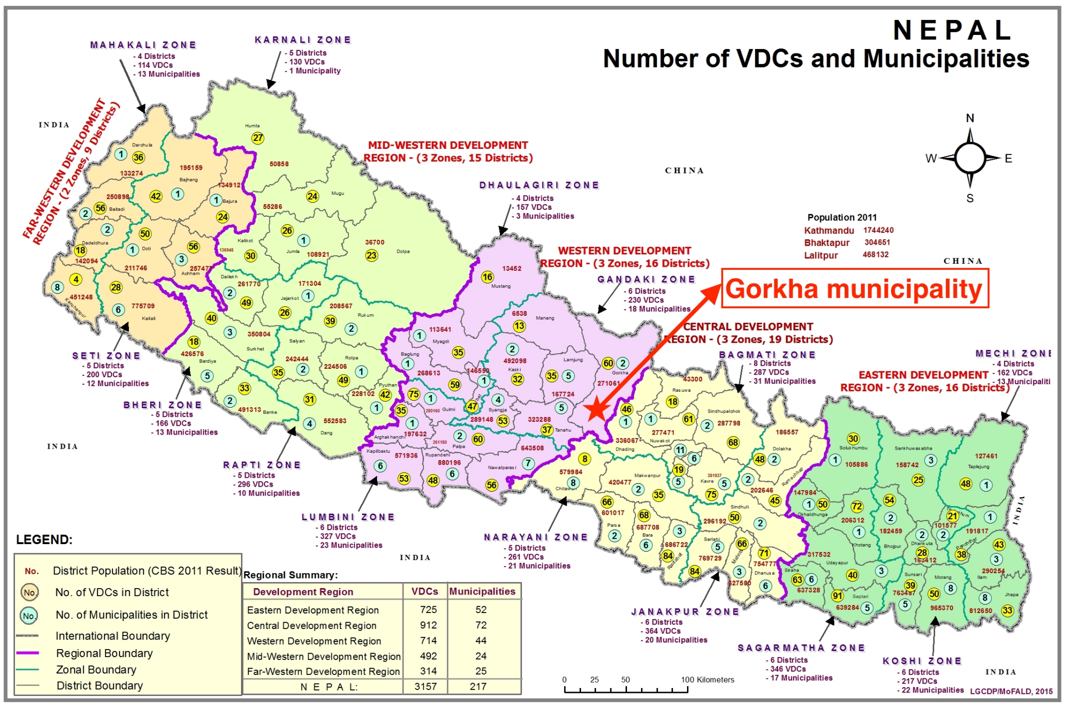

Figure 3.2 Map of Nepal
Source: Local Governance and Community Development Programme [LGCDP] (2017)

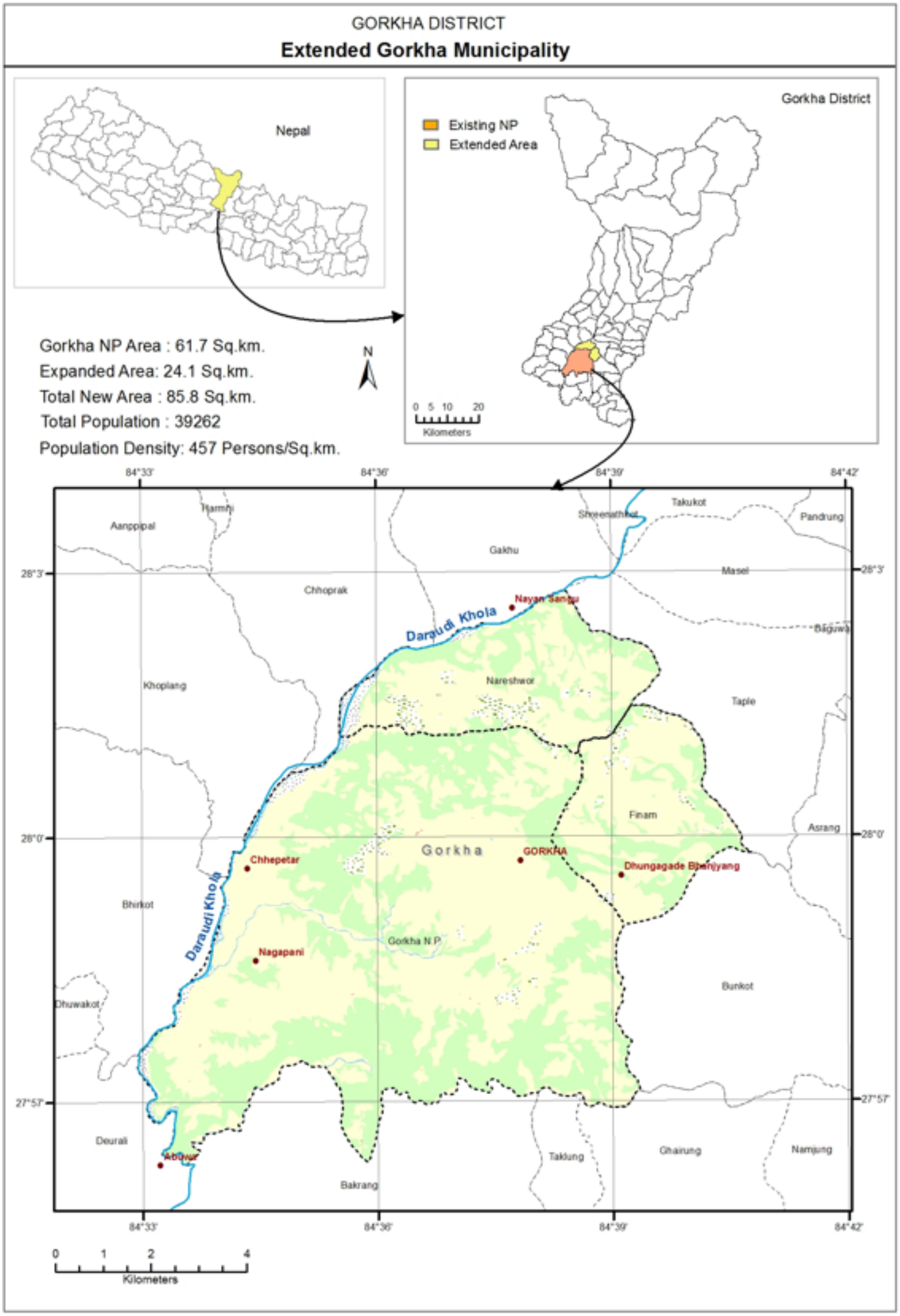

Figure 3.3: Map of Gorkha municipality
Source: Local Governance and Community Development Programme [LGCDP] (2016)

3.3 Status of Municipal Solid Waste in Gorkha Municipality

Most of the SWM related studies in Nepal are concentrated in Kathmandu valley in either one or all of its three districts: Kathmandu, Lalitpur and Bhaktapur (Baker, 1997; Devkota, Watanabe, & Dangol, 2004; Duwal, 2015; Japan International Cooperation Agency [JICA], 2005b; Pokhrel & Viraraghavan, 2005; M. E. I. Shrestha, Sartohadi, Ridwan, & Hizbaron, 2014; Society for Environment and Economic Development Nepal [SEED Nepal], 2009). Among these, many are still confined within Kathmandu district or to be precise KMC (Alam, Chowdhury, Hasan, Karanjit, & Shrestha, 2008; Dangi, Pretz, Urynowicz, Gerow, & Reddy, 2011; Premakumara, 2013; Ranabhat, 2015; S. L. Shrestha, 2015; Singh, Yabar, Mizunoya, Higano, & Rakwal, 2014; Thapa, 1998). While it is understandable that waste problem will be more severe in the most urbanized areas, other municipalities are also equally affected in their own right. However, only few studies have focused on some or all of the then 58 municipalities of Nepal (ADB, 2013; Practical Action Nepal, 2008; SWMRMC, 2004, 2008). The number of municipalities have increased significantly over the years. Currently, there are 212 municipalities (MoFALD, 2017) and there is no doubt that SWM is a greater challenge for new municipalities, especially resource deprived ones.

Gorkha municipality is selected because it represents one such municipality that does not fall under the priority of SWM researchers or implementers, but growing amount of waste nonetheless demands proactive action. It is one of the least resource intensive municipalities in Nepal. When it comes to having human resources in waste management, only one staff is available to serve 5,392 inhabitants and daily cleaning service covered only 0.4 km of the street in 2003 that increased to just 2.5 km in 2008 (SWMRMC, 2004, 2008). It has door-to-door waste collection service on every alternate day but possess only one tractor as waste collection and transportation equipment. Recycling is dealt by scrap dealers and sweepers; but harmful waste such as medical, dead animals, construction and industrial are dumped openly. At management level, there is lack of cooperation at different levels with no integrated approach. At implementation level, there is no landfill site; inadequate human resources; no technical knowhow; lack of transportation; lack of reuse, recycling and composting; political problems; and lack of community participation (ADB, 2013; SWMRMC, 2004, 2008).

Comparison of the amount of waste generated in Gorkha municipality with national average and composition of such waste is presented in Table 3.1 and Table 3.2, respectively (ADB, 2013; SWMRMC, 2004, 2008). These studies however only considered one day waste generation data and did not cover all municipal wards. Furthermore, due to lack of consistent scientific methods and different assumptions made to quantify waste generated from different sources, the findings of these studies are inconsistent. As such, there is no consistent trend of increase in per capita waste generation, and total municipal waste generation and collection. Thus, this leads us to question the very authenticity of such data and whether the local authority should rely on it for making decisions. Unfortunately, this is a common problem for many developing countries where either statistics are lacking or are inconsistent because of data sources that cannot be validated and are sometimes based on assumptions rather than scientific measurements (Miezah et al., 2015). In 2012, organic waste (48.2%) accounted for the highest amount of waste generation followed by paper (20.4%), plastic (12.3%), glass (2.7%), metal (0.8%) and textile (0.5%), while the rest accounted for other types of waste. Except for paper, plastic and other types of waste; composition of all other waste is lower than national average. Compared to 2003, the amount of paper and plastic waste seem to have increased but nonetheless organic waste still accounts for the largest share and by significant difference compared to all other waste types (ADB, 2013; SWMRMC, 2004, 2008).

Table 3.1. Comparison of waste generation of Gorkha municipality with national municipal average.

Variables	**2003**		**2008**		**2012**	
	National Average	Gorkha	National Average	Gorkha	National Average	Gorkha
HH waste generation (kg/capita/day)	0.25	0.26	0.27	0.30*	0.15	0.14
Total municipal waste generation (tonnes/day)	23.60	9.35	19.89	8.10	24.74	6.60
Total municipal waste collection (tonne/day)	11.79	1.50	13.05	4.86	18.27	2.00
Collection efficiency (%)	42.35	16.05	65.61	60.00	62.30	30.30

Note. * per capita municipal waste generation.
Source: ADB (2013); SWMRMC (2004, 2008)

Table 3.2. Comparison of waste composition of Gorkha municipality with national municipal average.

Waste Type	2003		2008		2012	
	National Average (%)	Gorkha (%)	National Average (%)	Gorkha (%)	National Average (%)	Gorkha (%)
Organic	62.0	46.9	61.2	69.6	66.4	48.2
Plastic	7.3	2.1	8.4	9.8	12.0	12.3
Paper and paper products	8.2	19.2	8.6	5.0	9.0	20.4
Glass	2.4	5.6	4.1	5.2	3.1	2.7
Metal	1.2	4.2	1.3	0.0	1.9	0.8
Textile	1.9	0.0	1.7	0.1	2.2	0.5
Rubber and Leather	0.9	4.9	1.1	0.8	1.1	0.0
Others	16.1	17.2	13.5	9.6	4.5	15.1

Source: ADB (2013); SWMRMC (2004, 2008)

3.4 Source of Data

This study relies on primary data gathered from individual HHs using semi-structured questionnaire, researcher's observation and key-informant interview. Field survey was conducted in two phases. The first survey was conducted from November to December 2015 using face-to-face interview method. Due to the vast nature of the survey to be conducted within a limited time frame, 6 competent university students were hired as enumerators. The enumerators were also selected based on their familiarity with the selected survey area. This is because it is very important to make the respondents feel comfortable to get reliable information. This could be one of the main reasons for the high response rate. The researcher gave training on how to conduct the survey to all the enumerators beforehand, assisted during the actual survey and also monitored the survey on a daily basis. Key informant interview with municipality officials, hospital staff, junkshop owners and hotel staff were conducted. After learning that the local government had promoted HH composting by distributing subsidized compost bins to 300 HHs over the years along with providing one day training and awareness program, a follow-up research was conducted from February to March 2016 to understand its status. Various published and unpublished secondary sources such as journal articles, books, reports, proceedings, scientific papers, theses and websites of relevant organizations were referred to complement the findings and to write this thesis.

3.5 Data Collection and Sampling Method

The total sample considered in this study is 401 HHs. Sample size was selected based on simplified formula for proportions by Yamane (1967). According to Yamane, at 95% confidence level,

$$n = \frac{N}{1 + N(e)^2} \tag{3.1}$$

Where n is the sample size, N is the population size, and e is the level of precision.

At 95% confidence level and 5% precision level, the required sample is 384 HHs which were proportionally divided among 15 wards. Additional 10% of HHs from all 15 wards were selected to avoid shortcomings of partly filled questionnaire and non-response. The final sample of 401 HHs selected for this study that is presented in Table 3.3 gives a 4.88% precision level at 95% confidence level and a response rate of about 95%.

The local government do not have dwellings data of all the HHs living within the municipality, which is often the case in developing countries (Alberini & Cooper, 2000). The municipality is covered mostly by hills and mountains, where all the houses do not have proper road infrastructure, and the houses are widely scattered in all 15 wards. At this stage, it would be impractical for the local government to provide waste collection service to all the HHs within the municipality and very difficult for the researcher to consider HHs which are located far from the nearest road for waste generation and characterization study. Thus, this study considered HHs that are easily accessible by road. Every alternate house on both sides of the road was approached for the survey. If the HH member was unwilling to participate then next HH was approached for the survey until the total sample requirement was fulfilled. Hence, HHs were selected based on HHs' willingness to participate in the survey and accessibility of the HHs' dwelling location so that the municipality can provide or improve waste collection services in the near future. Despite this limitation, we strongly believe that the sample for this study better represents the whole population of the municipality as all 15 wards are included in this study.

HH questionnaire survey was conducted to get information on their socio-economic background, waste generation and management practices, willingness-to-segregate waste, WTP for improved waste collection service, and compost making practices at HH level. The probable respondents were first explained about the purpose, objective and scope of the survey that is to collect information from the HHs so that recommendations can be given to the concerned stakeholders to improve the current waste management practices and that the researcher cannot guarantee its implementation. It was also mentioned that their identity would be strictly kept anonymous. With their consent to be interviewed, questionnaire interview was proceeded. The questionnaire survey was conducted with one meeting and it took an average of about 45 minutes to complete.

For waste characterization study, Each HH was given two disposable containers (polythene bags), which was numbered and was asked to segregate organic (food/kitchen waste including wet paper, leaves, tree branches, wood waste, and agricultural waste) and other waste types (all others including dry paper) for a period of one week, after providing proper training on waste sorting. It is assumed that weekly data (Dahlén & Lagerkvist, 2008; Gu et al., 2015) and inclusion of all 15 wards provide much more robust output than one day data covering only few selected municipality wards which previous studies (ADB, 2013; SWMRMC, 2004, 2008) relied on. To determine the amount and composition of HH waste, collecting waste at generation site and directly hand sorting method was adopted, which is known to be the most accurate method for reliable data collection (Gu et al., 2015). With the help of municipal employees, segregated waste was collected and transferred through municipal tractor to the disposal site for re-segregating and weighing manually all waste types for more meticulous analysis. Different method of waste categorization makes analysis incomparable, which is true even for nationally aggregated figures that may overlook significant differences among cities in the same country (Aleluia & Ferrão, 2016). Using similar waste components for classification and usually not more than 10 categories is recommended to reduce risk of misunderstanding and be useful for comparison (Dahlén & Lagerkvist, 2008). Thus, following most recent study by ADB (2013), this study categorizes waste into 8 types: organic, metal, paper and paper products, plastic, glass, textile, rubber and leather, and others.

As for the composting, due to poor record keeping, the municipality only had information of 174 recipients out of which 149 HHs (86%) were randomly selected and visited to investigate the usage rate of compost bin.

Table 3.3 Sample selection from all wards of Gorkha municipality

Ward No.	No. of Household	Required Sample Size for ±5% Precision Level at 95% Confidence Level	Total Sample Selected after Additional 10% of the Required Sample	Final Sample for this Study (Response %)
Ward 1	518	21	23	22 (96%)
Ward 2	538	22	24	22 (92%)
Ward 3	594	25	28	25 (89%)
Ward 4	786	33	36	35 (97%)
Ward 5	469	19	21	21 (100%)
Ward 6	678	28	31	30 (97%)
Ward 7	450	19	21	19 (90%)
Ward 8	910	38	42	40 (95%)
Ward 9	760	32	35	33 (94%)
Ward 10	653	27	30	29 (97%)
Ward 11	723	30	33	32 (97%)
Ward 12	456	19	21	20 (95%)
Ward 13	430	18	20	19 (95%)
Ward 14	693	29	32	31 (97%)
Ward 15	578	24	26	23 (88%)
Total	9236	384	423	401 (95%)

Source: Gorkha Municipality (2015); Field Survey (2015)

3.6 Data Analysis

Data was analyzed both qualitatively and quantitatively using relevant statistical tools and econometric models such as percentage, mean, standard deviation, logit regression model, tobit regression model and ordinary least square (OLS) regression model. The statistical software Stata (Release 13, StataCorp LP, College Station, Texas, USA) was employed to run the models for this study.

Chapter 4. Determinants of Household Waste Generation and its Composition Study

4.1 Introduction

Before deciding upon the optimal waste recovery and management options, it is important to know the current status of waste related issues. The primary step is to understand how much and what kind of waste is generated in order to decide the most effective strategy for its management (Adeniran, Nubi, & Adelopo, 2017; Aleluia & Ferrão, 2016; Armijo de Vega, Ojeda Benítez, & Ramírez Barreto, 2008; Edjabou et al., 2015; Gallardo, Edo-Alcón, Carlos, & Renau, 2016; Khan, Kumar, & Samadder, 2016; Miezah et al., 2015; Trang, Dong, Toan, Hanh, & Thu, 2017). This study attempted to make a move in this direction by analyzing generation and composition of HH waste in Gorkha municipality. In developing countries, about 55-80% of MSW are known to be generated by HHs (Miezah et al., 2015). In Nepal too, it is assumed that HHs account for on average 75% of total municipal waste generation (SWMRMC, 2004). In addition, this study also analyzes HHs' socioeconomic factors impacting waste generation. Waste generation is heterogeneous (Miezah et al., 2015) and are highly dependent on socioeconomic status of the population (Sankoh, Yan, & Conteh, 2012). Socioeconomic factors enable people to access resources required to improve their living standard. It includes material goods, money, power, networks, healthcare, leisure time or educational opportunities. The combination of these factors determine how a social hierarchy is structured, one's standing within this hierarchy and most often one's opportunities as well (Senzige et al., 2014). Although the characteristics among urban areas of developing countries are quite common, waste management tactics should be context specific, locally sensitive, critical, creative, and owned by the community of concern; as their specific circumstances may be significantly different (Aleluia & Ferrão, 2016; Marshall & Farahbakhsh, 2013). Thus, this study is expected to highlight socioeconomic factors impacting waste generation and assesses waste composition in Gorkha municipality, based on its unique characteristics that is expected to contribute in decision-making of stakeholders, especially at the local municipality level.

4.2 Methodology

4.2.1 Variables Selection

In order to select relevant factors that influence waste generation for this study, number of related literatures were reviewed in addition to referring to the characteristics of the study area itself. Significant factors that affect waste generation from those relevant studies are considered in this study. The referred literatures are conducted in different parts of the world, thus reflecting unique characteristics of each of these places. Variables used in this study and its description and measurement are summarized in Table 4.1.

Table 4.1 Description and measurement of selected variables of households on waste generation.

Variables	Description	Unit of measure
HH waste	Solid waste generation by the HH	Kg/day
Gender	Gender of household head (HHH)	1 = Male; 0 = Female
Age	Age of HHH	Years
Education	Educational attainment of HHH	Years
Occupation	Occupation of HHH	Employed = 1; Unemployed = 0
HH size	Total number of family members currently residing	Number of individuals
House ownership	House ownership	1 = Owned; 0 = Rented
Income	Total monthly income of HH	Nepalese Rupees (NRs.)

4.2.1.1 Gender

Men and women might have different attitude towards environmental problem and thus a gender-sensitive approach in waste management can boost effectiveness in resource allocation and avoid unnecessary costs (Organization for Security and Co-operation in Europe [OSCE], 2009). Kayode and Omole (2011) found adverse impact of sex on waste generation in Nigeria. According to Dalen and Halvorsen (2011), there are studies emphasizing women generating more waste, and yet many others do not find significant gender effects in waste generation because it is the accumulated result of all HH members' behavior. In Nepal, female-headed HHs have increased from 14.87% in 2001 to 25.73% in 2011 (CBS, 2014a). Since usually women are responsible for management of HH work including those related to waste than men (OSCE, 2009), it would be interesting to see how female-headed HHs impacts waste generation compared to men.

4.2.1.2 Age

Depending on age, one can have a very different waste-generating behavior. In Czech Republic, the lowest level of MSW generation was by children and teenagers, and the highest was by people reaching towards the end of their working career or around the time of their retirement because of various activities (reconstruction of home, replacement of HH goods, sorting and discarding one's belongings accumulated during previous decades, etc.) which lead to generating large amounts of waste (Soukopová, Struk, & Hřebíček, 2016). Study by Kayode and Omole, (2011) found adverse impact of age in Nigeria; while Maskey, Maharjan, and Singh (2016) found age of HHH to have significant positive relation with waste generation in the Philippines.

4.2.1.3 Education

Gu et al. (2015) found education level of HH's daily manager in China to have negative impact on HH waste generation. Organisation for Economic Co-operation and Development [OECD] (2014) too found education to have negative relation on per capita generation of solid waste. On the other hand, Kayode and Omole (2011) found positive influence of educational status. Sujauddin, Huda, and Hoque (2008) also showed average level of education of family members in Bangladesh to have significant positive impact. Usually higher education is related with high level of awareness on environmental issues, but sometimes it can have opposite relation because of the cumulative nature of education that increases with the new number of graduates every year, but environmental awareness (such as impact of higher waste generation) does not increase at the same pace (Oribe-Garcia, Kamara-Esteban, Martin, Macarulla-Arenaza, & Alonso-Vicario, 2015).

4.2.1.4 Occupation

Studies by Maskey et al. (2016) in the Philippines; Kayode and Omole (2011) in Nigeria and Sankoh et al. (2012) in Sierra Leone showed employment status to have positive impact in generating more waste. Bandara, Hettiaratchi, Wirasinghe, and Pilapiiya (2007) in Sri Lanka revealed that number of employed people in HH contributed in increasing waste amount. In Turkey, Keser, Duzgun, and Aksoy (2012) measured unemployment rate as it signifies family's inability to generate higher income and found it to have significant negative impact on waste generation. With unemployed members, purchasing power of HHs diminishes and so does their consumption, which will result in lesser HH waste generation (Oribe-Garcia et al., 2015). But sometimes employment rate can have negative effect on HH waste generation too because with employment, HHs will have higher income which they might use for dining outside rather than cooking at home, thus decreasing the intensity of human activities at home and generating less waste (Lilai Xu et al., 2016).

4.2.1.5 Household Size

Studies by Afroz, Hanaki, and Tudin (2011); Khan et al. (2016); Maskey et al. (2016) Sankoh et al. (2012); Senzige et al. (2014); Sujauddin et al. (2008); Suthar and Singh (2015); and Trang et al. (2017) showed HH size to have positive impact on generating more waste. Increase in HH size will lead to more waste generation but at a decreasing rate (OECD, 2014). While it is apparent for more members of a HH to generate more waste, the phenomena of 'group living' and 'common consumption' can sometimes saturate the amount of waste being generated as number of generators increase (Gu et al., 2015; Ojeda-Benítez, Vega, & Marquez-Montenegro, 2008). Many studies have also supported HH size to have opposing effect on waste generation (Bandara et al., 2007; Irwan, Basri, & Watanabe, 2012; Kayode & Omole, 2011; Miezah et al., 2015; Ogwueleka, 2013; Qu et al., 2009). Large family are at an advantage when it comes to intensive utilization of materials such as food, paper and plastic, etc.; thus decreasing per capita waste generation compared to the small family (Lilai Xu et al., 2016).

4.2.1.6 House Ownership

Sankoh et al. (2012) showed number of rooms to have positive impact in generating more waste. Lebersorger and Beigl (2011) found percentage of buildings with solid fuel heating as one of the important factors influencing MSW. Kayode and Omole (2011) found positive influence of type of building on waste generation. While all these studies included certain feature of dwelling, this study assesses how people living in their own house impacts waste generation compared to tenants. During the test survey, it was observed that those who live in their own house are more caring about their surrounding and thus are more cautious in keeping their surrounding clean, which might impact on their waste generating behavior. Conversely, tenants might not care as much about their surrounding because they do not have a strong sense of belonging to that place and that they are there only temporarily. Although most HHs live in their own house, HHs residing in rented houses have been increasing in urban areas of Nepal (CBS, 2014a).

4.2.1.7 Income

Studies by Afroz et al. (2011); Gu et al. (2015); Irwan et al. (2012); Kayode and Omole (2011); Maskey et al. (2016); Ogwueleka (2013); Sankoh et al. (2012) and Sujauddin et al. (2008) showed monthly income to have positive impact on waste generation. With higher income, it is expected to increase demand for commodity products, the consumption of which will ultimately produce more waste. Bandara et al. (2007) explained the relatively high food consumption trends of higher income groups increased purchases of packaged products and reading material that will result in higher waste generation. Contrarily, Qu et al. (2009) in China found family income to have negative impact on waste generation. Trang et al. (2017) clarified those having higher income dine outside more frequently than cooking at home, whether it be at work or for leisure; thus, generating less waste. Another study in China by Xu et al. (2016) explained per capita HH waste and income cannot be simply linearly correlated. Often times, in early stages of urbanization, growth in family income leads to material consumption, which increases waste amount. However, as urbanization level matures, it will have gradual weakening positive effect and in an advanced stage, growth of income will barely have any positive effect. Sometimes it even prevents HH waste generation because income growth encourages environmental awareness among urbanites to certain extent.

4.3 Empirical Model

This study uses OLS as multiple linear regression model. It is widely used because of its simplicity (Hoffmann, 2010; Keser et al., 2012). This study defines dependent variable as HH waste and independent variables are their socioeconomic factors. Transformation of data and various tests such as natural log transformation, heteroskedasticity and multicollinearity were conducted to ensure model robustness. Statistical analysis in this study was conducted by using data analysis and statistical software - Stata 13.

OLS model can be expressed as:

$$y_i = \beta_0 + x_i\beta_i + \varepsilon_i \tag{4.1}$$

where;

y: HH waste

x: HH's socioeconomic factors

i: Number of observations

β_0: Coefficient of intercept

β_i: Parameter to be estimated

ε: Error term

Empirical specification for the model can be given by:

$$\text{HH waste} = \beta_0 + \beta_1(\text{gender}) + \beta_2(\text{age}) + \beta_3(\text{education}) + \beta_4(\text{occupation}) + \beta_5(\text{HH size}) + \beta_6(\text{house ownership}) + \beta_7(\ln \text{income}) + \varepsilon \tag{4.2}$$

where;

ln = Natural log

Heteroskedasticity causes standard errors to be biased. Thus, Breusch-Pagan/Cook-Weisberg and White's test for heteroskedasticity were used to test linear and non-linear forms of heteroskedasticity respectively. The former (chi^2 (1) = 152.70, Probability > chi^2 = 0.0000) and the later (chi^2 (32) = 159.65, Probability > chi^2 = 0.0000) both showed significant P-value, thus rejecting null hypothesis of homoskedasticity. To fix the problem of heteroskedasticity, we used robust standard errors. OLS assumes that errors are both independent and identically distributed; however robust standard errors reduces either or both of these assumptions and is tend to be more trustworthy (Williams, 2015). It neither changes model significance nor the coefficients, but gives relatively accurate P-values and is an effective way of dealing with heteroskedasticity (Wooldridge, 2012).

Higher degree of multicollinearity leads to regression model with unstable estimates of coefficients by wildly inflating its standard errors. One way to check for multicollinearity is through Variance Inflation Factor (VIF), the value of which should be less than 10 to conclude multicollinearity problem does not exist (Kutner, Nachtsheim, Neter, & Li, 2004). In this case, the lowest VIF is 1.10, highest was 1.60, and mean was 1.32, which proves there is no multicollinearity.

4.4. Results and Discussions

4.4.1 Waste Generation

Table 4.2 and Table 4.3 provides summary of measured variables. Study by ADB (2013) showed Gorkha municipality generated 0.14 kg/capita/day waste, which was similar to bigger municipalities like Biratnagar SMC (Sub-Metropolitan City) (0.14 kg/capita/day) and Birgunj SMC (0.14 kg/capita/day), but was lesser than Pokhara SMC (0.22 kg/capita/day), LMC (0.19 kg/capita/day) and KMC (0.23 kg/capita/day). On the other hand, this study found average HH waste generation of 0.85 kg/day and 0.24 kg/capita/day, which is higher than that of KMC's. Bigger sample size, inclusion of all wards and weekly-based data in this study might have contributed for such discrepancy and could be considered more accurate to estimate the actual waste generation of the municipality. This range is also similar to cities of other developing countries (Friedrich & Trois, 2011) but much lower compared to OECD countries with generation rate of 1.43 kg/capita/day (OECD, 2016). Given the population of 39,172 inhabitants, it is estimated that 9.4 tonnes of HH waste per day is being generated in Gorkha municipality. It can be said that HH waste per day has increased by about 4.78 tonnes or 103.46% since 2012 (ADB, 2013) to 2015. If the waste from other sources are also considered, then the total municipal waste generation will be more than 9.4 tonnes per day. If the HH waste is estimated to be comprised of 75% of total municipal waste, then it can be estimated that around 12.53 tonnes of total municipal waste is generated in Gorkha municipality. In 2012, it was estimated that only about 6.6 tonnes of municipal waste is generated in Gorkha municipality which has now increased by around 90%.

Table 4.2 Summary of continuous variables.

Variable	Observation	Mean	Standard Deviation	Min	Max
HH waste (per capita per day)	401	0.24	0.10	0.07	0.81
HH waste (per day)	401	0.85	0.40	0.10	2.42
Age	401	47.90	13.07	23.00	85.00
Education	401	7.22	4.33	1.00	17.00
HH size	401	3.72	1.36	1.00	9.00
Income*	401	36854.20	28509.48	8020.00	244083.00

Note. * Income is in NRs. 1 U.S. Dollar = 102.13 NRs. (Nepal Rastra Bank, 2017)

Table 4.3 Summary of categorical variables.

Variable	Observation (Percentage)
Gender:	
Male	296 (73.82)
Female	105 (26.18)
Occupation:	
Employed (Businessman + Government/Private employee + Farmer)	363 (90.52)
Unemployed (Housewife + Retired)	38 (9.48)
House ownership:	
Owned	350 (87.28)
Rented	51 (12.72)

Table 4.4 shows result from OLS model. R-squared value, which measures goodness of fit for estimated regression model, of 0.6356 depicts good fitting of the model. It indicates 63.56% of total variation in per day HH waste generation is accounted for by 7 included independent variables in the model.

Table 4.4 OLS result after robust standard error estimation.

HH waste	Coefficient	Robust Standard Error	t	P>|t|	[95% Confidence Interval]	
Gender	0.0137	0.0292	0.47	0.639	-0.0437	0.0710
Age	0.0007	0.0012	0.54	0.586	-0.0017	0.0031
Education	0.0036	0.0038	0.96	0.339	-0.0038	0.0110
Occupation	-0.0031	0.0502	-0.06	0.951	-0.1018	0.0956
HH size	0.1169*	0.0133	8.81	0.000	0.0908	0.1430
House ownership	0.0316	0.0365	0.87	0.387	-0.0402	0.1035
Ln income[a]	0.3678*	0.0281	13.11	0.000	0.3126	0.4230
Constant	-3.4608*	0.2919	-11.85	0.000	-4.0348	-2.8869

Note. [a] Ln is natural log. *significant at 1%. Number of observations = 401; Probability > F = 0.0000; F (7, 393) = 65.32; R-squared = 0.6356; Root MSE = 0.24577

Except for HH size and HH monthly income, other variables did not show any significant impact on HH waste generation. Both HH size and HH monthly income have positive influence on HH waste generation. In this case, holding all other variables constant, a member increase in HH will increase the total HH waste generation by 0.12 kg/day, significant at 1%. Other studies have also found similar positive result (Afroz et al., 2011; Afroz, Masud, Akhtar, & Duasa, 2013; Gu et al., 2015; Khan et al., 2016; Maskey et al., 2016; Sankoh et al., 2012; Senzige et al., 2014; Sujauddin et al., 2008; Suthar & Singh, 2015; Trang et al., 2017). The more members in a HH, the more will be purchased and consumed that will ultimately result in higher waste generation.

Holding all other variables constant, a percent increase in HH's monthly income will lead to generating extra waste of 0.0037 kg/day, significant at 1%. This correlation has been supported by many other studies (Afroz et al., 2011; Bandara et al., 2007; Gu et al., 2015; Irwan et al., 2012; Kayode & Omole, 2011; Maskey et al., 2016; Ogwueleka, 2013; Sankoh et al., 2012; Sujauddin et al., 2008). Higher income increases purchasing power to consume more, which is bound to have impact on waste generation. In an early stage of urbanization, growth in family income leads to material consumption, which increases the waste amount (Lilai Xu et al., 2016). This could also be the case in Gorkha municipality.

The rest of the variables did not show any significant impact on waste generation. In case of gender, as Dalen & Halvorsen (2011) stated, there is no significant gender effects in waste generation because it is the accumulated result of all HH members' behavior. Similarly, age of HHH also has no significant impact. Although educated people are supposed to be more aware of waste impact on environment, in this case it does not have any significant impact and can be explained by the slower rate at which such awareness increases compared to rate of being educated (Oribe-Garcia et al., 2015). It can also be said that the content of education does not specifically educate or make people aware enough about waste impact on the environment to have any significant impact on their behavior. It was assumed that occupation demands more time outside of ones' house which might result in generating higher waste compared to housewives and retirees because latter would have more time to do activities that generate less waste or to manage it well. For example, they will have more time to prepare their own meal, rather than buying packaged instant food. The reason it did not show significant result could be because since people having different occupation live under the same roof, those staying-at-home members would compensate for the act/work of waste generation/management on behalf of those whose occupation demands more time outside one's house. Overall, it can be said that in case of the study area, characteristics of HHH alone does not determine waste generation as it is the outcome of combined activities of all HH members. Similarly, those who own the house also do not significantly differ than those who rent when it comes to generating more waste.

4.4.2 Waste Composition

Figure 4.1 provides HH waste composition of Gorkha municipality from this study. It was found that out of 343 kg/day waste generated by 401 HHs; organic form almost half (47.25%), which is in line with previous studies conducted within Nepal (ADB, 2013; SWMRMC, 2004, 2008). Organic waste of developing countries in general consists of more than 50% of total waste composition (Aleluia & Ferrão, 2016; Hoornweg & Bhada-Tata, 2012). However, the average municipal organic waste composition in Nepal was found to be 66.4% (ADB, 2013) but the organic waste composition in the study area is rather similar to the global municipal organic waste composition of 46% (Hoornweg & Bhada-Tata, 2012). Table 4.5 provides list of waste component within each category. Organic waste included both kitchen and yard waste. Paper and paper products comprised of 10.38%, followed by glass (9.88%), metal (6.92%), plastic (5.39%), textile (3.57%), and rubber and leather (1.38%). Other waste comprised significant share of 15.23%, which also included hazardous waste like batteries and light bulbs. Hazardous waste contains corrosive or toxic ingredients and are prone to catch fire, react or explode under certain circumstances. While immediate danger of such waste if disposed haphazardly may not be known, it can pollute environment and pose threat to human health if not disposed properly (EPA, 2017).

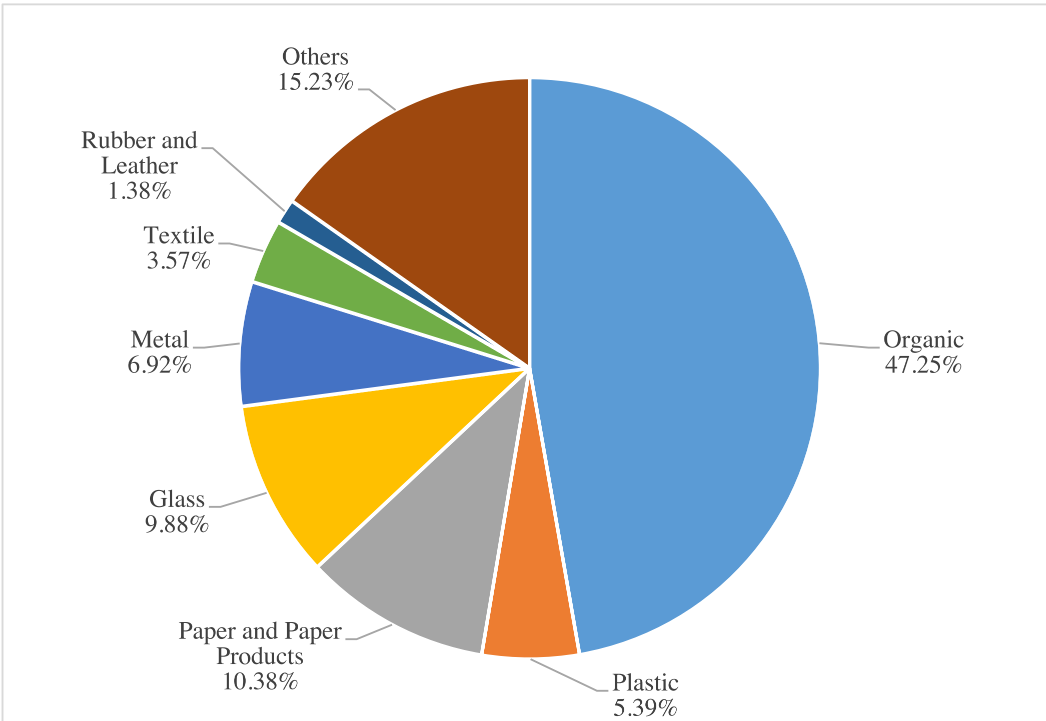

Figure 4.1. Waste composition of Gorkha municipality.

Table 4.5 Description of waste component under each category.

Category	Description
Organic waste	Kitchen waste (vegetable and fruit peelings, eggshells, food leftovers, tainted food, tea leaves, bones, oil, etc.) and yard waste (leaves, grasses, weeds, plants, flowers, woods, branches, etc.)
Recyclable materials:	
Metal	Aluminum cans, broken construction steel rods, broken umbrella metal rods and old utensils.
Paper and paper products	Notebooks, books, newspapers and cardboards.
Plastic	Polyethylene Terephthalate bottles such as beverage bottles; low-density polyethylene such as trash bags and high-density polyethylene plastics such as bags and sacks, sheets, toiletries containers, condiment containers, water bottles, drums, toys; and polystyrene such as food packages.
Glass	Beer bottles, alcohol bottles, jars and medicine bottles.
Textile	Old clothes.
Rubber and leather	Slippers, shoes and belts.
Others	Ceramics, medicines, light bulbs (Compact fluorescent, incandescent bulbs), batteries, electronics (radios, wires) and inert waste.

At present, all these wastes are dumped in municipality designated open dumpsite where some scavengers pick up recyclable waste to sell it to junkshop owners. However, there is no data to confirm the recycling rate. If all the waste generated is to be collected and managed by the municipality, the total waste generated by HHs would be about 3,431.5 tonnes/year. Assuming 47.25% of these would be organic waste, about 1,621.4 tonnes/year of organic waste would be generated. Organic waste when decomposed in landfill or dumpsite produces methane, a major GHG 21 times more potent than carbon dioxide (EPA, 2002). Methane emission from landfill is known to be the largest source of GHG emission from waste sector (UNEP, 2010). Organic waste is also the major source for leachate production in landfill and causes unpleasant odors (Tai, Zhang, Che, & Feng, 2011). Leachate, a fluid infiltrating from landfill generated from liquid already present in the waste or water from outside penetrating through the waste, contains various contaminants at concentration level impacting ground and surface water. It may be highly toxic for several decades or even centuries before reaching a level acceptable to be non-threat (Cointreau, 2006; EPA, 2002; Zorpas et al., 2015).

Thus, given the amount and intensity of its impact, organic waste should be prioritized for management. It can be managed in several ways but composting has proven to be the most economical and efficient technique among other management options in developing countries given the waste type, nature and composition (Taiwo, 2011). Composting is a natural biological degradation process where microorganisms convert organic matter into humus-like material that can be a valuable soil amendment integral to sustainable agriculture (Hoornweg et al., 2000). But it is also a matter of who should take responsibility of composting as it can be done at HH, community or institutional level. From key informant interview it was found that out of 15 wards, municipality provides waste collection service to only 6 wards which even today is done with the possession of only one tractor. Overall collection efficiency is estimated to be about 30% only (ADB, 2013). This lack of capacity proves that majority of organic waste still gets left behind uncollected. Composting organic waste at source is known to be the best way of solid waste disposal as it will reduce the waste volume transported to the landfill and will increase landfill's life (Pokhrel & Viraraghavan, 2005). It thus favors HHs, the main source of waste generation, to compost so that it reduces amount of waste that needs to be collected and managed, decreasing the overall cost of SWM.

From the follow-up survey of HHs who were provided subsidized compost bin by the local government, only about 56% of them are found to be continuing to use compost bin and the rest 44% are not using either because of insect invasion, bad smell, leachate generation, lack of space, lack of waste as input, lack of expertise in making quality compost, damaged bin or simply because they could not invest enough time. All this could also be because HHs do not realize the economic benefit of using compost. While supporting HHs through follow-up training can increase the adoption rate to certain extent, there is bound to be some who will not prefer composting on their own. That is why municipality should take their own initiative of composting as well. Another way is to assign duties at the ward-level where material recovery and composting facilities can be built. This method has proven to be very successful in lessening waste generation and improving waste management process in developing country like the Philippines (Maskey et al., 2016). Smaller administrative units like wards would be more efficient in collecting and handling waste given proper resources are available.

Composting requires organic waste to be separated from other waste, which makes it easier to collect other recyclable waste as well. Source separation of waste is important to reduce waste treatment cost (Pokhrel & Viraraghavan, 2005). According to Tai et al. (2011), because of lack of kitchen waste separation, municipal recycling system receives 60% of food remnants, thus causing MSW to be of low calorific value, high moisture content and high proportion of organisms with low average net heating value. Therefore, waste segregation should be encouraged at least in two categories: organic and non-organic. From the follow-up interview while collecting one-week segregated waste, it was revealed that 91% of respondents are willing to segregate waste in the future, which can be trustworthy as they just had first-hand experience of waste segregation. The reasons were for cleaner environment and self-satisfaction on being part of a good waste management practice that stimulated recycling.

Since this survey is conducted on just 401 HHs, local government should examine and encourage all HHs through environmental education, and training and awareness programs that will gradually instill value, followed by action. Public education on MSW source-separated collection through various media such as radio, television, newspaper and internet have helped increase residents' awareness (75%) and their behavior (50%); but it should also be supported with required facility as inadequate number of classified containers in residential areas have led to poor source-separated collection rate (18%) (Tai et al., 2011).

Recyclables including metal, paper, plastics, glass, textiles, and rubber and leather also comprised of about 37.52% of HH waste, which totals to be about 1,287.5 tonnes/year. There is only one junkshop within the municipality, which collects recyclables from the HHs and also buys from the scavengers or waste pickers who collect recyclables from the dumpsite. The collected recyclables are transported and sold to recyclable dealers in bigger cities where recycling facilities exists. While there is no formal data as to how much waste is being diverted by recycling, institutionalizing the current waste pickers in addition to enforcing waste segregation would lead to better diversion of recyclable waste. This might also increase local job opportunity of recyclable waste collection and transportation. Other waste formed about 522.6 tonnes/year, which also includes hazardous waste. Unfortunately, municipality does not have any separate system to collect and manage hazardous waste but is amassed together with other municipal waste and is disposed at the dumpsite. There should be an arrangement for managing especially the hazardous waste to the highest possible environmentally and socially acceptable standards. It is also worth mentioning that if waste from other sources such as commercial, industrial or institutional entities were to be included, the total waste that is actually generated in each of the category would be much higher and most probably ends up being uncollected or disposed at the open dumpsite.

4.5 Conclusion and Recommendations

Like any other cities in developing countries, Gorkha municipality of Nepal is marred by growing amount of MSW but is severely devoid of required resources and reliable data to make an effective waste management strategy. To the best of our knowledge, this study is the first in Gorkha municipality to assess correlation of relevant socioeconomic factors affecting HH waste generation. Socioeconomic factors are an important indicator in behavioral studies and HHs were focused among other categories of waste generators because in Nepal they are responsible for about 75% of total municipal waste generation. Perhaps one of the most important aspects of this study that strengthens the accuracy of its result is that it relied on bigger sample size, included all municipality wards and collected weekly instead of just one-day data on waste generation as was done by previous studies. Among the socioeconomic factors, this study found that family size and income are important indicators to forecast solid waste generation trend.

Meanwhile, focus should also be on waste management strategy. While analyzing waste composition, organic waste formed the highest share of total waste. From this study, it is estimated that in Gorkha municipality, HHs generate about 1,621.4 tonnes of organic waste every year, most of which are uncollected, and the rest discarded in an open dumpsite. If left unattended, it will create problems of smell, leachate, flies, rodents and methane emission that will affect human health and environment. Thus, given the amount and intensity of its impact, organic waste should be prioritized for management. It can be managed in several ways, but composting has proven to be the most economical and efficient technique among other management options in developing countries given the waste type, nature and composition. The best strategy would have been to promote HH composting as managing at source would lead to environmentally sound and economically feasible means, but most importantly it reduces waste volume that needs to be transported to the dumpsite, which municipality is already incapable of. However, follow-up survey found that the success rate of HH composting has proven to be just 56% even after providing training and distributing subsidized compost bins by the municipality. While supporting HHs through follow-up training shall increase the adoption rate to certain extent, there is bound to be some who will not prefer composting on their own. That is why municipality should take their own initiative of composting as well. Another way is to assign duties at the ward-level with proper resources in place so that collection and handling of waste would be more efficient.

The recyclable potential of remaining waste (metal, paper, plastic, glass, textiles, and rubber and leather) is also very high (37.52% of total waste or about 1,287.5 tonnes/year). Even though there is no recycling institution within the municipality, the current waste pickers who collect recyclable waste from landfill should be institutionalized in order to effectively channel recyclable waste to junkshop owners who are responsible for transporting these materials in cities where recycling exists. This might also increase local job opportunity of recyclable waste collection and transportation. Other waste formed 15.23% of total waste (about 522.6 tonnes/year) which is of significant amount as well and should be managed accordingly. It includes hazardous waste as well, which should be managed in the highest possible environmentally and socially acceptable standards as it contains corrosive or toxic ingredients that pollute environment and pose threat to human health. If waste from other sources such as commercial, industrial or institutional entities were to be included, the total waste generated in the municipality would be much higher.

In the midst of waste management, waste segregation should be the most important step that assures waste management in an environmentally sound and economically feasible way.

HHs should be encouraged to segregate waste at least in two categories: organic and non-organic. It was revealed that 91% of respondents are willing to segregate waste in the future, which can be trustworthy as they just had first-hand experience of waste segregation in the process of taking part in this study. The local government should encourage all HHs through environmental education, and training and awareness programs that will gradually instill value, followed by action.

Chapter 5. Households' Willingness-to-Segregate Waste

5.1 Introduction

With rapidly increasing urbanization and population growth along with the changing consumption pattern, the amount of global solid waste generation has increased significantly. In 2012, 1.3 billion tonnes of solid waste was generated by urban population globally which is about 48% increase over the past 10 years and it is expected to increase to 2.2 billion tonnes by 2025 (Hoornweg & Bhada-Tata, 2012). MSWM is a growing concern and to effectively manage solid waste is a major challenge for any country. MSWM is inadequate in most of the cities of developing countries, where a significant portion of the population does not have access to a waste collection service and only a fraction of the generated waste is actually collected. Developing countries faces even bigger challenge as huge amount of investment is required for MSWM. About 20-50% of municipal budget is spent on MSWM. In spite of spending half of the municipal budget on MSWM, 30-60% of the waste are uncollected and less than 50% of its population is served (The World Bank, 2016). The uncollected waste, which is often mixed with human and animal excreta, is dumped indiscriminately in the streets, banks of the river and in drains which contributes to flooding, breeding of insects and rodent vectors leading to spreading of diseases. Furthermore, even collected waste is often disposed of in uncontrolled dumpsites and/or burnt, polluting water resources, air and environment (Zurbrugg, 2002). Such inadequate waste disposal creates serious environmental problems that affect health of humans and animals and cause serious economic and other welfare losses. The environmental degradation caused by inadequate disposal of waste can be expressed by the contamination of surface and ground water through leachate, soil contamination through direct waste contact or leachate, air pollution by burning of waste, spreading of diseases by different vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste.

Nepal is one of the least developed countries in the world. With the total area of 147,181 square kilometers, Nepal has the population of over 26 million (CBS, 2014c), which is 13.03% increase over the past ten years. In nominal terms, per capita consumption increased from NRs. 6,802 in 1995/96 to NRs. 15,848 in 2003/04. Average HH income grew by more than 80% from 1995/96 to 2003/04. During the same period, per capita income increased from NRs. 7,690 to NRs. 15,162 (CBS, 2004).

Population and purchasing power has a direct correlation with the generation of solid waste. With the increasing population and purchasing power, more and more solid waste is being generated and Nepal is facing even more difficulty and challenge to deal with solid waste. With urbanization comes rise in the amount of municipal solid waste and the problems of managing such waste. Waste can be a valuable resource if used properly but if remained untreated, it can cause serious environmental and public health hazards. In Nepal, about 62.3% of total municipal waste is collected and managed by the municipalities (ADB, 2013).

Waste segregation at source, i.e. at HH level plays a very important role to effectively manage municipal waste. Although Solid Waste Management Act of Nepal, 2011 has clearly stated the provision for segregation of the solid waste, for which the local body is given the full responsibility to prescribe for segregation of solid waste at source, it has hardly been made into practice. A study conducted by ADB (2013) found that only 30% of the surveyed HHs were segregating waste at source. Waste segregation at source has not yet been implemented in Gorkha municipality and this study tries to assess the willingness of the HHs to participate in waste segregation if the government enforces the law. The findings from this study will help the concerned stakeholders to come up with relevant effective plans and programs for waste segregation at source to successfully implement and put into practice.

5.2. Literature Review

Segregation of waste at source and separate collection of waste is the first and a fundamental step to solve municipal HH solid waste problem (Chu, Wang, Wang, & Zhuang, 2016). Waste segregation at HH level can preserve the quality of recyclables, which will improve the accessibility to informal recycling sectors and help in overall reduction of waste for disposal (Matter, Dietschi, & Zurbrügg, 2013). In order to make recycling a success; political, economic, social conditions and most importantly the attitudes of people plays a crucial role (Ball & Lawson, 1990; De Feo & De Gisi, 2010a; Martin, Williams, & Clark, 2006; McDonald & Oates, 2003; Perrin & Barton, 2001; Tonglet, Phillips, & Bates, 2004).

Policy implementation is a huge challenge for the government and it may not be successful if there is a lack of clarity and awareness by the stakeholders and if it is not strictly enforced (Mani & Singh, 2016). Compulsory recycling program implemented by the government can have a higher participation rate than voluntary recycling by the resident (Everett & Peirce, 1993; Noehammer & Byer, 1997). Technological dimension has greatest impact followed by political, economic and sociocultural dimensions on effectiveness of municipal HH solid waste separate collection (Chu et al., 2016).

Financial incentive is one of the significant factor that influence separate waste collection. Financial incentive policies should be made by the government to encourage more public participation for recycling (Steuteville, 1995). Economic incentives significantly influence recovery of recyclables at HH level (Yau, 2010).

Environmental awareness and concern influences the behavior of the people (Desa, Kadir, & Yusooff, 2011; Minton & Rose, 1997) for effective recycling program to be successful (Derksen & Gartrell, 1993; Miafodzyeva & Brandt, 2013),which can also have an impact on waste segregation for proper waste management.

Zhang and Wen (2014) found that waste segregation at HH level is influenced by age, source separation facilities and government policies. De Feo and De Gisi (2010b) found that older age group of participants were more satisfied than the younger ones for separate waste collection programs for recycling. Convenience and existence of infrastructure are important factors that can influence segregation of waste at source (Bernstad, 2014). Lack of knowledge is one of the major factors that prevents people from recycling and females are more likely to participate in waste recycling than males (Otitoju, 2014). A study by Lober (1996) found that recycling is more efficient and accepted by the participants than waste reduction activities at source.

Information about recycling, condition of recycling facility and personal recycling skills influence the recycling behavior (Ittiravivongs, 2012). Number of HH member and HH who does environmental protection activities such as waste water treatment and waste reduction influences recycling behavior of the HH (Kato, Tran, & Hoang, 2015). HHs participation in solid waste segregation and recycling activities are influenced by the promotional campaign, training programs and age of the residents (Atthirawong, 2016). Study by Xu et al. (2017) found that the effect of governmental incentives on recycling behavior is greater on male than female and income of the HH negatively influences recycling behavior. Low income HHs are more likely to recycle than higher income HHs.

5.3. Data Collection

HHs were requested to segregate waste into organic and inorganic waste for a week to assess waste generation and characterization of HH waste in Gorkha municipality. After a week, the waste was collected, and waste generation and characterization study were conducted. All the participant HHs were approached with the semi-structured questionnaire. The semi-structured questionnaire included questions related to the socioeconomic characteristics of the HHs, current SWM practices, services provided by the municipality, awareness about the impact of waste on environment, WTP for improved waste collection service, whether they segregated waste for a week or not, and willingness of the HHs to segregate waste if the government enforces the law.

5.4. Empirical Model

Logit regression model was used in this study to identify the determinants of HHs' willingness-to-segregate waste into organic and inorganic waste if the government enforces the law in future. Logit model was used because of its comparative mathematical simplicity and asymptotic characteristics, as has been mentioned and used by many other authors for similar studies (Addai & Danso-Abbeam, 2014; Aggrey & Douglason, 2010; Anjum, 2013; Awunyo-Vitor, Ishak, & Jasaw, 2013; Bhattarai, 2015; Mary & Adelayo, 2014; Oteng-Ababio, 2010; Song, Wang, & Li, 2016). It has a cumulative probability function with the ability to deal with dependent variable which allows for estimating the probability that an event will occur or not through prediction of a binary dependent outcome from a set of independent variables (Aggrey & Douglason, 2010). The logit model to identify HH's WTP for improved waste collection service can be specified as:

$$Y = \frac{1}{1 + \exp^{-z}} \tag{5.1}$$

where,

Y = Respondents' response to WTP (Yes = 1, No = 0)

Z = Summation of explanatory variables multiplied by their coefficient, i.e.,

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots\dots\dots + \beta_9 X_9 + \varepsilon_i \tag{5.2}$$

where,

β_0 = Constant

β_1…… β_9 = Coefficient of explanatory variables X_1……X_9

ε_i = Error term

To find out the probability of HHs' willingness-to-segregate waste, the parameters from logit model cannot be used to interpret effects of each of the explanatory variable as the model is nonlinear. In this case, marginal effects are calculated to find the relative magnitude of effects of each of the explanatory variable. The effects of the jth explanatory variable can be summarized as below:

$$\frac{1}{n}\sum_{i=1}^{n}\frac{\partial P[Y_i = 1]}{\partial X_{ji}} = \beta_j \frac{1}{n}\sum_{i=1}^{n} f(X_i' \beta), \qquad j = 2, \dots, k. \tag{5.3}$$

i.e., the mean marginal effects over the sample of n individuals.

Maximum likelihood method is used to estimate the parameters of the multiple logistic response function. The log-likelihood function is as follows:

$$logL(\beta) = \sum_{i=1}^{n} Y_i(X_i'\beta) - \sum_{i=1}^{n} log[1 + \exp(X_i'\beta)] \quad (5.4)$$

5.5. Variables Selection

The explanatory variables used in this study are based on the assumption that it will influence on the respondent's decision to segregate or not to segregate waste in the future. The explanatory variables used in this study are described in Table 5.1 and explained below:

Table 5.1 Description of explanatory variables used in this study

Variable	Description	Unit of Measure
Income	Total average monthly income of HH	NRs. (1US$ = NRs. 102.13) *
HH size	Total number of members currently residing in the house	Number of individuals
Gender	Gender of HHH	1 = Male 0 = Female
House ownership	Ownership of currently resided house	1 = Owned 0 = Rented
Environmental awareness	Whether respondent is aware about environmental impacts by waste or not	1 = Yes 0 = No
Waste collection service	Have access to waste collection service or not	1 = Yes 0 = No
WTP	Whether respondent is willing to pay for improved waste collection service or not	1 = Yes 0 = No
Make compost	Whether the HH use their organic waste to make compost or not	1 = Yes 0 = No
Segregated waste for a week	Whether the HH segregated the waste for a week or not	1 = Yes 0 = No

*The exchange rate as of August 31, 2017 (Nepal Rastra Bank, 2017)

5.6. Results and Discussions

5.6.1 Characteristics of Households in the Study Area

This study found that HHHs are predominantly male (73.82%), and the average size of the HH is 3.72, which is almost similar to the national census result of 3.69 (CBS, 2014a). The average monthly HH income is found to be NRs. 36,854.20 (360.86 US$). There is a huge difference between the minimum and maximum HH income found in this study, which is NRs. 8020 (78.53 US$) and NRs. 244,083 (2389.92 US$), respectively. This result reflects the huge economic gap between HHs residing within Gorkha municipality. HHs in very rural setting within the municipality were also considered, which also included very poor HHs whose livelihood depends only on farming. Most of the HHs who participated in this study lives in their own house (87.28%), and less than half of the HHs (36.66%) have the waste collection service offered by the municipality. Although more than half of the HHs (58.35%) are aware about the adverse effects caused by waste and its improper management on the environment, it cannot be denied that the remaining HHs (41.65%) who are unaware about such adverse effects also constitute a significant percentage.

Out of 401 respondents, about 61% are willing to pay for the improved waste collection service (Table 5.3). This share of respondents' WTP is somewhat similar to other similar studies where more than 60% of the respondents provided positive response (Anjum, 2013; Eshun & Nyarko, 2011; Jones, Evangelinos, Halvadakis, Iosifides, & Sophoulis, 2010; Karthigarani & Elangovan, 2016; Mahima & Thomas, 2013; Roy & Deb, 2013). The total number of HHs who use their waste to make compost is slightly greater than those HHs who do not make compost. About 52% of the surveyed HHs make compost and about 48% do not make compost. Most of the HHs segregated waste for a week (95.76%) and they were very happy with the practice, because they saw changes in the cleanliness of the house and surrounding as well as behavior among the HH member to manage waste properly. Although, almost all of the households segregated waste for a week, only 67.33% of them are willing to segregate waste in future if the government enforces the law. Some of the main reasons for those households who do not want to segregate waste in future are:

(i) Do not want to be forced to segregate waste.

(ii) Law implementation will not be successful because people will not obey the law.

(iii) Generate less amount of waste so it can be self-managed.

The summary of these characteristics of the HHs in this study are also summarized in Table 5.2 and Table 5.3.

Table 5.2 Summary of continuous variables

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Income	401	36854.20	28509.48	8020	244083
HH Size	401	3.72	1.36	1	9

Source: Field survey (2015)

Table 5.3 Summary of categorical variables

Variable	Observation (Percentage)
Gender:	
Male	296 (73.82)
Female	105 (26.18)
House Ownership:	
Owned	350 (87.28)
Rented	51 (12.72)
Waste Collection Service:	
Have service	147 (36.66)
Do not have service	254 (63.34)
Environmental Awareness:	
Aware	234 (58.35)
Not aware	167 (41.65)
WTP	
Yes	244 (60.85)
No	157 (39.15)
Make compost	
Yes	208 (51.87)
No	193 (48.13)
Segregated waste for a week	
Yes	384 (95.76)
No	17 (4.24)

Source: Field survey (2015)

5.6.2 Factors Influencing Households' Willingness-to-Segregate Waste if the Government Enforces Law

The results from the logit regression model is presented in Table 5.4. All 401 observations are used in this analysis. The log likelihood for this fitted model is -185.59087 and the likelihood ratio (LR) chi-square of 135.53 (df=9) with a p-value 0.0000 (significant at 1%) states that this model is statistically significant and as a whole fit significantly better than an empty model, i.e., only with the dependent variable.

Table 5.4 Logit regression results of factors influencing willingness-to-segregate waste if the government enforces

Independent Variables	Coefficient	Standard Error	Z-statistics	Marginal Effect
Income	-0.000011**	0.000005	-2.30	-0.000002
HH size	-0.039201	0.096006	-0.41	-0.005904
Gender	-0.517621*	0.311353	-1.66	-0.077964
House ownership	-0.196384	0.389795	-0.50	-0.029579
Environmental awareness	1.740836***	0.264437	6.58	0.262203
Waste collection service	1.117412***	0.303545	3.68	0.168304
WTP	0.725199***	0.272514	2.66	0.109229
Make compost	1.256562***	0.274483	4.58	0.189262
Segregated waste for a week	1.874554***	0.583208	3.21	0.282344
Constant	-2.167573***	0.783154	-2.77	
Number of observations	401			
Log likelihood	-185.59087			
LR $chi^2(9)$	135.53			
Probability > chi^2	0.0000***			
Pseudo R^2	0.2675			

Source: Field survey (2015)
* significant at 10% ** significant at 5% and *** significant at 1%

This study found that the significant variables that influence HHs' willingness-to-segregate waste in future if the government enforces the law are income, gender, environmental awareness, waste collection service, WTP, make compost and segregated waste for a week. Only HH size and house ownership variables do not have any statistically significant influence on the HHs' willingness-to-segregate waste.

The total average income of the HH is statistically significant at 5% level and it negatively influences HHs' willingness-to-segregate decision. The marginal effect results show that a unit increase in HH income would decrease the likelihood for HHs' willingness-to-segregate waste by 0.000002%, i.e., if the monthly HH income increases by NRs. 100,000 (970.91 US$), the likelihood for HHs' willingness-to-segregate decreases by 0.2%. Even though, the effect is very less, it is important to understand the negative effect of the income variable.

The gender variable is statistically significant at 10% level, with a negative coefficient value. This shows that female HHH are more likely to segregate waste in future than male HHH. This could be because, in Nepal, females are responsible to do HH chores, which also includes management of HH waste. Hence, they are more effected and concerned for proper management of waste.

The environmental awareness variable has a positive coefficient and is statistically significant at 1% level. This result shows that HHs are more likely to segregate waste if they are aware about the adverse impacts of waste on environment by 26.22% than those HHs who are not aware.

The waste collection service variable is significant at 1% level of significance with positive coefficient. This shows that the HHs who have the current waste collection service must be aware about the importance of such service and that segregating waste would only help in improving waste collection service.

The WTP variable is statistically significant at 1% level of significance with positive coefficient. This implies that, HHs who are willing to pay for the improved services are more concerned about the proper management of waste and they want to be a responsible citizen by obeying the law. The HHs who are willing to pay for the improved service is likely to segregate waste than those who are not willing to pay by 10.92%.

HHs who make compost are more likely to segregate waste than who do not make compost by 18.93%, which is statistically significant at 1% level of significance. This could be because these HHs are using their organic waste to make compost and for that they might have already been segregating their waste.

HHs who segregated waste for a week are also likely to segregate waste in future by 28.23% than those HHs who did not segregate waste for a week. This variable is statistically significant at 1% level of significance. This could be because, these HHs saw the changes in cleanliness of their house and also could recover recyclable waste. They understood the benefit of waste segregation and so would like to continue segregating waste if the government enforces the law.

Although the national government has enacted law for waste segregation at source, local government in the study area has not implemented the law. The significant variables found from this study can be taken as a guiding tool to understand the characteristics of the households before enforcing the law. Although household income negatively influences the waste segregation behavior, environmental awareness and waste segregation practice can positively influence the waste segregation behavior of the household. Therefore, concerned stakeholders should educate and make households aware about the importance of waste segregation and environmental impacts caused by waste. This would encourage the households with higher income and also the male household heads to segregate waste. Households who make compost is highly statistically significant with willingness-to-segregate waste. The concerned stakeholders should provide training programs so that quality compost can be made and also to encourage other households to make compost. Furthermore, the concerned stakeholders should also make a market to buy and sell the compost. Households who are willing to pay for the improved waste collection service are also likely to segregate waste if the government enforces the law. Therefore, the government should improve the current solid waste management services provided in the municipality to encourage household waste segregation. Currently, waste collection service is provided only in few areas within the municipality and households who have such service are willing to segregate waste. For the local government, it may not be feasible to provide waste collection service to all the areas within the municipality. But, as a pilot phase, the local government can enforce waste segregation to the areas where it provides the waste collection service. In long term, after the municipality has enough technical, financial and manpower resources to provide waste collection service to all the areas, waste segregation at source can be enforced for the whole municipality.

5.7. Conclusion and Recommendations

This study tried to highlight the importance of waste segregation at source for effective waste management and identify the determinants of willingness of HHs to segregate waste in future if the government enforces the law. This study found that environmental awareness, waste collection service, WTP for the improved services, make compost, and segregated waste for a week variable are statistically significant at 1% level of significant. Income variable is significant at 5% level of significance and gender variable is significant at 10% level of significance. Policy implementation is a huge challenge for the government and so the findings from this study could be taken into consideration to enforce the law of waste segregation at source in the study area as well as other municipalities in Nepal and even in other developing countries.

Chapter 6. Households' Willingness-to-Pay for Improved Waste Collection Service

6.1 Introduction

Increase in population, income level and urbanization increases the amount of solid waste generation, and if not managed properly, it creates serious negative impact on human health, environment and also the economy (Hoornweg & Bhada-Tata, 2012). Greater economic prosperity and increase in consumption level has intensified the problem of SWM and is now a major challenge in urban areas of developing countries (JICA, 2005a). Significant portion of municipal budget is spent on SWM in Asian countries but rapid increase in population, economic growth and improvement of living standard have resulted in the substantial increase in the amount of solid waste being generated, making SWM even more challenging (APO, 2007).

SWM is a huge problem for the local and national government of Nepal as well. The average municipal budget spent for SWM is only about 10% and only 62.3% of the total municipal waste generated is collected by the municipalities in Nepal (ADB, 2013). The most significant aspect of municipal SWM is collection and transportation of solid waste as it demands the major share of municipal budget and has the greatest impact on urban life (Manus Coffey & Coad, 2010). In case of Nepal, almost all of the municipal budget allocated for SWM is spent on solid waste collection, transportation and street-sweeping. The Solid Waste Management Act of 2011 was enacted by the Government of Nepal to be effective from 15th June 2011, which gave full responsibility to the local bodies like municipalities for the SWM service, including an authority to impose and collect fees for the service provided (Government of Nepal, 2011). However, most of the municipalities do not have a formal system to impose fees for SWM related services (ADB, 2013). Therefore, financial constraint proves to be the greatest hindrance for providing adequate SWM services in Nepal. Nonetheless, collecting fees from the public for improving the service seems to be the only viable option.

This study was conducted in Gorkha municipality of Nepal where SWM service is restricted by the limited resources. The estimated total MSW generation is about 6.6 tonnes/day, out of which only 2 tonnes/day is being collected by the municipality; i.e., only about 30.3% of the total daily waste generated is collected (ADB, 2013). The municipality has only one tractor to collect waste within the whole municipality and therefore only limited HHs who live nearby the pitched main road are able to receive the service of waste collection. Until now, this service is provided free of cost and thus the most attainable way to improve the current service is through generating revenue by imposing waste collection fees so that the geographical coverage of waste collection could be expanded and maximum number of HHs can be served. But willingness of the HHs to pay for such service remains a question as it depends on many factors including their financial ability and how they value the importance and impact of such service.

In order to identify the WTP for certain goods or services, especially when the goods being transacted are not being traded in the market, contingent valuation (CV) method can be used. The CV method is a widely used and accepted technique to study WTP for both marketable and non-marketable goods such as travel cost, reduction in the risk of death, improvement in air quality, sanitation, water supply and other environmental services. Because such conditions are non-existent in the targeted location, WTP cannot be extrapolated from the existing conditions (Alberini & Cooper, 2000; Mitchell & Carson, 1989). In such scenario, “stated preference” approach such as CV is used, which is a direct assessment technique that measures the expected amount of the project in monetary terms by directly asking those who will be benefited by the services under hypothetical circumstances through a questionnaire survey with the assumption that it will be implemented in the near future (Alberini & Cooper, 2000; Damschroder, Ubel, Riis, & Smith, 2007; Fujita, Fujii, Furukawa, & Ogawa, 2005; Mitchell & Carson, 1989).

Thus, with this intent, this study tries to evaluate WTP by the HHs for improved SWM service of waste collection and factors influencing it. The findings from this study will help the local government and concerned stakeholders to understand about the relevant characteristics of HHs and come up with a suitable fee for waste collection service, which shall help to improve the current overall SWM scenario. This study can also be a guiding tool to conduct WTP study in other municipalities of Nepal and other developing countries where there is no waste collection fee imposed.

6.2 Methodology

6.2.1 Willingness-to-Pay Techniques

In this study, we have used CV method, which is a stated preference valuation method to elicit WTP by the HHs in Gorkha municipality for improved waste collection service. A seminal paper by Menegaki et al. (2016) have compiled a checklist from studies conducted around the world, which the authors recommends that it should be reported when stated preference valuation method is used. Although the checklist is for web-based survey, it can also be applied for personal interview. Therefore, we have tried to include relevant checklist for this study to describe in detail about the sample selection, questionnaire design and data collection procedures.

WTP techniques can be applied in five different ways: (i) Open-ended questions, (ii) iterative bidding, (iii) alternative approach, (iv) dichotomous choice and (v) multiple-bounded CV approach (Accent, 2010; Alberini & Cooper, 2000).

i. Open-ended questions method is a straightforward way where respondent is asked his/her WTP for a hypothetical service. Its disadvantage is that respondents find it difficult to base a value on and therefore might end up without giving any responses.

ii. Iterative bidding starts with an amount that allows respondent to base his willingness on. If he/she is willing to pay, then the amount will be raised till the respondent accepts to pay. Likewise, if the respondent is not willing to pay, then the amount will be lowered till the respondent accepts to pay. Its disadvantage is that the starting price will have some kind of bias and asking question repeatedly might irritate or tire respondents, ultimately leading them to say yes or no just for the sake of ending the interview.

iii. Alternative approach asks the respondents to choose among the list of possible values that could be in range or multiple specific values. Its disadvantage is also that the starting price might be biased. Besides this, when the value is in range, WTP cannot be directly observed and so the amount has to be predicted.

iv. Dichotomous choice means asking the respondents if they are willing to pay a specified amount and repeat the process until one gets the amount that the respondent is willing to pay. For example, if a respondent is not willing to pay $10 for the proposed plan, the follow-up question might be to ask him his WTP $5. If the respondent still answers "no", it can be assumed that his WTP amount falls between 0 and $5. Again, the disadvantage of this method is that WTP cannot be directly observed as it will be in range, and hence needs to be assumed.

v. Multiple-bounded CV approach asks the respondent with questions of different amounts and willingness such as yes, no, don't know, etc., which is illustrated in the table 6.1.

Table 6.1 Multiple-bounded payment questions

Cost	Definitely Yes	Probably Yes	Not Sure	Probably No	Definitely No
$1					
$5					
$10					
$20					
$50					
$100					
$500					
$1000					

Source: (Alberini & Cooper, 2000)

Its disadvantage is that it does not observe specific amount. According to Alberini, Boyle, & Welsh (1999), in practice, there is no basis supported by economic theory to use such polychotomous-choice, multiple-bounded elicitation approach, and the researchers are compelled to make arbitrary assumptions when specifying the econometric model for the responses.

6.2.2 Questionnaire Design

A semi-structured questionnaire was used to collect data from the HHs, which included questions related to the socioeconomic characteristics of the HHs, current SWM services provided by the municipality, awareness about the impact of waste on environment, and questions related to willingness of the HHs to pay fee for improved waste collection service.

The WTP for improved service is mostly reliant on HH's economic conditions and thus it could also be validated by regressing WTP with socioeconomic variables of the target group (Alberini & Cooper, 2000; Mitchell & Carson, 1989). The awareness about the impact of waste on environment was an open-ended question, which allowed respondents to answer based on their own understanding rather than influencing their decision by providing additional information. The information was used to identify the current situation of SWM practices and characteristics of the HHs that can influence their WTP and the maximum amount they are willing to pay for the improved waste collection services.

In order to elicit the maximum WTP amount for improved waste collection service, an open-ended CV method was used in this study. In the present context, it is the most informative and supposedly superior elicitation technique (Whynes, Frew, & Wolstenholme, 2005). Open-ended method does not have a range nor a starting point biases, and thus can be highly statistically efficient compared to other discrete formats. Other elicitation techniques are most suited when there is already a price system or fee charged specially to study WTP for improved SWM services (Addai & Danso-Abbeam, 2014; Afroz, Hanaki, & Hasegawa-Kurisu, 2009; Awunyo-Vitor et al., 2013; Banga, Lokina, & Mkenda, 2011; Bhattarai, 2015; Hagos, Mekonnen, & Gebreegziabher, 2012; Oteng-Ababio, 2010; Padi, Addor, & Nunfam, 2015). Sumukwo, Kiptui, and Cheserek (2012) opted for an open-ended technique as there was no adequate data on pricing for solid waste collection and disposal services. It has also been followed by numerous other studies (Anjum, 2013; Banga et al., 2011; Hagos et al., 2012; Mahima & Thomas, 2013; Roy & Deb, 2013). Thus, open-ended question format was considered in this study. A pilot study was conducted with 10 HHs before finalizing on the questionnaire, which gave us better understanding about the local issues. Irrelevant questions were excluded, and relevant ones were included based on the specific context of the study area.

6.2.3 Contingent Valuation Scenario

Currently, waste collection service is irregular and is provided only in few main areas in Gorkha municipality. A hypothetical scenario was described to the respondents in order to elicit their WTP for the improved service. The scenario was as follows:

> In order to provide regular waste collection service by the municipality, human resource and number of vehicles should be increased, which incur cost. The municipality can finance the program by imposing waste collection fee. If the municipality provides regular waste collection service in the near future, are you willing to pay for the improved service considering your HH income and expenditure?

If the respondents answered “yes”, they were asked the following question:

> How much of maximum amount per month are you willing to pay for the improved service?

They were then asked to give reasons why they are willing to pay.

If the respondents answered “no”, they were asked to give reasons why they are not willing to pay for the improved service.

For both of the reasons for respondents’ willingness or unwillingness to pay, they were asked to give their own personal opinion so that they will not be restricted or influenced by the structured answers.

6.2.4 Empirical Model

Two levels of analysis using logit and tobit regression models were used in this study. Logit model was used to identify the determinants of HHs' WTP for improved waste collection service and tobit model to identify the factors influencing on the maximum amount of money they are willing to pay.

Logit model was used because of its comparative mathematical simplicity and asymptotic characteristics, as has been mentioned and used by many other authors for similar studies (Addai & Danso-Abbeam, 2014; Aggrey & Douglason, 2010; Anjum, 2013; Awunyo-Vitor et al., 2013; Bhattarai, 2015; Mary & Adelayo, 2014; Oteng-Ababio, 2010; Song et al., 2016). It has a cumulative probability function with the ability to deal with dependent variable which allows for estimating the probability that an event will occur or not through prediction of a binary dependent outcome from a set of independent variables (Aggrey & Douglason, 2010). The logit model to identify HH's WTP for improved waste collection service can be specified as:

$$Y = \frac{1}{1 + \exp^{-z}} \qquad (6.1)$$

where,

Y = Respondents' response to WTP (Yes = 1, No = 0)

Z = Summation of explanatory variables multiplied by their coefficient, i.e.,

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots\ldots\ldots + \beta_8 X_8 + \varepsilon_i \qquad (6.2)$$

where,

β_0 = Constant

$\beta_1 \ldots\ldots \beta_8$ = Coefficient of explanatory variables $X_1 \ldots\ldots X_8$

ε_i = Error term

To find out the probability of HHs' WTP for improved waste collection service, the parameters from logit model cannot be used to interpret effects of each of the explanatory variable as the model is nonlinear. In this case, marginal effects are calculated to find the relative magnitude of effects of each of the explanatory variable. The effects of the j^{th} explanatory variable can be summarized as below:

$$\frac{1}{n}\sum_{i=1}^{n}\frac{\partial P[Y_i = 1]}{\partial X_{ji}} = \beta_j \frac{1}{n}\sum_{i=1}^{n} f(X_i' \beta), \qquad j = 2, \dots, k. \tag{6.3}$$

i.e., the mean marginal effects over the sample of n individuals.

Maximum likelihood method is used to estimate the parameters of the multiple logistic response function. The log-likelihood function is as follows:

$$logL(\beta) = \sum_{i=1}^{n} Y_i(X_i'\beta) - \sum_{i=1}^{n} log[1 + \exp(X_i'\beta)] \tag{6.4}$$

However, logit model provides information only about respondents' decision to pay or not to pay for the improved SWM service, but not on the maximum amount of money they are willing to pay. Therefore, tobit model was used to evaluate factors influencing the maximum amount of money HHs are willing to pay as used by other similar studies (Awunyo-Vitor et al., 2013; Ezebilo & Animasaun, 2011; Hagos et al., 2012; Nkansah, Dafor, & Essel-Gaisey, 2015; Padi et al., 2015). When dependent variable is not fully observed, i.e., if there are zero values for substantial part of the sample then tobit model is preferred than other linear regression model like OLS (Hagos et al., 2012; Padi et al., 2015). Although for convenience the invalid responses could have been discarded to use the valid ones, it could lead to sample selection bias as it will no longer be a random sample despite the initial sample was a random one. This will result in invalidity of the estimates obtained from the given sample that may not be suitable for policy inference.

The tobit model can be given by:

$$y_i = \beta x_i + \varepsilon_i, \qquad i = 1,2, \ldots n \tag{6.5}$$

where y_i is the dependent variable, i.e., the maximum amount of money the respondents are willing to pay; x_i is a set of explanatory variables, and ε_i is assumed to be $N(0, \sigma^2)$, i.e. normally distributed and independent of x_i. The observed y_i counter part of y_i^* can be expressed as:

$y_i = 1$ if $y_i^* > 0$, for willing to pay for improved waste collection service

$y_i = 0$ if $y_i^* \leq 0$, for not willing to pay for improved waste collection service

and y_i^* is a latent (unobservable) variable for WTP_i,

The log-likelihood function for the tobit model is given by:

$$logL = \sum_{y_i > 0} -\frac{1}{2}\left[\log(2\pi) + log\sigma^2 + \frac{(y_i - x_i\beta)^2}{\sigma^2}\right] + \sum_{y_i = 0} log\left[1 - \emptyset\left(\frac{x_i\beta}{\sigma}\right)\right] \tag{6.6}$$

where ∅ is the standard normal cumulative distribution function.

The maximum likelihood estimates of the parameters is done by maximizing the likelihood function with respect to β and σ.

In case of open-ended questions, mean WTP can be calculated by averaging the total amount (Alberini & Cooper, 2000) that the HHs are willing to pay, which is given by:

$$Mean\,WTP = \frac{1}{n}\sum_{i=1}^{n} y_i \tag{6.7}$$

where *n* is the sample size and each y is a reported WTP amount.

6.2.5 Variables Selection for Logit and Tobit Models

The explanatory variables used in the logit and tobit models were based on the significant variables used in other similar WTP studies for improved SWM services. The explanatory variables used in this study are described in Table 6.2 and explained below:

Table 6.2 Description of explanatory variables used in this study

Variable	Description	Unit of Measure
Income	Total average monthly income of HH	NRs. (1US$ = NRs. 102.13) *
HH size	Total number of members currently residing in the house	Number of individuals
Gender	Gender of HHH	1 = Male 0 = Female
Age	Age of HHH	Years
Education	Total years of education attained by HHH	Years
House ownership	Ownership of currently resided house	1 = Owned 0 = Rented
Environmental awareness	Whether respondent is aware about environmental impacts by waste or not	1 = Yes 0 = No
Waste collection service	Have access to waste collection service or not	1 = Yes 0 = No

*The exchange rate as of August 31, 2017 (Nepal Rastra Bank, 2017)

6.2.5.1 Income

The income variable refers to the total HH income in NRs. There are many studies which have found that income is positively significant to the WTP for improved SWM services (Aggrey & Douglason, 2010; Anjum, 2013; Banga et al., 2011; Bhattarai, 2015; Ezebilo & Animasaun, 2011; Hagos et al., 2012; Nkansah et al., 2015; Padi et al., 2015; Subhan, Ghani, & Joarder, 2014; Sumukwo et al., 2012). Income is expected to have a strong influence on the demand for environmental quality and affordability to pay higher waste collection fees.

Hence, income is one of the major determinants of WTP and it is also expected to positively influence HHs' WTP for improved waste collection service.

6.2.5.2 Household Size

This variable refers to the total number of person currently living in the house including relatives or any other person. In general, the more the number of person living in the house, more waste will be generated and might become difficult to manage. Therefore, HH size is expected to positively influence HHs' WTP for improved waste collection service. Significant positive relationship was found in other similar studies (Bhattarai, 2015; Nkansah et al., 2015; Roy & Deb, 2013).

6.2.5.3 Gender

This variable refers to the gender of HHH. In general, in case of developing countries, women are responsible to manage the house which includes cooking, cleaning and disposing waste. Therefore, this study also expects that female HHHs are more willing to pay for improved waste collection services. Other studies have also found similar relationship (Addai & Danso-Abbeam, 2014; Bhattarai, 2015).

6.2.5.4 Age

Age refers to the age of the HHH and this study expects age to negatively influence HHs' WTP for improved waste collection service. Currently, HHs do not have to pay any fee for any SWM related services and older people would be more resilient to change, i.e., they would not be willing to pay for the waste collection service if fee is imposed. Younger HHHs could be more educated and aware about the importance of proper waste management than the older ones Previous studies have also found age variable to negatively influence WTP (Aggrey & Douglason, 2010; Banga et al., 2011; Mary & Adelayo, 2014; Padi et al., 2015; Sumukwo et al., 2012).

6.2.5.5 Education

The education variable is the total years of formal education attained by the HHH. Educated people are expected to understand the adverse effects of waste on human health and environment. This study expects that education will have positive influence on HHs' WTP for improved waste collection service, as found by many other previous related studies (Addai & Danso-Abbeam, 2014; Aggrey & Douglason, 2010; Anjum, 2013; Awunyo-Vitor et al., 2013; Banga et al., 2011; Bhattarai, 2015; Ezebilo & Animasaun, 2011; Mary & Adelayo, 2014; Nkansah et al., 2015; Roy & Deb, 2013; Song et al., 2016; Sumukwo et al., 2012).

6.2.5.6 House Ownership

This study expects that those HHs who are living in their own house are more willing to pay for the improved waste collection service than those HHs who are living in a rented property. This is because, house owners are more concerned to maintain the cleanliness of their property and surrounding. Other studies have also found positive relationship between house ownership and WTP (Awunyo-Vitor et al., 2013; Banga et al., 2011; Hagos et al., 2012; Padi et al., 2015).

6.2.5.7 Environmental Awareness

Environmental awareness is likely to increase the demand for environmental goods and services. Therefore, this study expects that HHs who are aware about the adverse effects of waste on environment are expected to pay for the improved waste collection service as found by other similar studies (Anjum, 2013; Hagos et al., 2012; Padi et al., 2015; Roy & Deb, 2013).

6.2.5.8 Waste Collection Service

Waste collection service is currently available only on few wards and limited only on few areas within those wards. This study expects that HHs who have the waste collection service will be willing to pay for the improved service. This is because the current service is irregular, and they might want to share the cost to improve the service presuming that these HHs are more affluent as they live in the core areas of the municipality than those HHs who do not have the service.

6.3. Results and Discussions

6.3.1 Characteristics of Households in the Study Area

This study found that HHH on an average is around 48 years old, predominantly male (73.82%), and has about 7 years of formal education. The average size of the HH is 3.72, which is almost similar to the national census result of 3.69 (CBS, 2014a). The average monthly HH income is found to be NRs. 36,854.20 (360.86 US$). There is a huge difference between the minimum and maximum HH income found in this study, which is NRs. 8020 (78.53 US$) and NRs. 244,083 (2389.92 US$), respectively. This result reflects the huge economic gap between HHs residing within Gorkha municipality. HHs in very rural setting within the municipality were also considered, which also included very poor HHs whose livelihood depends only on farming. Most of the HHs who participated in this study lives in their own house (87.28%), and less than half of the HHs (36.66%) have the waste collection service offered by the municipality. Although more than half of the HHs (58.35%) are aware about the adverse effects caused by waste and its improper management on the environment, it cannot be denied that the remaining HHs (41.65%) who are unaware about such adverse effects also constitute a significant percentage. The summary of these characteristics of the HHs in this study are also summarized in Table 6.3 and Table 6.4.

Table 6.3 Summary of continuous variables

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Income	401	36854.20	28509.48	8020	244083
HH Size	401	3.72	1.36	1	9
Age	401	47.90	13.07	23	85
Education	401	7.22	4.33	1	17

Source: Field survey (2015)

Table 6.4 Summary of categorical variables

Variable	Observation (Percentage)
Gender:	
Male	296 (73.82)
Female	105 (26.18)
House Ownership:	
Owned	350 (87.28)
Rented	51 (12.72)
Waste Collection Service:	
Have service	147 (36.66)
Do not have service	254 (63.34)
Environmental Awareness:	
Aware	234 (58.35)
Not aware	167 (41.65)

Source: Field survey (2015)

6.3.2 Willingness of Households to Pay for the Improved Waste Collection Service

Out of 401 respondents, about 61% are willing to pay for the improved waste collection service (Table 6.5). This share of respondents' WTP is somewhat similar to other similar studies where more than 60% of the respondents provided positive response (Anjum, 2013; Eshun & Nyarko, 2011; Jones et al., 2010; Karthigarani & Elangovan, 2016; Mahima & Thomas, 2013; Roy & Deb, 2013).

Table 6.5 Households' willingness-to-pay for improved waste collection service

WTP	Frequency	Percentage
Yes	244	60.85
No	157	39.15
Total	401	100

Source: Field survey (2015)

Although the respondents were free to give reasons for their willingness or unwillingness to pay for the improved waste collection service, interestingly most of the HHs gave similar reasons. Almost identical answers were grouped together and categorized as one reason. For example, HHs gave reasons that they want to keep their house clean, surrounding clean or environment clean. These answers were grouped together as "to keep their surrounding clean". The answers are presented below based on the frequency of the provided reasons and because most of the respondents gave multiple reasons, the percentage does not tally to be 100%.

The reasons for their WTP for improved waste collection service are summarized as follows:

(i) To keep their surrounding clean (92%).

(ii) Can dispose their waste on a regular basis (65%).

(iii)Willing to share the cost for effective waste management (63%).

(iv)Willing to pay to get the waste collection service as they are devoid of such service (47%).

(v) For regular waste collection service as the current service is irregular (32%).

About 39% of the HHs are not willing to pay for the improved waste management service. The reasons for their unwillingness to pay are as follows:

(i) Did not have to pay for the service until now and so do not want to pay (91%).

(ii) HH income is less (77%).

(iii)It is responsibility of the government to provide the service (71%).

(iv)Generate less amount of waste so can self-manage it (54%).

(v) Pay municipal tax so the service should be free of charge (46%).

Although some of the reasons for both willingness and unwillingness to pay are more or less interrelated, it can be generalized that those willing to pay are more concerned about the cleanliness of their house and surrounding, want better waste collection service and feel responsible to share the cost of proper waste disposal. Similarly, HHs who are not willing to pay do not feel that it is their responsibility and that it should be managed by the local government without any fee being imposed on them.

6.3.3 Factors Influencing Households' Willingness-to-Pay for Improved Waste Collection Service

The results from the logit regression model is presented in Table 6.6. All 401 observations are used in this analysis. The log likelihood for this fitted model is -234.69 and LR chi-square of 67.50 (df=8) with a p-value 0.0000 (significant at 1%) states that this model is statistically significant and as a whole fit significantly better than an empty model, i.e., only with the dependent variable. Thus, the validity of logit model to estimate determinants of WTP for waste collection service is consistent with other similar studies (Addai & Danso-Abbeam, 2014; Aggrey & Douglason, 2010; Anjum, 2013; Awunyo-Vitor et al., 2013; Bhattarai, 2015; Mary & Adelayo, 2014; Oteng-Ababio, 2010; Song et al., 2016).

Table 6.6 Logit regression results of factors influencing willingness-to-pay for improved waste collection service

Independent Variables	Coefficient	Standard Error	Z-statistics	Marginal Effect
Income	0.000015***	5.58e-06	2.64	0.000296
HH size	-0.013933	0.0850556	-0.16	-0.0027974
Gender	0.034510	0.2768044	0.12	0.0069288
Age	-0.002535	0.010983	-0.23	-0.000509
Education	0.083569**	0.0835693	2.48	0.016779
House ownership	0.135316	0.3496184	0.39	0.0271687
Environmental awareness	0.672828***	0.2273787	2.96	0.1350899
Waste collection service	1.257810***	0.2523935	4.98	0.2525424
Constant	-1.420311**	0.6871384	-2.07	
Number of observations		401		
Log likelihood		-234.68687		
LR chi²(8)		67.50		
Probability > chi²		0.0000***		
Pseudo R^2		0.1257		

Source: Field survey (2015)
** significant at 5% and *** significant at 1%

This study found that the significant variables that influence HHs' WTP for the improved waste collection service are income, education, environmental awareness and waste collection service. HH size, gender, age and house ownership variables do not have any statistically significant influence on the HHs' WTP.

The total average income of the HH is statistically significant at 1% level and it positively influences HHs' WTP decision. This result is supported by other similar studies (Aggrey & Douglason, 2010; Anjum, 2013; Banga et al., 2011; Bhattarai, 2015; Hagos et al., 2012; Padi et al., 2015; Sumukwo et al., 2012). The marginal effect results show that a unit increase in HH income would increase the likelihood for HHs' WTP for improved waste collection service by 0.000296%, i.e., if the monthly HH income increases by NRs. 10,000 (97.91 US$), the likelihood for HHs' WTP increases by 2.96%.

The total years of education attained by the HHH is statistically significant at 5% level, with a positive coefficient value. This shows that higher the education level, higher the likelihood for HHs' WTP for improved waste collection service. The positive relationship between education and WTP for better waste management services is also supported by other studies (Addai & Danso-Abbeam, 2014; Aggrey & Douglason, 2010; Anjum, 2013; Banga et al., 2011; Bhattarai, 2015; Mary & Adelayo, 2014; Song et al., 2016; Sumukwo et al., 2012). This is because education increases the awareness and desire for better environmental goods and services. The marginal effect results show that a year increase in education level increases the WTP for improved waste collection service by 1.68%.

The environmental awareness variable has a positive coefficient and is statistically significant at 1% level. This result shows that HHs are more likely to pay for improved waste collection service if they are aware about the adverse impacts of waste on environment by 13.51% than those HHs who are not aware. This result supports the findings from other similar studies (Anjum, 2013; Hagos et al., 2012; Padi et al., 2015).

The waste collection service variable is also significant at 1% level of significance. The coefficient is positive, which was expected in this study. This shows that the HHs who have the current waste collection service must be aware about the negative consequences if the service is irregular or if there is no service at all. Also, it could be that the level of service is not satisfactory, thus with the hope of improving its quality, HHs are willing to pay. HHs who currently have waste collection service are likely to pay for the improved waste collection service by 25.25% than those HHs who currently do not have such service. However, similar study conducted in Nepal (Bhattarai, 2015) found that HHs who are getting waste collection service are likely to pay less than those HHs who are not getting the service. This was because the HHs were getting the service at a very low fee and were unwilling to pay more.

All other variables which were expected to have a significant relationship with WTP is found not to influence HHs' WTP decision in Gorkha municipality. HH size was expected to have a positive influence like found in the study by Bhattarai (2015) but the insignificant relationship is consistent with the findings from other studies (Hagos et al., 2012; Oteng-Ababio, 2010; Padi et al., 2015; Song et al., 2016). This study expected that female HHH would be more willing to pay for improved waste collection service like in other studies (Addai & Danso-Abbeam, 2014; Bhattarai, 2015; Oteng-Ababio, 2010). However, no relationship could be concluded as the variable is not statistically significant but this finding is consistent with other similar studies (Hagos et al., 2012; Padi et al., 2015; Song et al., 2016; Sumukwo et al., 2012). Age of the HHH variable was expected to have a negative relationship with WTP decision as found by similar studies (Aggrey & Douglason, 2010; Banga et al., 2011; Mary & Adelayo, 2014; Sumukwo et al., 2012). The result from this study could not establish this relationship as it is not statistically significant. Other studies have also found similar insignificant relationship (Awunyo-Vitor et al., 2013; Padi et al., 2015; Song et al., 2016). Lastly, this study expected that HHs who live in their own house would be more willing to pay for improved waste collection service, as they would be more concerned about the cleanliness of their surrounding than those who are living in a rented dwelling. Similar studies have also found positive relationship (Awunyo-Vitor et al., 2013; Banga et al., 2011; Padi et al., 2015) but the insignificant finding is consistent with Hagos et al. (2012).

6.3.4 Average Amount of Money that Households are Willing to Pay for Improved Waste Collection Service

Out of 401 HHs surveyed for this study, 244 HHs, i.e., around 61% are willing to pay for the improved waste collection service in Gorkha municipality. The remaining 39% of the HHs who rejected to pay for the improved waste collection service was not included to calculate mean WTP amount. Therefore, the mean WTP amount found from this study may not be considered as the representative WTP amount for the whole population of the municipality. Nevertheless, the amount could be taken into consideration as a reference amount to impose waste collection fee. This study used open-ended CV method to elicit the maximum amount HHs are willing to pay. The minimum and the maximum amount is NRs. 10 (0.10 US$) and NRs. 500 (4.90 US$) per month, respectively. The mean WTP amount is calculated using equation (6.7). This study found that the mean WTP amount for the improved waste collection service in Gorkha municipality is NRs. 73.38 (0.72 US$) per month. Studies conducted in other developing countries have used single-bounded or double-bounded dichotomous method to conduct WTP study but the researchers also used open-ended method to identify the maximum amount the respondents are willing to pay for improved service. Although it may not be conclusive to compare with these studies because of different approaches used, it will give an idea about the WTP amount for improved waste management services. The mean WTP amount found from this study is less than WTP study conducted in another municipality of Nepal (Bhattarai, 2015), which was 1.69US$ per month, but is greater than the study conducted in Bangladesh (Afroz et al., 2009), which was 0.18US$ per month. Studies conducted in Uganda (Banga et al., 2011) and Ethiopia (Hagos et al., 2012) found WTP amount to be 1.3US$ and 1.2US$ respectively. Though the WTP amount in Ethiopia was 1.2US$, when mean amount from the open-ended answer was calculated, WTP amount decreased to 0.80US$. The details of these findings from these studies are presented in Table 6.7. The WTP amount from this study seems to be an acceptable amount for the concerned stakeholders to take as a reference amount to impose waste collection fee in Gorkha municipality.

Table 6.7 Comparison of willingness-to-pay amount from various studies

Mean WTP Amount (US$)	**CV Method**	**Country**	**Author**
0.72	Open-ended	Nepal	This study
0.80	Open-ended	Ethiopia	Hagos et al. (2012)
1.2	Single-bounded dichotomous	Ethiopia	Hagos et al. (2012)
1.69	Single-bounded dichotomous	Nepal	Bhattarai (2015)
0.18	Double bounded dichotomous	Bangladesh	Afroz et al. (2009)
1.3	Double bounded dichotomous	Uganda	Banga et al. (2011)

6.3.5 Factors Influencing Amount of Money that Households are Willing to Pay for Improved Waste Collection Service

The result from tobit model is presented in Table 6.8. All 401 observations are used in this analysis. To censor the zero values for 157 observations, i.e., for the HHs who are not willing to pay, a lower limit of 0 was specified and the model was run. The LR chi-square of 78.06 (df=8) with a p-value 0.0000 (significant at 1%) shows that this model as a whole fit significantly better than an empty model, i.e., at least one of the regression coefficients in the model is not equal to zero.

Table 6.8 Tobit regression results of factors influencing the amount of money households are willing to pay for improved waste collection service

Independent Variables	Coefficient	Standard Error	t	[95% Interval]	Confidence
Income	0.00077***	0.00016	4.80	0.00046	0.00109
HH size	0.09660	3.32337	0.03	-6.43720	6.63039
Gender	0.98878	10.77724	0.09	-20.19948	22.17704
Age	-0.17172	0.43021	-0.40	-1.01753	0.67409
Education	1.59789	1.27318	1.26	-0.90521	4.10100
House ownership	8.23168	13.68001	0.60	-18.66347	35.12684
Environmental awareness	35.24244***	8.94840	3.94	17.64972	52.83516
Waste collection service	46.36408***	9.08806	5.10	28.49678	64.23138
Constant	-58.30723**	26.41487	-2.21	-110.23930	-6.37511
/sigma	80.18481	3.88383		72.54913	87.82049
Number of observations	401				
Log likelihood	-1525.5514				
LR $chi^2(8)$	78.06				
Probability > chi^2	0.0000***				
Pseudo R^2	0.0249				
Observation summary:	157 left-censored observations at amount<=0				
	244 uncensored observations				
	0 right-censored observations				

Source: Field survey (2015)
** significant at 5% and *** significant at 1%

The tobit model results shows that three independent variables; income, environmental awareness and waste collection service are statistically significant with the maximum amount of money that the HHs are willing to pay for the improved waste collection service. These three variables were also significant variables in logit model used in this study. Although education variable was expected to positively influence the maximum amount that HHs are willing to pay like in similar studies (Awunyo-Vitor et al., 2013; Ezebilo & Animasaun, 2011; Nkansah et al., 2015; Roy & Deb, 2013), which was also statistically significant in logit model but the relationship could not be established in tobit model. The insignificant result shows that number of education attained by the HHH does not influence the maximum amount of money the HHs are willing to pay for the improved waste collection service. All other variables which are not significant in logit model are also not significant in tobit model.

The HH size variable was expected to have positive relationship with the maximum WTP amount for improved waste collection service. While some studies have found this positive significant relationship (Nkansah et al., 2015; Roy & Deb, 2013), this study could not find any statistically significant relationship, which is consistent with the findings from other studies (Ezebilo & Animasaun, 2011; Hagos et al., 2012; Padi et al., 2015).

This study expected that female HHH would be willing to pay more for the improved waste collection service than male HHH. However, the gender variable is statistically insignificant and we could not derive any relationship but the finding is consistent with other similar studies (Awunyo-Vitor et al., 2013; Ezebilo & Animasaun, 2011; Hagos et al., 2012; Padi et al., 2015).

Some studies have found age variable to have a positive relationship with the maximum WTP amount (Awunyo-Vitor et al., 2013; Nkansah et al., 2015; Subhan et al., 2014). However, this study expected that younger HHH, who could be more educated and aware about the importance of proper waste management, would pay more for improved waste collection service as found by Padi et al. (Padi et al., 2015). The insignificant result could not establish this relationship but confirms the study by Ezebilo and Animasaun (2011).

The house ownership variable was expected to have a positive influence on the maximum WTP amount but the tobit regression model gave insignificant result and the relationship could not be confirmed. This result contradicts the findings from other studies (Awunyo-Vitor et al., 2013; Hagos et al., 2012; Padi et al., 2015) that showed positive relationship.

The income variable is significant at 1% level of significance with positive coefficient. This implies that a unit increase in monthly income of HH increases the maximum amount of money that the HH is willing to pay by NRs. 0.00077 per month, i.e., an increase of monthly HH income of NRs. 10,000 (97.91 US$) increases the maximum amount that the HH is willing to pay by NRs. 7.7 (0.08 US$) per month. This positive relationship is also supported by other similar studies (Ezebilo & Animasaun, 2011; Hagos et al., 2012; Nkansah et al., 2015; Padi et al., 2015; Subhan et al., 2014).

HHs who are aware about the impacts of waste on environment are likely to pay more for the waste collection service as its coefficient is positive and the variable is significant at 1% level, as expected for this study. This relationship is also consistent with other studies (Hagos et al., 2012; Padi et al., 2015; Roy & Deb, 2013). The tobit regression result shows that HHs who are aware about the impacts of waste on environment are likely to pay NRs. 35.24 (0.35 US$) per month more than those who are not aware.

HHs who have current waste collection service are likely to spend more for the waste collection service as the coefficient is positive and significant at 1% level. The result shows that HHs who have current waste collection service are likely to pay NRs. 46.36 (0.45 US$) per month more than those HHs who currently do not have the service. This could be because they are expecting better service with the amount they pay.

6.4 Conclusion and Recommendations

With the growing amount of MSW and municipalities' inability to manage it properly mainly due to financial constraint, collecting fees from the public for improving the waste management service seems to be the only viable option. The waste collection service is restricted only to limited areas in Gorkha municipality of Nepal. It evaluates WTP by 401 HHs selected using stratified sampling method from all 15 wards of the municipality for improved SWM service of waste collection and factors influencing it. This study employed CV method which directly asks the beneficiaries their desired amount under hypothetical circumstances with the assumption that it will be implemented in the near future. Logit regression model was used to determine the factors that influence WTP for improved waste collection service and tobit regression model was used to determine the factors that influence the maximum amount of money that the HHs are willing to pay for the improved waste collection service.

This study found that the majority of surveyed HHs (61%) are willing to pay for the improved waste collection service. The mean WTP amount that HHs are willing to pay is NRs. 73.38 (0.72 US$) per month. The municipality or the concerned stakeholders may consider this as a reference amount to impose solid waste collection fee in Gorkha municipality as no such fee has been charged to the HHs until now. Improved regularity of SWM services and better geographical coverage of solid waste collection can be achieved by the revenue generated by the solid waste collection fee.

The factors that significantly influence HHs' WTP are monthly HH income, education of HHH, environmental awareness and waste collection service. The significant factors that influence the maximum amount of money HHs are willing to pay for improved waste collection service are monthly HH income, environmental awareness and waste collection service. Concerned stakeholders and policy makers should consider these traits of HHs before enforcing waste collection fee. For instance, since HHs' awareness about environmental impact is positively significant to both WTP and the maximum amount of waste collection fee they are willing to pay, the government and concerned stakeholders should educate the HHs about adverse effects of indiscriminate disposal of waste on the environment in order to raise more funding for SWM.

Chapter 7. Compost Making Practices at Household Level

7.1 Introduction

Composting is a natural method in which organic matters such as crop residues, animal waste, food garbage, some municipal waste and suitable industrial waste are biologically decomposed by microorganisms under controlled conditions. Compost is the source of organic matter and plant nutrient and improves the physio-chemical and biological properties of the soil. With its application, the soil becomes more resistant to stresses such as drought, diseases and toxicity, improves crops' uptake of plant nutrients, and activates nutrient's cycling capacity because of dynamic microbial activity. These benefits result in improved soil fertility, reduced cropping risks, higher yields; thus, lowering the need for inorganic fertilizers (Misra, Roy, & Hiraoka, 2003).

Besides its end result, composting is highly regarded from the viewpoint of SWM as well. As a consequence of rapidly increasing urbanization and population growth, significant increase in solid waste has become a huge problem world over (Hoornweg & Bhada-Tata, 2012). In fact, MSW is increasing at the rate much faster than urbanization (Hoornweg & Bhada-Tata, 2012). Especially in developing countries, with their inability to invest in technologies related to waste management, the pace of managing such waste lags way behind the rate at which it is increasing (World Bank, 2011). Although local government in developing countries spend up to 50% of municipal budget for waste collection and disposal, its management is far from satisfactory (Aleluia & Ferrão, 2016). SWM is a burgeoning problem for urban areas in Nepal as well. Municipalities and community groups in Nepal are mainly characterized by having limited access to information, especially on improving waste management system and using waste in an economically productive way (Practical Action Nepal, 2008). Within the existing SWM scenario, there is no proper and effective waste collection system and only limited recycling and composting activities are practiced all over Nepal (Padeco Co. Ltd. & Consultants, 2010).

MSW includes all types of durable goods (e.g., tires, furniture), nondurable goods (e.g., newspapers, plastic plates/cups), containers and packaging (e.g., milk cartons, plastic wrap), and other waste (e.g., food and garden waste); generated by HHs and commercial, industrial or institutional entity (Center for Sustainable Systems, 2015). Except for high-income countries, organic waste has the highest share, usually more than 50%, in the overall waste composition (Hoornweg & Bhada-Tata, 2012). A study conducted in all 58 municipalities of Nepal finds that HHs are the biggest waste-producing sector, comprising 75% of the total municipal waste (SWMRMC, 2004). HH waste usually consists of food and garden waste, which have abundant organic matter, and other types of waste containing inorganic components such as plastics, metals, glass, and inert materials such as dust. In case of Nepal, organic waste shares 66% of HH waste composition (ADB, 2013).

Organic waste if left unattended creates problems of smell, leachate, flies and rodents, and emission of methane in landfill sites (Tuladhar & Spuhler, 2016). Composting has been proven to be the best option for managing organic waste in developing countries as it remains the most economical and efficient management technique among other management options given the types, nature and composition of waste (Taiwo, 2011). Minimizing and managing waste at source, such as HHs, can be cost effective and improves overall efficiency of waste management system (ADB, 2013). It is especially desirable in areas that are devoid of an effective waste collection and management system, thus reducing haphazard waste disposal and its related environmental impacts. The waste scavengers or scrap dealers usually do not collect organic waste; thus, HH composting can help increase the recycling rates of such waste. Composting requires organic waste to be separated from other waste, which results in clean surrounding and makes it easier to collect other recyclable waste as well (Tuladhar & Spuhler, 2016). In recent years, the trend of home composting has been observed in many parts of the world (Vázquez & Soto, 2017; Faverial & Sierra, 2014)

In Nepal, the government with the assistance from various organizations have been promoting home composting but despite offering training programs to encourage HHs to take-up home composting, it was successful only in creating awareness among participants about the benefits of composting rather than inevitably transforming into practicing. It was found that many got discouraged because of space and time constraint, foul odor, loss of aesthetic value, health concern and/or differing acceptance level among the HH members (Tuladhar, 2003). Thus, even though composting does not require sophisticated training and can be done with minimum resources and space within the comfort of one's home, its adoption rate is highly impacted by its usability such as houses with gardens or flower pots (Tuladhar & Spuhler, 2016).

Over the years, in Gorkha municipality, the government had also distributed around 300 compost bins to the HHs, but the extent of its practice remains unknown. Thus, this study attempts to identify if HHs continue to compost using the local government subsidized bins and if so, assess their compost making practices and analyze the associated challenges therein. The potential benefits of composting can only be realized if it is of good quality (Taiwo, 2011; Bera, et al., 2013). Hence, this study also assesses the quality of compost made at HH level. The findings of this study are expected to give some insight to make HH composting programs more successful.

7.2 Types of Composting

Composting technologies can be broadly categorized into anaerobic composting, aerobic composting, and vermicomposting. Anaerobic composting is done in the absence of air/oxygen while aerobic composting is done in the presence of air/oxygen. The former requires more time to prepare compost compared to the latter. Compost pit is an example of anaerobic composting where organic waste is simply put in pit over a period of six months or more. Since there is no temperature rise during the composting process, the destruction of pathogen is less efficient. Though it is aesthetically desirable, as waste will be buried in the pit, the amount of space and time required by this system makes it less desirable. Compost pile is an example of aerobic composting where organic waste is put in pile on the ground and turned regularly for aeration. In-vessel composting is another example of aerobic composting, which requires a bin that is normally separated by a grill into two sections. The top section accommodates organic waste to degrade which then falls on the bottom section as it turns into compost. The bin will have holes to allow aeration, which is why frequent turning of waste is not necessary in this method. Vermi-composting involves earthworms to convert organic waste into worm casting and is considered to be better than ordinary compost in improving soil's structure and fertility. It requires very little space and can be done indoors as it does not cause odor problems (Mazumdar, 2012;

Bobeck, 2010). But on the other hand, vermicomposting is expensive in terms of its operation and management and requires expert judgment (Zafar, 2015).

7.3 Composting Practices at Household Level in Nepal

Nepal has a history of composting organic waste that used to take place at individual houses or community yards, especially in the Kathmandu valley and was known by the term *saagaas* ("*saa*" means compost and "*gaa*" means pit in the Newar language, one of the ethnic languages of Nepal). In the previous days, people also used to sell waste, mainly human excreta, to farmers. But today such recycling practice no longer exists as the habit of throwing waste indiscriminately or handing over to the waste collector has become very convenient. Realizing composting as the best way to get rid of organic waste, the municipality has put lots of emphasis on giving composting related training. But since training programs alone were not sufficient to motivate people to practice composting, a new initiative of developing compost bin considering the requirement of and convenience for Kathmandu's urbanites has been taken up. The compost bin is made to look attractive, strong and durable, light weighted, technically sound, affordable, sizable, simple and user-friendly. A 100-liter capacity bin made of plastic with a natural aeration for quick compost production without causing offensive odor is designed. A private company has start selling the bins that comes with necessary accessories (such as a set of gardening/composting tools, a packet of compost, a cloth shopping bag, Effective Micro-organisms (EM) to produce high quality compost and a book on composting in Nepalese language). In 2003, KMC provided around 30 percent subsidy on such bins which originally costs NRs. 850 including the accessories, in addition to continue giving training and provide staffs for visiting people having problems with their home composting system (Tuladhar, 2003).

To encourage waste segregation and minimization by HHs at source, other municipalities are also trying to promote composting by providing subsidized compost bins with the assistance from various International Non-Governmental Organizations (INGOs) and NGOs. Bhaktapur municipality is selling compost bins at NRs. 600 each after subsidization. It has so far distributed almost 500 composting bins of 50 kg capacity. An NGO (Practical Action) distributed 530 compost bins of 50 kg capacity costing NRs. 700 each, 550 plastic buckets of 10 kg capacity and 1200 suiro hooks (used to hold plastic bags for segregating from organic waste) to the residents of Bharatpur municipality. In Hetauda municipality, 400 compost bins with a capacity of 50 kg and 500 suiro hooks for separating organic and inorganic waste have been distributed. Besides distributing bins at HH level, the municipalities also promote community-based composting facilities, training and system of buying back composts (Practical Action Nepal, 2008).

7.4 Composting in the Study Area

In Gorkha municipality, government had distributed compost bins, which is for in-vessel composting. In-vessel composting is a type of aerobic composting which is done in the presence of air/oxygen (Figure 7.1). It requires less time to prepare compost compared to anaerobic composting, which is done in the absence of air/oxygen. In anaerobic composting the destruction of pathogen is also less efficient since there is no temperature rise during the composting process (ADB, 2012). It is considered to be the most feasible method at the HH level given the limited amount of waste produced, its aesthetic value and simplicity in using. The compost bin is designed to help HHs produce high quality compost in the convenience of their homes without creating a mess (Tuladhar, 2003). Besides Nepal, municipalities and NGOs in other countries such as Bangladesh and Sri Lanka have also distributed such bins at subsidized rates to promote HH composting (Lekammudiyanse & Gunatilake, 2009; Tuladhar & Spuhler, 2016).

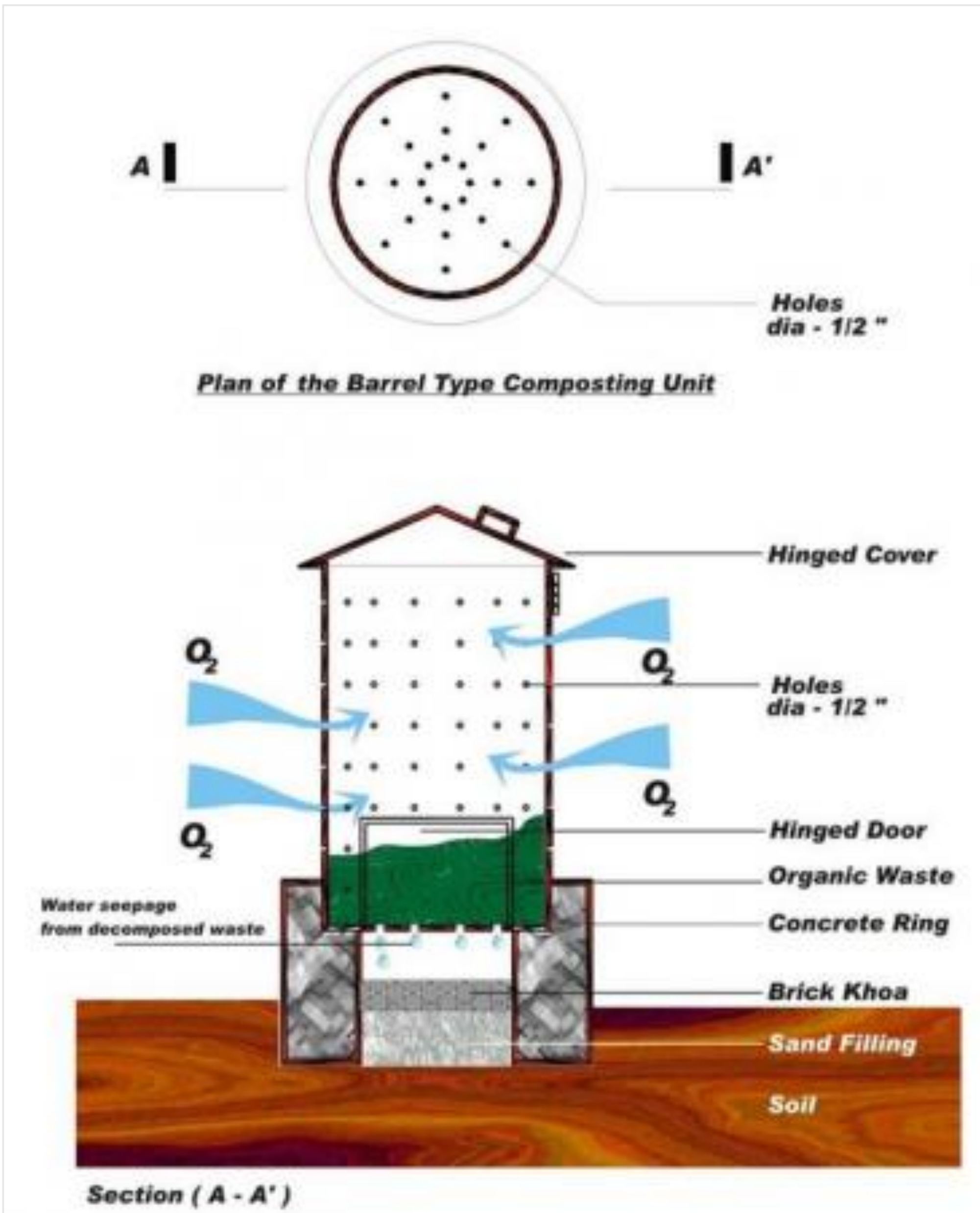

Figure 7.1. In-vessel compost bin
Source: (Tuladhar & Spuhler, 2016)

7.5 Sample Selection

The municipality had promoted HH composting by distributing subsidized compost bins to 300 HHs over the years along with providing one day training and awareness program on converting organic waste to compost using the bins. This study was conducted from February to March 2016 to understand the usability rate of such bins for making compost, the process of making compost and analyze the associated challenges therein. Due to poor record keeping, the municipality only had information of 174 recipients out of which 149 HHs were randomly selected as a study sample which constitute almost 86% of the identified users. For evaluating chemical properties of the HH compost, six samples were selected which took different approaches during preparation of compost. These six approaches are considered to represent the general compost making practices of most of the HHs (Table 7.1). Samples were tested in Nepal Environment and Scientific Services (P.) Ltd. (NESS), Kathmandu, Nepal and Nepal Standard value for each parameter that were referred to for the analysis were also received from NESS.

Table 7.1 Samples based on household's use of composting inputs

Sample	Approaches
Sample A	All types of waste (kitchen, sweeping, meat, bones, plastic, egg shells and garden waste)
Sample B	Garden and kitchen waste (no meat)
Sample C	Garden and kitchen waste (used more amount of food waste such as lentil soup and rice, had lots of white bugs)
Sample D	Garden and kitchen waste, ash, chicken litter
Sample E	Garden and kitchen waste
Sample F	Garden (dry leaves and flowers) and kitchen waste (raw vegetable)

Source: Field survey (2016)
Note: Kitchen waste consisted of vegetable residues and food waste

7.6 Results and Discussions

7.6.1 Usage Rate of Compost Bin

As shown in Figure 7.2, out of 149 surveyed HHs, about 56% are using compost bin, 15% are not using it anymore and the rest 29% never used it. Those 15% who discontinued using compost bin did so because of insects and foul smell that made it aesthetically unappealing, produced leachate and/or contaminated the water tank (55%), bins got damaged overtime especially the metal stand that got rusted and broken (18%) (Picture 7.1) and post 2015 earthquake, they did not have required facility to compost (27%) as their house was damaged. Among the 29% who never used it included HHs who did not have enough space for composting (16%), were busy (33%), unconcerned because they either burned all their waste or fed it to animals (16%) and did not receive the bin because of shortage (35%). The HHs acquiring the bin but not using for composting have turned it into a dustbin, are using as a storage for vegetables such as potato or simply have given them away to friends or neighbors.

This does not imply that those 56% who are using compost bin are free from complications. Some feel that they are not able to make quality compost because the end product turns out to be too wet and does not fall on the bottom section of the bin as it is supposed to. Some also admitted that other HH members do not take the job of segregating waste properly before being used as an input for composting. Insects such as flies, cockroaches, maggots, larvae, ants and scolopendra; rodents; foul odor; damaging metal frame within the compost bin; damaged bins from the sunlight; time constraint; and limited capacity of bins are some of the problems current users are facing.

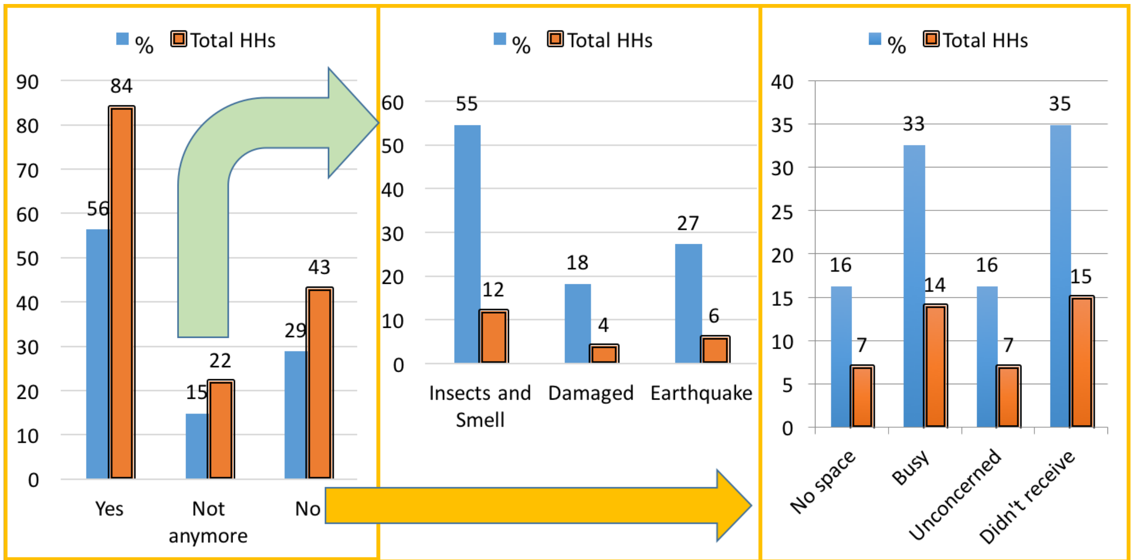

Figure 7.2 Households using compost bin

Figure 7.3 Reasons for stop using compost bin

Figure 7.4 Reasons for not using compost bin

Picture 7.1 Compost making practice in Gorkha municipality

Picture 7.2 Household member putting household waste into compost bin

Picture 7.3 Inorganic waste used into compost bin


Picture 7.4 Problem of leachate and wet by-product

7.6.2 Compost Making Process

Before using waste as an input in the compost bin, it needs to be sorted and prepared for rapid degradation (Tuladhar & Spuhler, 2016). Adding mature compost or EM can speed up the overall composting process. The degradation process should be controlled by maintaining adequate temperature, moisture and aeration. The composting process can be considered finished when its internal temperature has decreased to within 5 degrees of outside temperature, there is no solid material visible, and it has dark brown, powdery texture. The compost should be left for about a month for curing and then screened using a fine screen (Tuladhar & Spuhler, 2016).

The compost bin should be placed at a convenient location such as kitchen, garden, balcony, etc. Usually food, garden clippings, etc. are used for inputs but meat items should be avoided in order not attract rats or other animals/insects. The waste should be cut into small pieces, usually an inch in length/diameter so that it degrades quicker. The waste should feel moist but should not be dripping. To maintain 50% moisture content, water should be added accordingly if it is too dry and if it is too wet, some saw dust or ash should be added. Green waste like leaves and vegetables (which is normal for HH waste) should be added with some brown waste like saw dust to balance the C:N ratio in the waste. The lid of the bin should be closed. Putting some straw at the bottom of the bin to prevent the waste from falling down into the bottom compartment is advisable. Using some Bokasi or liquid EM, or old compost or garden soil to activate the degradation process is also preferable. The waste should be stirred about once a week for making it aerated as lack of oxygen produces foul smell from the garbage as it degrades. The compost should be ready in about two months. It will be an earthy smell with dark brown in color. The compost should be screened to place the rejected materials that hasn't been decomposed properly back into the bin. Compost is then ready to be used. It can also be stored but should be covered properly as it may lose some of its nutrients in the open (Tuladhar, 2003).

Kitchen and garden waste are the most common types of waste that were used as an input for HH composting. Kitchen waste included vegetable and fruit peelings and remains, eggshells, food leftovers/stale and tainted food, tea leaves, bones, oil, etc.; and garden waste included leaves, grasses, weeds, plants, flowers, woods, branches, etc. About 63% use kitchen and garden waste, followed by 21% who only use kitchen waste (Figure 7.5). Around 1-2% of HHs also mixed other inputs like dust, wet paper, chicken litter, cow dung and/or ash in the process of making compost. Most (25%) of the HH harvest compost 2 times a year, meaning they take out compost every 6 months (Figure 7.6). About 21%, 20%, 11%, 6%, 4%, 2% and 1% harvest 4, 3, 1, 6, 2.4, 12 and 8 times a year, respectively. About 10% said they have not yet harvested, because they have just begun the practice of composting or do not use compost bin that often. About 39%

use the compost on garden crops (potato, cauliflower, spinach, garlic, onion, turmeric, ginger, eggplant, sponge gourd, coriander, field mint), followed by 31% on garden crops and flowers, 17% on flowers, 2% on garden crops and field crops (usually corn) and 1% on field crops and flowers (Figure 7.7). Most of the respondents (82%) felt that composting has better impact on production (Figure 7.8). The size of vegetables is bigger and overall quantity of production is also higher. Only 6% and 2% said they didn't see any change and they cannot differentiate, respectively.

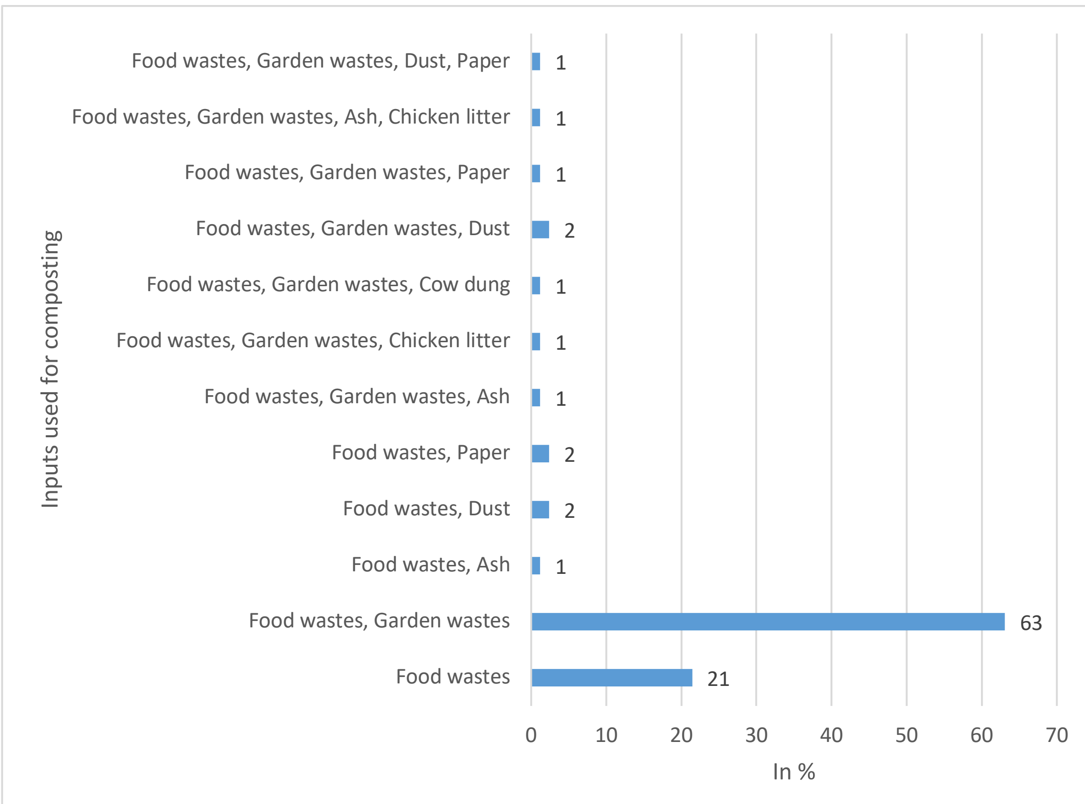

Figure 7.5 Inputs used for composting

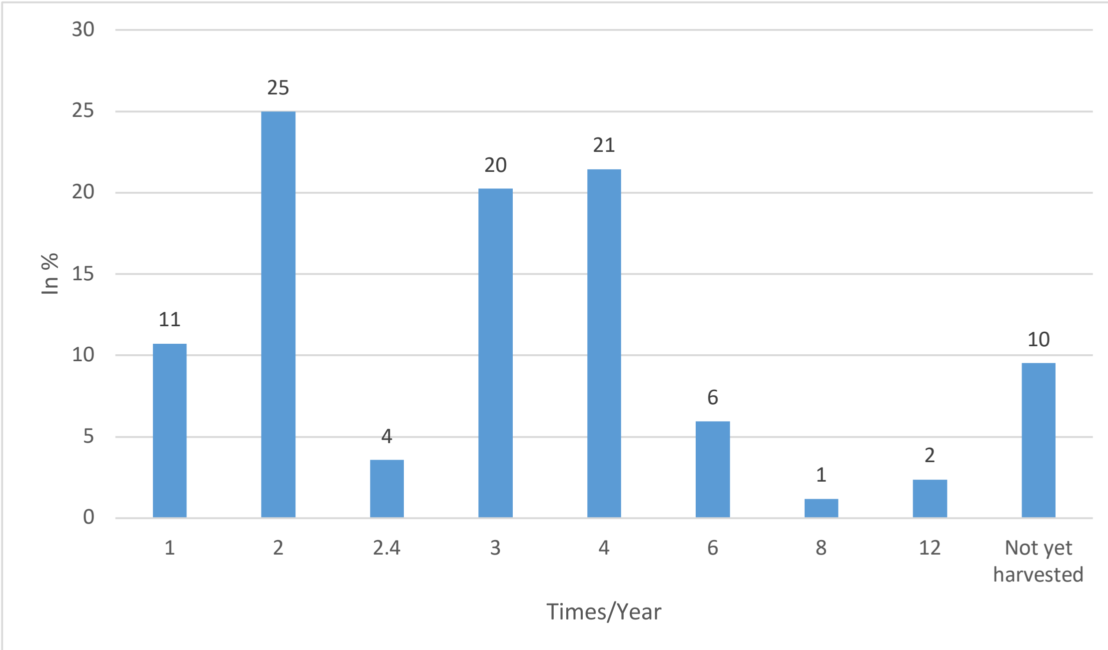

Figure 7.6 Frequencies of compost harvest

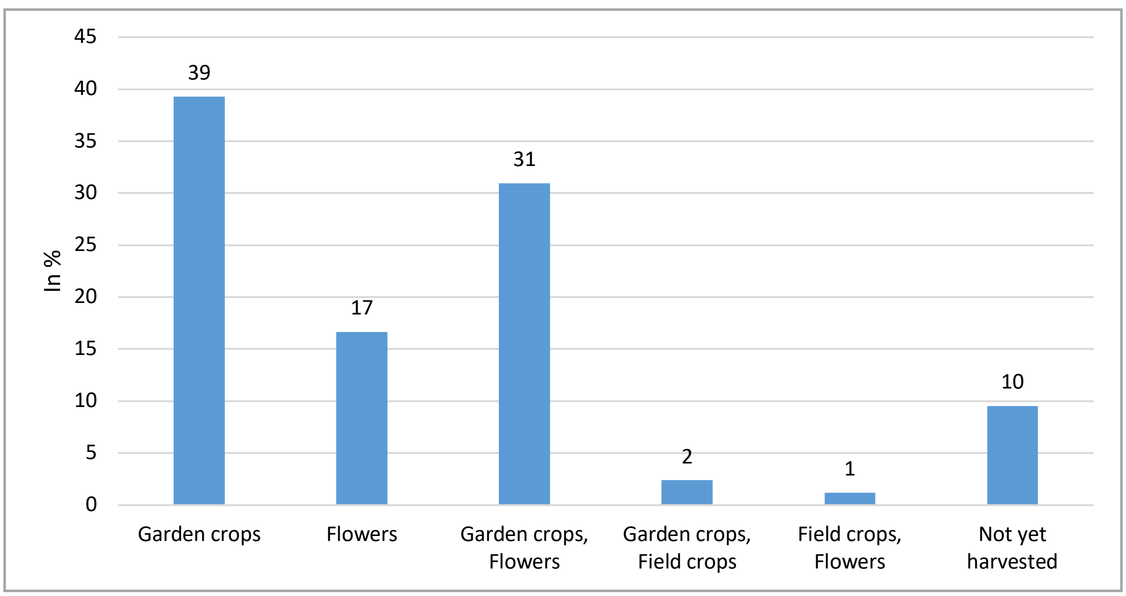

Figure 7.7 Compost usage
Note:
Garden crops: potato, cauliflower, spinach, garlic, onion, turmeric, ginger, eggplant, sponge gourd, coriander and field mint.
Field crop: corn

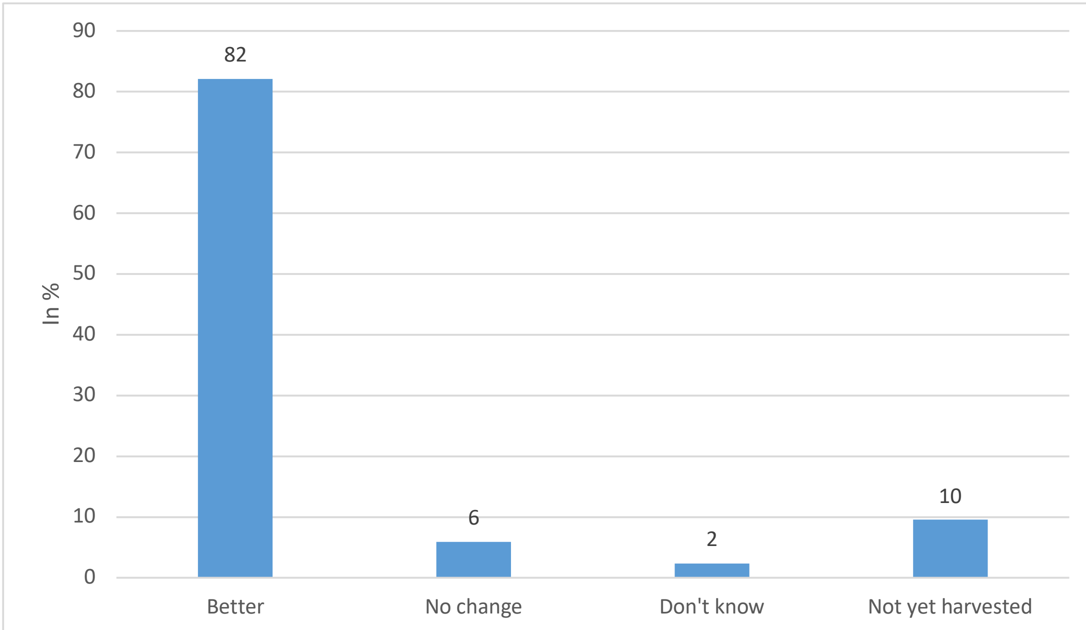

Figure 7.8 Change in production

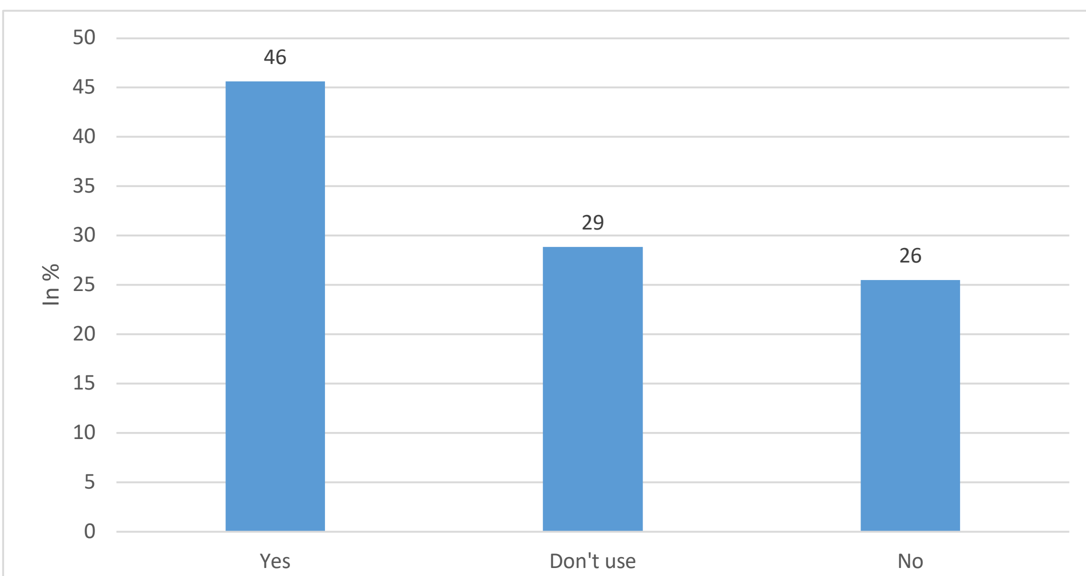

Figure 7.9 Problems faced using compost bin

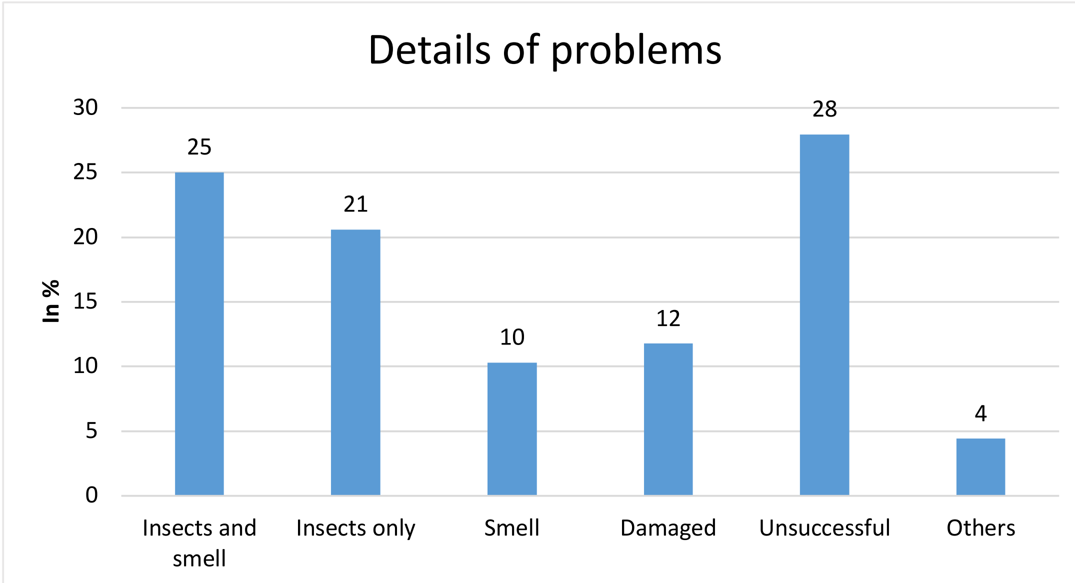

Figure 7.10 Details of problems faced using compost bin

7.6.3 Chemical Properties of Compost

This study tested moisture, nitrogen (N), phosphorous (P), potassium (K), organic matter, Carbon to Nitrogen (C:N) ratio, pH, cadmium (Cd) and lead (Pb) among other parameters for chemical analysis of six selected compost samples. The tested samples are compared with the recommended values provided by Nepal Standard (Source: NESS) which are presented in Table 7.2.

Table 7.2 Chemical analysis of compost

References for desired values/ Samples		Quality parameters for finished compost								
		Moisture (%)	Total N (%)	Total P (%)	Total K (%)	Organic Matter (%)	C:N ratio	pH @ 21° C (1:5)	Cd (µg/g)	Pb (µg/g)
References	Nepal Standard*	20-30	1.5, min	0.5, min	1.5, min	10-20	20	6.5-7.5	5-10	100, max
	A&L Canada Laboratories (2004)	30-50	0.60	0.25	0.20	>30	22	5.5-8.5	<3.0	<150
	Darlington (2011)	35-60	-	-	-	50	35	5.5 – 8.0	-	-
Samples*	A	35.68	2.69	2.74	3.08	38.54	8.27	8.4	39.28	31.42
	B	33.74	1.47	0.83	1.23	17.76	6.97	8.7	35.94	11.98
	C	7.32	2.69	2.16	1.1	47.54	10.2	8.4	31.86	3.98
	D	10.3	1	1.49	0.99	16.92	9.77	8.9	35.94	19.97
	E	8.33	1.31	2.24	1.15	32.97	14.53	9.1	27.79	N.D. (<0.05)
	F	39.47	3.01	2.16	3.07	48.97	9.44	8.7	11.96	<0.05
Average		22.47	2.03	1.94	1.77	33.78	9.86	8.70	30.46	16.84

Source: Field survey (2016)

Moisture

Moisture content is one of the key elements of good composting as it determines its decomposition rate. Water helps transport substances within the composting mass and makes the nutrients physically and chemically accessible to the microbes (Aryal & Tamrakar, 2013). Although too much moisture can lead to producing molds and the composting pile becoming anaerobic. A moisture of more than 65% results in slow decomposition, odor production and nutrient leaching; while too little moisture (less than 30%) prevents bacterial activity by dehydrating and killing microorganisms that are required in the process of composting, thus making the final product look dusty (A&L Canada Laboratories , 2004; Ramesh & SivaRam, 2017). The optimum moisture content is defined differently by different studies. For example, A&L Canada Laboratories (2004) mentions moisture content to be between 35-40% while Ramesh & SivaRam (2017) mentions it to be 50 – 60%. Surprisingly, in this case none of the samples met the requirement put forth by Nepal Standard. Samples A, B and F have higher while sample C, D and E have lower than the recommended moisture content of 20-30%. The higher moisture content in this case might be due to the penetration of rain water, addition of excess water and/or use of food waste in higher quantity that contains more moisture. The drainage system for the compost bin and protecting against heavy rain should also be reviewed to reduce moisture (Vázquez & Soto, 2017). In case of high moisture level, garden soil, saw dust, ash, shredded papers or fully dried leaves should be used; while in case of low moisture level simply adding some water is recommended to bring moisture to the optimum level (Ramesh & SivaRam, 2017; A&L Canada Laboratories , 2004; Tuladhar, 2003).

Nitrogen (N)

Nitrogen is an essential constituent of amino acid, nucleic acid and chlorophyll which increases the growth and development of living tissues and is necessary for microbial activity and for adjusting the C:N ratio of the composting material (Aryal & Tamrakar, 2013). A total N level between 0.75-2.5% is considered normal as it indicates high mineral content in the compost. N content above 2.5% is mostly associated with high organic matter level (>60%). Compost can be a significant source of N. About 10% of total N is considered to become available during the year of application (Allen & Kariuki, 2014). The N content was highest for sample F (3.01%) and lowest for sample D (1%). Nepal Standard considers 1.5% as the minimum level of N content. In this case, except for sample D and E, all other samples have enough amount of N content. Materials derived from bio solids often have substantial N (Darlington, 2011). Therefore, to increase N content; materials such as vegetable scraps, coffee grounds, grass clippings and manure are recommended (A&L Canada Laboratories , 2004).

Phosphorous (P)

Phosphorus is needed for storage and transfer of energy in the plant. It is essential in every metabolic process, protein synthesis, sugar development and legume N fixation. It is crucial for root development, rapid seedling growth, winter hardiness, disease resistance, efficient water use, early maturity, and maximum yield (Rosato, 2016). About 0.25% P is considered desirable (A&L Canada Laboratories , 2004). The P content was highest for sample A (2.74%) and lowest for sample B (0.83%). All the samples contain more than 0.5% minimum level of P which is deemed necessary by Nepal Standard. Although manure products are typically high in P (Darlington, 2011).

Potassium (K)

Potassium is a regulator of metabolic activities and is essential for photosynthesis and protein synthesis as well as carbohydrate transport and storage. It provides strength to plants by promoting root reserves, winter hardiness, cell development, strong walls, and reduces stalk lodging. It also improves water use efficiency, increases yield, improves crop quality, and reduces incidence of disease (Rosato, 2016; Aryal & Tamrakar, 2013). About 0.20% K is considered desirable (A&L Canada Laboratories , 2004). The K content was highest for sample A (3.08%) and lowest for sample D

(0.99%). Samples B (1.23%), C (1.1%), D (0.99%) and E (1.15%) failed to have minimum level of 1.5% K recommended by Nepal Standard. In order to increase K, yard waste products should be used (Darlington, 2011).

Organic Matter

Organic matter improves the soil structure, resists soil erosion and improves soil's water holding capacity. One of the main reasons why compost is applied in farming is because it works as soil amendment to eroded soils (Aryal & Tamrakar, 2013). Organic matter content is the measure of carbon-based materials in compost that is typically expressed as a percentage of dry weight. The nature of the starting materials and the degree of decomposition determines the amount of organic matter in a compost sample. There is no ideal organic matter content for finished compost, although if biochemical breakdown of inputs is ideal, a final organic matter percentage near 30% by weight is common. The remaining 70% is mineral matter and ash (Allen & Kariuki, 2014). The study found that all samples have above or within the range of organic matter content suggested 10-20% range by Nepal Standard. The organic matter content was highest for sample F (48.97%) and lowest for sample D (16.92%). Samples A (38.54%), C (47.54%), E (32.97%) and F (48.97%) have excess amount of organic matter than the prescribed rate.

Carbon to Nitrogen (C:N) Ratio

Microbes such as bacteria and fungi feed on and breakdown organic materials. Higher the population of microbes, higher will be the composting process as they accelerate the act of decomposition (Ramesh & SivaRam, 2017). Carbon and Nitrogen are two such most important elements required for microbial decomposition. Microbes use carbon substrate as their main energy source, oxidizing it and releasing carbon dioxide gas;

while N provides protein, nucleic acid, amino acid, enzyme and co-enzyme necessary for cell growth and its function. The ideal C:N ratio for compost ingredients is around 25-30:1. The level much below indicates excess N supply that will be lost as ammonia gas causing undesirable odor. On the other hand, the level higher than the ideal range indicates lack of enough N for optimal growth of the microbial population that makes compost relatively cool, leading to slow degradation. In a moist, well-aerated pile, N is not lost as a gas or leached and thus is conserved; decreasing C:N ratio overtime. C:N ratio helps assess the rate of decomposition of compost mixtures. Unless coarse woody materials are used in the raw feed stocks and are still present, C:N ratio of 15 to 20 or within the range of 12-22 indicates a finished product (A&L Canada Laboratories , 2004; Allen & Kariuki, 2014).

The C:N ratio of 35 or lower is preferred to have stable N in compost. Wood by-products have high C:N ratios while bio-solids and manures generally have low C:N ratios since these materials are N rich. When C:N ratio is high, N can be tied as the compost further decomposes, making it less available to plant material that can interrupt plant color and growth. Compost with less than 20 carbons to nitrogen ratios can supply significant quantities of N as they decompose (Darlington, 2011).

The C:N ratio was highest for sample E (14.53) and lowest for sample B (6.97), although none of the sample came close to the ratio of 20 as suggested by Nepal Standard. This means that the amount of ‘brown’ material that are high in carbon are lower than needed compared to the ‘green’ material that are high in N that are generated from the kitchen which is very common for HH waste. This is one of the reasons why it takes longer for composting. It is inevitable that HHs would regularly generate kitchen waste more such as discarded vegetables or its peel, food waste, coffee and tea bags, egg shells, cut flowers, pruning/fresh grass clippings, houseplants and in some cases animal manure that can feed the compost bin regularly. But to increase the C:N ratio; carbon rich materials such as dry leaves, dry grass, saw dust, wood chips, paddy, straw, hay, twigs, barks, shredded paper/card board, newspaper, paper napkins/tissue papers or even garden soil that has organic carbon should be added (Ramesh & SivaRam, 2017; A&L Canada Laboratories , 2004).

pH@21°C (1:5)

Soil pH reading shows acid-alkaline balance and controls a wide range of physical, chemical and biological processes and properties that affect soil fertility and plant growth. It significantly influences availability of nutrients to plants, activity of microorganisms in the soil and even stability of soil aggregates (Rosen, Bierman, & Eliason, 2016; Parikh & James, 2012). pH scale ranges from 0 to 14, with higher range indicating alkaline, lower range indicating acidity and 7 indicating neutrality (Rosen, Bierman, & Eliason, 2016). In this case, the pH value for all samples is above the recommended value of 7.5 that ranged from the lowest 8.4 to the highest 9.1, which means that the compost tested are alkaline.

Products derived from wood residuals or peat moss can have pH values as low as 4.5, while manures are frequently alkaline (pH 8.0-8.5). Composts with pH lower than 4 can form potentially toxic organic acids. Also, different level of pH is demanded by different plant species. Thus, pH level can be adjusted accordingly by using lime to increase pH and sulfur or iron sulfate to decrease pH (Darlington, 2011).

Soil pH is a measurement of the active acidity of the soil. A pH between 5.5 and 8.5 is optimal for compost micro-organisms. The nutrients required for plant growth are water soluble in soils with pH between 6 and 7.8. If pH goes much above this, micronutrients and phosphorus become less available to roots and if it drops below 5.5, many of the major nutrients become less available and some of the micronutrients can become toxic to the roots system (A&L Canada Laboratories , 2004). The pH was highest for sample E (9.1) and lowest for sample A and C (8.4). All the samples have pH content higher than what is recommended by Nepal Standard (6.5-7.5).

Cadmium (Cd) and Lead (Pb)

Traces of heavy metals can include arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. Although many of these elements are actually needed by plants for normal growth, they have potential to be toxic to humans, animals, and plants (Darlington, 2011).

Cd and Pb are the indicators of level of heavy metals in the compost sample. Certain heavy metals are known to cause phytotoxic effects in plants at high concentrations and specific plant species are known to be more sensitive than others. However, little information is available to interpret the significance of these values in compost (Allen & Kariuki, 2014). Cd is used in metal alloy to make it stronger and wear resistant, also Cd pigments are used to create plastics (Mead, 2010).

The Cd content was highest for sample A (39.28µg/g) and lowest for sample F (11.96µg/g). All samples have excess amount of Cd content than as prescribed by Nepal Standard (5-

10μg/g). The plastic compost bin and the metal rod used inside the compost bin may be one of the main reasons for this high Cd content in the compost samples.

The Pb content was highest for sample A (31.42μg/g) and lowest for sample E and F (<0.05μg/g). All samples have Pb content below what is prescribed by Nepal Standard (1000μg/g maximum).

7.7 Conclusion and Recommendations

HH composting is known to be an effective approach to manage organic waste, which reduces significant burden for the municipality to collect and manage HH waste, thus minimizing the amount of waste going to the dumping or landfill site for final disposal. With this realization, Gorkha municipality had distributed 300 subsidized compost bins to the HHs along with one day training and awareness program. However, the continuity in self-composting depends on various other factors such as the easiness in the process of composting and quality and usefulness of the compost itself. Thus, this study attempted to identify if HHs are continuing to compost using the local government subsidized bins and if so, assess their compost making practices and analyze the associated challenges therein. Out of 174 registered recipients of such bins in the municipality, 149 HHs (86%) were randomly selected as a study sample. In order to evaluate quality of compost, six samples were selected from among these that represented the common method of composting in the study area.

The study showed that 56% are continuing to use compost bin, 15% are not using it anymore and the rest 29% never used it. It can be said that 29% who never used it either didn't receive the bin or showed lack of interest. Those who discontinued the practice did so because of insect invasion, foul smell, leachate production, water tank contamination, damaged bins and natural calamity that halted everyday routine. Even those continuing to compost are not free from complications as they too face similar problems in addition to being unable to segregate waste properly by all HH members, make quality compost and limited capacity of bins. Kitchen and garden waste are the most common types of waste that were used as an input for HH composting. Around 1-2% of HHs also mixed other inputs like dust, wet paper, chicken litter, cow dung and/or ash in the process of making compost. Respondents were found to harvest compost 1-12 times per year, although majority would harvest about 2 times per year. The compost is used for crop production and flowering. On the optimistic side, majority of respondents (82%) also perceived to have better production of vegetables in the form of size and quality after applying home-made compost.

Chemical analysis of the sampled compost suggests that compost made from HH waste does have nutrient content and the average nutrient content even exceeds the minimum standard set by the government. It can definitely add value to the soil when applied. Though C:N ratio did not meet the standard, education and training programs should be given by the concerned stakeholders to the HHs on what kind of waste and how it should be used to put in compost bin. This can help to improve the overall quality of compost being produced at HH level. The content of Cd, one of the heavy metals, was found to be higher than the standard value for all the samples tested. Further studies should be carried out to understand the main cause for it to be present in HH compost and identify solutions to prevent it. Even though traces of Pb, another heavy metal, were found in all the samples, it was below the standard value for all the samples tested. Finally, it is necessary to continue making efforts through regular monitoring, getting feedback and provide repetitive training to improve compost making processes of the HHs and sustaining it in a long run. The option of buying back compost by the municipality might also encourage HHs to take up composting practice.

Chapter 8. Overall Conclusion and Recommendations

8.1 Summary of Results, Discussions and Recommendations

MSW is a growing problem in urban areas around the world that is increasing faster than the rate of urbanization. More so, lower income countries are expected to affect more by it because of lack of technological advancement and socio-political setting favorable to overcome such condition. About 20-50% of municipal budget in developing countries is spent on managing MSW but still 30-60% of the waste is uncollected and less than 50% of its population is served. The uncollected waste is dumped indiscriminately on streets, banks of river and in drains; gets mixed with human and animal excreta; thus, contributing to flooding, breeding of insects and rodent vectors, and spreading of diseases. Even the limited waste that gets picked is often disposed in uncontrolled dumpsites and/or burnt; thus, polluting water resources, air and the environment.

Nepal, one of the least developed countries in South Asia, is no exception to such situation. Rapid population growth in urban areas and increase in purchasing power have contributed to growing municipal waste. Municipalities and community groups in Nepal are mainly characterized by having limited access to information, especially on improving waste management system and using waste in an economically productive way. Within the existing SWM situation, there is no proper and effective waste collection system and only limited recycling and composting activities are practiced all over Nepal. Haphazard depositing and burning piles of waste along the roads and riversides is a common sight, causing health hazards and environmental problems in-situ as well as downstream. This has caused SWM to be the most important environmental problem in urban areas of Nepal.

Before deciding upon the most effective waste management option, the current status of waste related issues should be identified. It includes how much waste is generated, what kind of waste is mostly produced, how it is managed, who are the actors involved in its management, what resources do these actors already have to manage the waste, etc. Although the characteristics among urban areas of developing countries are quite common, waste management tactics should be context specific, locally sensitive, critical, creative, and owned by the community of concern; as their specific circumstances may be significantly different. This is why there needs to be a comprehensive study on waste, particularly in a country like Nepal where there is barely any study that has done detailed analysis of waste generation and management practices to suggest for the most effective solution.

This study analyzed the current household solid waste situation in Gorkha municipality of Nepal in order to identify the effective methods for its management. Gorkha municipality is selected for this study because it is one of the least resource intensive municipalities in Nepal but does not fall under the priority of SWM researchers or implementers. However, growing amount of waste nonetheless demands for proactive action. There are 9,236 households spread across 15 wards, which is the lowest administrative unit. The municipality owns only one tractor and thus only 6 wards have regular waste collection services. The municipality estimates that about 4 tons of waste is generated per day, but only 2 tons per day is collected so far. When it comes to having human resources in waste management, only one staff is available to serve 5,392 inhabitants and daily cleaning service covered only 0.4 km of the street in 2003 that increased to just 2.5 km in 2008. Recycling is dealt by scrap dealers and sweepers; but harmful waste such as medical, dead animals, construction and industrial are dumped openly. At management level, there is lack of cooperation at different levels with no integrated approach. At implementation level, there is no landfill site; inadequate human resources; no technical knowhow; lack of transportation; lack of reuse, recycling and composting activities; political problems; and lack of community participation. The limited studies conducted so far in this municipality considered only one day waste generation data and did not cover all municipal wards. Furthermore, due to lack of consistent scientific methods and different assumptions made to quantify waste generated from different sources, the findings of these studies are inconsistent.

Specifically, this research assessed socioeconomic factors affecting households' waste generation and conducted characterization study of households' waste, assessed households' socioeconomic factors influencing households' willingness-to-segregate waste, analyzed households' socioeconomic factors affecting willingness-to-pay for solid waste collection service, and evaluated households' compost making practices using organic waste. Among others, HHs are focused because in developing countries, about 55-80% of MSW are known to be generated by HHs. In Nepal too, it is assumed that HHs account for on average 75% of the total municipal waste generation.

This study was done in two phases. The first survey was conducted from November to December 2015 to collect data relating to socio-economic background, amount and types of waste generated, waste management practices, willingness-to-segregate waste and WTP for improved waste collection service. The data was collected from 401 individual households using stratified random sampling method, using face-to-face interview. It is assumed that weekly data and inclusion of all 15 wards provide much more robust output than one day data covering only few selected municipality wards which previous studies relied on. The second survey was done from February to March 2016 to understand the status of compost made by HHs using compost bins that were distributed by the local government to 300 HHs at subsidized rate along with providing one day training and awareness program.

This study found that HHHs are predominantly male (73.82%) and the average size of the household is 3.72, which is almost similar to the national census result of 3.69. The average monthly household income is found to be NRs. 36,854.20 (360.86 US$). There is a huge difference between the minimum and maximum household income found in this study, which is NRs. 8020 (78.53 US$) and NRs. 244,083 (2389.92 US$), respectively. This result reflects the huge economic gap between households residing within Gorkha municipality. Households in very rural setting within the municipality were also considered, which also included very poor households whose livelihood depends only on farming. Most of the households who participated in this study lives in their own house (87.28%), and less than half of the households (36.66%) have the waste collection service offered by the municipality. Although more than half of the households (58.35%) are aware about the adverse effects caused by waste and its improper management on the environment, it cannot be denied that the remaining households (41.65%) who are unaware about such adverse effects also constitute a significant percentage.

This study found average HH waste generation of 0.85 kg/day or 0.24 kg/capita/day. Given the population of 39,172 inhabitants, it is estimated that 9.4 tonnes of HH waste per day is being generated in Gorkha municipality. If the HH waste is estimated to account for 75% of total municipal waste generation then it can be estimated that the total waste generation of Gorkha municipality is about 12.53 tonnes per day. In order to analyze impact of socioeconomic factors on HH waste generation, OLS model was used. Among the socioeconomic factors, this study found that family size and income are important indicators to forecast solid waste generation trend. Meanwhile, focus should also be on waste management strategy. While analyzing waste composition, organic waste formed the highest share (47.25%) of the total waste. This share of organic waste is similar to the global municipal waste composition rather than the national municipal waste composition. From this study, it is estimated that in Gorkha municipality, HHs generate about 1,621.4 tonnes of organic waste every year, most of which are uncollected, and the rest discarded in an open dumpsite. If left unattended, it will create problems of smell, leachate, flies, rodents and methane emission that will affect human health and environment. Thus, given the amount and intensity of its impact, organic waste should be prioritized for management. It can be managed in several ways, but composting has proven to be the most economical and efficient technique among other management options in developing countries given the waste type, nature and composition. The best strategy would have been to promote HH composting as managing at source would lead to environmentally sound and economically feasible means, but most importantly it reduces waste volume that needs to be transported to the dumpsite, which municipality is already incapable of. However, follow-up survey found that the success rate of HH composting has proven to be just 56% even after providing training and distributing subsidized compost bins by the municipality. While supporting HHs through follow-up training shall increase the adoption rate to certain extent, there is bound to be some who will not prefer composting on their own. That is why municipality should take their own initiative of composting as well. Another way is to assign duties at the ward-level with proper resources in place so that collection and handling of waste would be more efficient.

The recyclable potential of remaining waste (metal, paper, plastic, glass, textiles, and rubber and leather) is also very high (37.52% of total waste or about 1,287.5 tonnes/year). Even though there is no recycling institution within the municipality, the current waste pickers who collect recyclable waste from landfill should be institutionalized in order to effectively channel recyclable waste to junkshop owners who are responsible for transporting these materials in cities where recycling exists. This might also increase the local job opportunity of recyclable waste collection and transportation. Other waste formed 15.23% of total waste (about 522.6 tonnes/year) which is of significant amount as well and should be managed accordingly. It includes hazardous waste as well, which should have been managed in the highest possible environmentally and socially acceptable standards as it contains corrosive or toxic ingredients that pollute environment and pose threat to human health. If waste from other sources such as commercial, industrial or institutional entities were to be included, the total waste generated in the municipality would be much higher.

In the midst of waste management, waste segregation should be the most important step that assures waste management in an environmentally sound and economically feasible way. HHs should be encouraged to segregate waste at least in two categories: organic and inorganic. It was revealed that 91% of respondents are willing to segregate waste in the future, which can be trustworthy as they just had first-hand experience of waste segregation in the process of taking part in this study. The local government should encourage all HHs through environmental education, and training and awareness programs that will gradually instill value, followed by action.

In the process of HH survey, most of the households segregated waste into organic and inorganic waste for a week (95.76%) and they were very happy with the practice, because they saw changes in the cleanliness of the house and surrounding as well as behavior among the household member to manage waste properly. In order to analyze HHs' willingness-to-segregate waste if the government enforces the law in the future, logit regression model was used because of its comparative mathematical simplicity and asymptotic characteristics. This study found that HHs who are aware about the adverse impacts of waste on environment, who have the current waste collection service, who are willing to pay for the improved waste collection services, who make compost, and who segregated waste for a week are statistically significant at 1% level of significant. It suggests that such HHs realize the importance of segregating waste for proper management of waste and they want to be a responsible citizen by obeying the law. As for the HHs who are composting might have already been segregating their waste which increases their readiness to continue in the future as well. Income variable is significant at 5% level of significance and gender variable is significant at 10% level of significance. In Nepal, females are responsible to do household chores, which also includes management of household waste. Hence, they are more affected and concerned for proper management of waste. Policy implementation is a huge challenge for the government and so the findings from this study could be taken into consideration to enforce the law of waste segregation at source in the study area as well as other municipalities in Nepal and other developing countries as well.

With the growing amount of MSW and municipalities' inability to manage it properly mainly due to financial constraint, collecting fees from the public for improving the waste management service seems to be the only viable option. The waste collection service is restricted only to limited areas in Gorkha municipality of Nepal and currently is provided free of charge. Out of 401 respondents, about 61% are willing to pay for the improved waste collection service. Although some of the reasons for both willingness and unwillingness to pay are more or less interrelated, it can be generalized that those willing to pay are more concerned about the cleanliness of their house and surrounding, want better waste collection service and feel responsible to share the cost of proper waste disposal. Similarly, HHs who are not willing to pay do not feel that it is their responsibility as they are already paying the municipal tax and that it should be managed by the local government without any additional fee being imposed on them.

In order to identify the WTP amount for improved waste collection service, CV method was used because HHs have never been charged for such service and due to lack of reference "stated preference" approach such as CV is used, which is a direct assessment technique that measures the expected amount of the project in monetary terms by directly asking those who will be benefited by the services under hypothetical circumstances through a questionnaire survey with the assumption that it will be implemented in the near future. The mean WTP amount that HHs are willing to pay is NRs. 73.38 (0.72 US$) per month. The municipality or the concerned stakeholders may consider this as a reference amount to impose solid waste collection fee in Gorkha municipality as no such fee has been charged to the HHs up until now.

Further logit model was used to identify the determinants of HHs' WTP for improved waste collection service and tobit model to identify the factors influencing the maximum amount of money they are willing to pay. The factors that significantly influence HHs' WTP are monthly HH income, education of HHH, environmental awareness and waste collection service. The significant factors that influence the maximum amount of money HHs are willing to pay for improved waste collection service are monthly HH income, environmental awareness and waste collection service. Concerned stakeholders and policy makers should consider these traits of HHs before enforcing waste collection fee. For instance, since HHs' awareness about environmental impact is positively significant to both WTP and the maximum amount of waste collection fee they are willing to pay, the government and concerned stakeholders should educate the HHs about adverse effects of indiscriminate disposal of waste on the environment in order to raise more funding for SWM.

HH composting is known to be an effective approach to manage organic waste, which reduces significant burden for the municipality to collect and manage HH waste, thus minimizing the amount of waste going to the dumping or landfill site for final disposal. With this realization, the municipality had promoted HH composting by distributing subsidized compost bins to 300 HHs over the years along with providing one day training and awareness program on converting organic waste to compost using the bins. Due to poor record keeping, the municipality only had information of 174 recipients out of which 149 HHs were randomly selected as a study sample which constitute almost 86% of the identified users. For evaluating chemical properties of HH compost, six samples were selected which took different approaches during preparation of compost but are considered to represent the general compost making practices of most of the HHs in the study area. Samples were tested in Nepal Environment and Scientific Services (P.) Ltd. (NESS), Kathmandu, Nepal and Nepal Standard value for each parameter that were referred to for the analysis were also received from NESS.

The study showed that 56% are continuing to use compost bin, 15% are not using it anymore and the rest 29% never used it. It can be said that 29% who never used it either didn't receive the bin or showed lack of interest. Those who discontinued the practice did so because of insect invasion, foul smell, leachate production, water tank contamination, damaged bins and natural calamity that halted everyday routine. Even those continuing to compost are not free from complications as they too face similar problems in addition to being unable to segregate waste properly by all HH members, make quality compost and limited capacity of bins. Kitchen and garden waste are the most common types of waste that were used as an input for HH composting. Around 1-2% of HHs also mixed other inputs like dust, wet paper, chicken litter, cow dung and/or ash in the process of making compost. Respondents were found to harvest compost 1-12 times per year, although majority would harvest about 2 times per year. The compost is used for crop production and flowering. On the optimistic side, majority of respondents (82%) also perceived to have better production of vegetables in the form of size and quality after applying home-made compost.

Chemical analysis of the sampled compost suggests that compost made from HH waste does have nutrient content and the average nutrient content even exceeds the minimum standard set by the government. It can definitely add value to the soil when applied. Although C:N ratio did not meet the standard, which is why education and training programs should be given by the concerned stakeholders to the HHs on what kind of waste is to be used and how it should be used to put in compost bin. This can help to improve the overall quality of compost being produced at HH level. The content of cadmium, one of the heavy metals, was found to be higher than the standard value for all the samples tested. Further studies should be carried out to understand the main cause for it to be present in HH compost and identify solutions to prevent it. Even though traces of lead, another heavy metal, were found in all the samples, it was below the standard value for all the samples tested. Finally, it is necessary to continue making efforts through regular monitoring, getting feedback and provide repetitive training to improve compost making processes of the HHs and sustaining it in a long run. The option of buying back compost by the municipality might also encourage HHs to take up composting practice more seriously.

8.2 Recommendations for Future Research

This dissertation focused on household waste generation, management practices including compost making practices at household level, willingness-to-segregate waste and willingness-to-pay for waste collection service. There are certain aspects which are recommended for future research and they are explained as follows:

1. The survey was conducted only in Gorkha municipality as a case study. However, it may not represent the situation in other municipalities. Therefore, inclusion of more number of municipalities is recommended and comparative study of bigger municipalities with smaller municipalities in terms of economy, diversity of population and its size could give a better picture about the overall situation in Nepal.
2. This study only focused on household waste generation and management practices. Future research work should also include waste generation and management practices of commercial establishments, schools, industries and other sources if available.
3. This study used open-ended question format as willingness-to-pay elicitation technique. This method is less frequently used nowadays, so the most widely used approach in present context so-called dichotomous-choice format should be employed in future research work.

4. The explanatory variables used in the model analyses to identify factors influencing waste generation, willingness-to-segregate waste and willingness-to-pay were based on relevant literatures. However, same variables should be used in future research to make consistency in findings, which will help to make robust discussions.
5. A follow-up study should be carried out to evaluate the compost making practices at the household level and also to understand the ongoing challenges faced by the households.
6. A detailed study to identify the reason for high cadmium content in household compost should be done.
7. The role of informal sectors and flow of recyclable materials should also be studied.
8. Traditional values, religious beliefs and the existing caste system are the major factors acting against effective solid waste management in urban areas of developing countries. Therefore, these aspects should also be considered in future research.

Bibliography

A&L Canada Laboratories . (2004). *Compost management: Compost analysis for available nutrients and soil suitability criteria and evaluation.* London, UK: A&L Canada Laboratories Inc.

Accent. (2010). *Review of stated preference and willingness to pay methods*.

Addai, K. N., & Danso-Abbeam, G. (2014). Determinants of willingness to pay for improved solid waste management in Dunkwa-on-Offin, Ghana. *Journal of Agriculture and Environmental Sciences*, *3*(1), 1–9.

Adeniran, A. E., Nubi, A. T., & Adelopo, A. O. (2017). Solid waste generation and characterization in the University of Lagos for a sustainable waste management. *Waste Management*, *67*, 3–10. https://doi.org/10.1016/j.wasman.2017.05.002

Afroz, R., Hanaki, K., & Hasegawa-Kurisu, K. (2009). Willingness to pay for waste management improvement in Dhaka City, Bangladesh. *Journal of Environmental Management*, *90*(1), 492–503. https://doi.org/10.1016/j.jenvman.2007.12.012

Afroz, R., Hanaki, K., & Tudin, R. (2011). Factors affecting waste generation: A study in a waste management program in Dhaka City, Bangladesh. *Environmental Monitoring and Assessment*, *179*(1–4), 509–519. https://doi.org/10.1007/s10661-010-1753-4

Afroz, R., Masud, M. M., Akhtar, R., & Duasa, J. B. (2013). Survey and analysis of public knowledge, awareness and willingness to pay in Kuala Lumpur, Malaysia - A case study on household WEEE management. *Journal of Cleaner Production*, *52*, 185–193. https://doi.org/10.1016/j.jclepro.2013.02.004

Aggrey, N., & Douglason, O. G. (2010). Determinants of willingness to pay for solid waste management in Kampala City. *Current Research Journal of Economic Theory*, *2*(3), 119–122.

Alam, R., Chowdhury, M. A. I., Hasan, G. M. J., Karanjit, B., & Shrestha, L. R. (2008). Generation, storage, collection and transportation of municipal solid waste – A case study in the city of Kathmandu, capital of Nepal. *Waste Management*, *28*(6), 1088–1097. https://doi.org/10.1016/j.wasman.2006.12.024

Alberini, A., Boyle, K., & Welsh, M. (1999). *Analysis of contingent valuation data with multiple bids and response options allowing respondents to express uncertainty* (University of Colorado Discussion Paper 99-18). Boulder, CO, USA. Retrieved from http://www.colorado.edu/economics/papers/papers99/wp99-18.pdf

Alberini, A., & Cooper, J. (2000). *Applications of the contingent valuation method in developing countries: A survey*. *FAO Economic and Social Development Paper* (Vol. 146). Rome: Food and Agriculture Organization of the United Nations.

Aleluia, J., & Ferrão, P. (2016). Characterization of urban waste management practices in developing Asian countries: A new analytical framework based on waste characteristics and urban dimension. *Waste Management*, *58*, 415–429. https://doi.org/10.1016/j.wasman.2016.05.008

Allen, T., & Kariuki, S. (2014). *Interpreting Your Compost Test Results.* Amherst, Massachusetts: Soil and Plant Tissue Testing Laboratory, University of Massachusetts.

Anjum, R. (2013). *Willingness to pay for solid waste management services: A case study of Islamabad* (No. 3). Islamabad, Pakistan.

Armijo de Vega, C., Ojeda Benítez, S., & Ramírez Barreto, M. E. (2008). Solid waste characterization and recycling potential for a university campus. *Waste Management*, *28*(Supplement 1), S21–S26.

https://doi.org/10.1016/j.wasman.2008.03.022
Aryal, J., & Tamrakar, A. S. (2013). Domestic organic waste composting in Madhyapur Thimi, Bhaktapur. *Nepal Journal of Science and Technology, 14*(1), 129-136.
Asian Development Bank [ADB]. (2012). *Nepal: Capacity building for waste management*.
Asian Development Bank [ADB]. (2013). *Solid waste management in Nepal: Current status and policy recommendations*. Mandaluyong City, Philippines: Asian Development Bank. Retrieved from https://www.adb.org/sites/default/files/publication/30366/solid-waste-management-nepal.pdf
Asian Productivity Organization [APO]. (2007). *Solid waste management: Issues and challenges in Asia*. Tokyo, Japan: Asian Productivity Organization.
Atthirawong, W. (2016). Factors affecting household participation in solid waste management segregation and recycling in Bangkok, Thailand. In *30th European Conference on Modelling and Simulation*. https://doi.org/10.7148/2016-0198
Awunyo-Vitor, D., Ishak, S., & Jasaw, G. S. (2013). Urban households' willingness to pay for improved solid waste disposal services in Kumasi metropolis, Ghana. *Urban Studies Research*, *2013*, 1–8. https://doi.org/10.1155/2013/659425
Baker, S. (1997). Community organization and solid waste management in the Kathmandu Valley. *Himalaya, the Journal of the Association for Nepal and Himalayan Studies*, *17*(1).
Ball, R., & Lawson, S. M. (1990). Public attitudes towards glass recycling in Scotland. *Waste Management & Research*, *8*, 177–192.
Bandara, N. J. G. J., Hettiaratchi, J. P. A., Wirasinghe, S. C., & Pilapiiya, S. (2007). Relation of waste generation and composition to socio-economic factors: A case study. *Environmental Monitoring and Assessment*, *135*(1–3), 31–39. https://doi.org/10.1007/s10661-007-9705-3
Banga, M., Lokina, R. B., & Mkenda, A. F. (2011). Households' willingness to pay for improved solid waste collection services in Kampala City, Uganda. *The Journal of Environment Development*, *20*(4), 428–448.
Bera, R., Datta, A., Bose, S., Dolui, A., Chatterjee, A., Dey, G., & Barik, A. (2013). Comparative evaluation of compost quality, process convenience and cost under different composting methods to assess their large scale adoptability potential as also complemented by compost quality index. *International Journal of Scientific and Research Publications, 3*(6), 1-11.
Bernstad, A. (2014). Household food waste separation behavior and the importance of convenience. *Waste Management*, *34*(7), 1317–1323. https://doi.org/10.1016/j.wasman.2014.03.013
Bhattarai, K. (2015). Households' willingness to pay for improved solid waste management in Banepa municipality, Nepal. *Environment and Natural Resources Journal*, *13*(2), 14–25.
Bobeck, M. (2010). *Organic Household Waste in Developing Countries - An overview of environmental and health consequences, and appropriate decentralised technologies and strategies for sustainable management.* Mid Sweden University, Department of engineering and sustainable development.
Center for Sustainable Systems. (2015). *Municipal Solid Waste Factsheet.* Michigan, USA: University of Michigan.
Central Bureau of Statistics [CBS]. (2004). Nepal living standards survey, (December), 1–146. https://doi.org/november, 2011

Central Bureau of Statistics [CBS]. (2014). *National population and housing census 2011: Urban tables* (Vol. 07, Part I). Kathmandu, Nepal: Central Bureau of Statistics.
Central Bureau of Statistics [CBS]. (2014). *National population and housing census 2011 (Village development committee/municipality)* (Vol. 6). Kathmandu, Nepal: Central Bureau of Statistics.
Central Bureau of Statistics [CBS]. (2014). *Population monograph of Nepal* (Vol. III). Kathmandu, Nepal: Central Bureau of Statistics. Retrieved from http://cbs.gov.np/image/data/Population/Population Monograph of Nepal 2014/Population Monograph V03.pdf
Chu, Z., Wang, W., Wang, B., & Zhuang, J. (2016). Research on factors influencing municipal household solid waste separate collection: Bayesian belief networks. *Sustainability*, *8*(2), 152. https://doi.org/10.3390/su8020152
Cointreau, S. (2006). *Occupational and environmental health issues of solid waste management: Special emphasis on middle- and lower-income countries*. *Urban Papers*. Washington, DC: The World Bank.
Cooperband, L. (2002). *The art and science of composting: A resource for farmers and compost producers*. Retrieved from http://www.cias.wisc.edu/wp-content/uploads/2008/07/artofcompost.pdf
Dahlén, L., & Lagerkvist, A. (2008). Methods for household waste composition studies. *Waste Management*, *28*(7), 1100–1112. https://doi.org/10.1016/j.wasman.2007.08.014
Dalen, H. M., & Halvorsen, B. (2011). *Gender differences in environmental related behaviour*. Statistics Norway. Retrieved from https://www.ssb.no/a/english/publikasjoner/pdf/rapp_201138_en/rapp_201138_en.pdf
Damschroder, L. J., Ubel, P. A., Riis, J., & Smith, D. M. (2007). An alternative approach for eliciting willingness-to-pay: A randomized Internet trial. *Judgment and Decision Making*, *2*(2), 96–106.
Dangi, M. B., Pretz, C. R., Urynowicz, M. A., Gerow, K. G., & Reddy, J. M. (2011). Municipal solid waste generation in Kathmandu, Nepal. *Journal of Environmental Management*, *92*(1), 240–249. https://doi.org/10.1016/j.jenvman.2010.09.005
Darlington, W. (2011). *Compost – A guide for evaluating and using compost materials as soil amendments.* California, USA: Soil and Plant Laboratory, Inc.
De Feo, G., & De Gisi, S. (2010a). Domestic separation and collection of municipal solid waste: Opinion and awareness of citizens and workers. *Sustainability*, *2*(5), 1297–1326. https://doi.org/10.3390/su2051297
De Feo, G., & De Gisi, S. (2010b). Public opinion and awareness towards MSW and separate collection programmes: A sociological procedure for selecting areas and citizens with a low level of knowledge. *Waste Management*, *30*(6), 958–976. https://doi.org/10.1016/j.wasman.2010.02.019
Derksen, L., & Gartrell, J. (1993). The social context of recycling. *American Sociological Review*, *58*(3), 434–442. Retrieved from http://www.jstor.org/stable/2095910
Desa, A., Kadir, N. B. A., & Yusooff, F. (2011). A study on the knowledge, attitudes, awareness status and behaviour concerning solid waste management. *Procedia Social and Behavioral Sciences*, *18*, 643–648. https://doi.org/10.1016/j.sbspro.2011.05.095
Devkota, D. C., Watanabe, K., & Dangol, V. (2004). Need for alternative approaches in solid waste management - Case study Kathmandu Valley. In *30th WEDC*

International Conference (pp. 79–82). Vientiane, Lao PDR.
Duwal, I. (2015). *Integrated sustainable waste management in Bhaktapur, Nepal: A case study of current practices regarding waste separation and spatial issues related with municipal solid waste management in Bhaktapur, Nepal*. Wageningen University, Wageningen, The Netherlands.
Edjabou, M. E., Jensen, M. B., Götze, R., Pivnenko, K., Petersen, C., Scheutz, C., & Astrup, T. F. (2015). Municipal solid waste composition: Sampling methodology, statistical analyses, and case study evaluation. *Waste Management*, *36*, 12–23. https://doi.org/10.1016/j.wasman.2014.11.009
Eshun, T. B., & Nyarko, F. (2011). Willingness to pay for improved waste management services: The case of Tarkwa-Nsuaem municipality. *Asian-African Journal of Economic and Econometrics*, *11*(1), 187–196.
Everett, J., & Peirce, J. W. (1993). Curbside recycling in the U.S.A.: Convenience and mandatory participation. *Waste Management & Research*. https://doi.org/10.1006/wmre.1993.1006
Ezebilo, E. E., & Animasaun, E. D. (2011). Economic valuation of private sector waste management services. *Journal of Sustainable Development*, *4*(4), 38–46. https://doi.org/10.5539/jsd.v4n4p38
Faverial, J., & Sierra, J. (2014). Home composting of household biodegradable wastes under the tropical conditions of Guadeloupe (French Antilles). *Journal of Cleaner Production, 83*, 238-244.
Friedrich, E., & Trois, C. (2011). Quantification of greenhouse gas emissions from waste management processes for municipalities – A comparative review focusing on Africa. *Waste Management*, *31*(7), 1585–1596. https://doi.org/10.1016/j.wasman.2011.02.028
Fujita, Y., Fujii, A., Furukawa, S., & Ogawa, T. (2005). *Estimation of willingness-to-pay (WTP) for water and sanitation services through contingent valuation method (CVM) - A case study in Iquitos City, The Republic of Peru -*.
Gallardo, A., Edo-Alcón, N., Carlos, M., & Renau, M. (2016). The determination of waste generation and composition as an essential tool to improve the waste management plan of a university. *Waste Management*, *53*, 3–11. https://doi.org/10.1016/j.wasman.2016.04.013
Gorkha Municipality Office. (2015). *नगर विकाश योजना २०७२ (Municipal development plan 2072)* (Vol. 6). गोरखा नगरपालिका कार्यालय (Gorkha Municipality Office). Retrieved from http://gorkhamun.gov.np/sites/gorkhamun.gov.np/files/documents/Gorkha books 2072 %282%29.pdf. [In Nepali]
Government of Nepal. (2011). *Solid waste management act, 2068 (2011)*. Retrieved from http://swmtsc.gov.np/solid-waste-management-act-2011-english
Gu, B., Wang, H., Chen, Z., Jiang, S., Zhu, W., Liu, M., … Bi, J. (2015). Characterization, quantification and management of household solid waste: A case study in China. *Resources, Conservation and Recycling*, *98*, 67–75. https://doi.org/10.1016/j.resconrec.2015.03.001
Hagos, D., Mekonnen, A., & Gebreegziabher, Z. (2012). *Households' willingness to pay for improved urban aaste management in Mekelle City, Ethiopia* (Discussion Paper Series).
His Majesty's Government of Nepal. (1989). *Solid Waste Management and Resource Mobilization Rules, 1989*. *Nepal Rajpatra* (Vol. 39).
His Majesty's Government of Nepal. (1997). *Environment protection act, 2053 (1997)*.

Retrieved from http://www.lawcommission.gov.np/index.php?option=com_remository&Itemid=2&func=startdown&id=9&lang=en

His Majesty's Government of Nepal. (1999). *Environment protection rules, 2054 (1997)*. Retrieved from http://lawcommission.gov.np/index.php?option=com_remository&Itemid=14&func=fileinfo&id=491&lang=en

Hisashi, O. (n.d.). *Sustainable Solid Waste Management in Developing Countries.* Kuala Lumpur: WHO Western Pacific Regional Environmental Health Centre (EHC).

Hoffmann, J. P. (2010). *Linear regression analysis: Assumptions and applications* (Second). Provo: Brigham Young University.

Hoornweg, D., & Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management* (Urban Development Series - Knowledge Papers No. 15). Washington, DC, USA: World Bank.

Hoornweg, D., Thomas, L., & Otten, L. (2000). *Composting and its applicability in developing countries* (No. 8). *Urban Waste Management*.

Hwa, T. J. (2007). Overview of solid-waste management in Asian countries. In *Solid waste management: Issues and challenges in Asia* (pp. 3–7). Tokyo: Asian Productivity Organization.

Irwan, D., Basri, N. E. ., & Watanabe, K. (2012). Interrelationship between affluence and household size on municipal solid waste arising: Evidence from selected residential areas of Putrajaya. *Journal of Asian Scientific Research*, *2*(11), 747–758. Retrieved from http://aessweb.com/journal-detail.php?id=5003

Ittiravivongs, A. (2012). Factors influence household solid waste recycling behaviour in Thailand: An integrated perspective. *WIT Transactions on Ecology and the Environment*, *167*, 437–448. https://doi.org/10.2495/ST110391

Japan International Cooperation Agency [JICA]. (2005a). *Supporting capacity development for solid waste management in developing countries: Towards improving solid waste management capacity of entire society*.

Japan International Cooperation Agency [JICA]. (2005b). *The study on the solid waste management for the Kathmandu valley* (Vol. II). Japan International Cooperation Agency.

Johannessen, L. M. (1999). *Guidance note on leachate management for municipal solid waste landfills* (Urban and local government working paper series ; no. UWP 5 No. 20962). The World Bank.

Jones, N., Evangelinos, K., Halvadakis, C. P., Iosifides, T., & Sophoulis, C. M. (2010). Social factors influencing perceptions and willingness to pay for a market-based policy aiming on solid waste management. *Resources, Conservation & Recycling*, *54*, 533–540. https://doi.org/10.1016/j.resconrec.2009.10.010

Karthigarani, R., & Elangovan, V. (2016). Household willingness to pay for better solid waste management in Sivagangai district, Tamil Nadu. In *XVII Annual International Seminar Proceedings* (pp. 171–182). Retrieved from http://www.internationalseminar.org/XVII_AIS/TS1_PDF/10.R. Karthigarani & V. Elangovan.pdf

Kato, T., Tran, A. ., & Hoang, H. (2015). Factors affecting voluntary participation in food residue recycling: A case study in Da Nang, Vietnam Nam. *Sustainable Environment Research*, *25*(2), 93–101.

Kawai, K., & Tasaki, T. (2016). Revisiting estimates of municipal solid waste generation per capita and their reliability. *Journal of Material Cycles and Waste*

Management, *18*(1), 1–13. https://doi.org/10.1007/s10163-015-0355-1
Kayode, A. M., & Omole, F. K. (2011). Some socio-economic factors affecting solid wastes generation and disposal in Ibadan Metropolis, Nigeria. *Journal of Environmental Issues and Agriculture in Developing Countries*, *3*(1), 55–64.
Keser, S., Duzgun, S., & Aksoy, A. (2012). Application of spatial and non-spatial data analysis in determination of the factors that impact municipal solid waste generation rates in Turkey. *Waste Management*, *32*(3), 359–371. https://doi.org/10.1016/j.wasman.2011.10.017
Khan, D., Kumar, A., & Samadder, S. R. (2016). Impact of socioeconomic status on municipal solid waste generation rate. *Waste Management*, *49*, 15–25. https://doi.org/10.1016/j.wasman.2016.01.019
Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2004). *Applied linear statistical models* (5th ed.). New York: McGraw-Hill/Irwin.
Lebersorger, S., & Beigl, P. (2011). Municipal solid waste generation in municipalities: Quantifying impacts of household structure, commercial waste and domestic fuel. *Waste Management*, *31*(9–10), 1907–1915. https://doi.org/10.1016/j.wasman.2011.05.016
Lekammudiyanse, L., & Gunatilake, S. (2009). Efficiency of the Household Compost bin as a Waste Management Technique in Sri Lanka (A Case Study in Gampaha Municipal Council Area). *International Journal of Basic & Applied Sciences, 10*(01), 89-94.
Lillesø, J.-P. B., Shrestha, T. B., Dhakal, L. P., Nayaju, R. P., & Shrestha, R. (2005). *The map of potential vegetation of Nepal - a forestry/agro-ecological/biodiversity classification system* (Development and Environment Series 2-2005 and CFC-TIS Document Series No.110). *Forest & Landscape*.
Lober, D. J. (1996). Municipal solid waste policy and public participation in household source reduction. *Waste Management & Research*, *14*(2), 125–143. https://doi.org/10.1177/0734242X9601400203
Local Governance and Community Development Programme [LGCDP]. (2016). 58 Old Municipality GIS Map. Retrieved July 17, 2016, from http://lgcdp.gov.np/gis_58mun?page=1
Local Governance and Community Development Programme [LGCDP]. (2017). GIS National Map. Retrieved August 3, 2017, from http://lgcdp.gov.np/GIS_national
Mahima, S., & Thomas, S. (2013). Estimating households willingness to pay for solid waste management with special reference to Palakkad district in Kerala. *International Journal of Social Science & Interdisciplinary Research*, *2*(1), 73–80.
Mani, S., & Singh, S. (2016). Sustainable Municipal Solid Waste Management in India: A Policy Agenda. *Procedia Environmental Sciences*, *35*, 150–157. https://doi.org/10.1016/j.proenv.2016.07.064
Manus Coffey, & Coad, A. (2010). *Collection of municipal solid waste in developing countries*. United Nations Human Settlements Programme (UN-HABITAT). Retrieved from file:///C:/Users/emm1v13/Downloads/3072_alt.pdf
Marshall, R. E., & Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management*, *33*(4), 988–1003. https://doi.org/10.1016/j.wasman.2012.12.023
Martin, M., Williams, I. D., & Clark, M. (2006). Social, cultural and structural influences on household waste recycling: A case study. *Resources, Conservation and Recycling*, *48*(4), 357–395. https://doi.org/10.1016/j.resconrec.2005.09.005
Mary, O., & Adelayo, A. (2014). Household willingness to pay for improved solid waste

management in Akinyele local government area. *Journal of Biology, Agriculture and Healthcare*, *4*(18), 76–82.
Maskey, B., Maharjan, K. L., & Singh, M. (2016). Ecological solid waste management act and factors influencing solid waste management in barangay Pansol of Quezon City, the Philippines. *Journal of International Development and Cooperation*, *22*, 37–45.
Matter, A., Dietschi, M., & Zurbrügg, C. (2013). Improving the informal recycling sector through segregation of waste in the household - The case of Dhaka Bangladesh. *Habitat International*, *38*, 150–156. https://doi.org/10.1016/j.habitatint.2012.06.001
Mazumdar, N. B. (2012). *Nepal: Capacity building for waste management.* Asian Development Bank (ADB).
McDonald, S., & Oates, C. (2003). Reasons for non-participation in a kerbside recycling scheme. *Resources, Conservation and Recycling*, *39*(4), 369–385. https://doi.org/10.1016/S0921-3449(03)00020-X
Mead, M. N. (2010). Cadmium confusion: Do consumers need protection? *Environmental Health Perspectives*, *118*(12), A528–A534. https://doi.org/10.1289/ehp.118-a528
Menegaki, A. N., Olsen, S. B., & Tsagarakis, K. P. (2016). Towards a common standard - A reporting checklist for web-based stated preference valuation surveys and a critique for mode surveys. *Journal of Choice Modelling*, *18*, 18–50. https://doi.org/10.1016/j.jocm.2016.04.005
Miafodzyeva, S., & Brandt, N. (2013). Recycling behaviour among householders: Synthesizing determinants via meta-analysis. *Waste and Biomass Valorization*, *4*(2), 221–235. https://doi.org/https://doi.org/10.1007/s12649-012-9144-4
Miezah, K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B., & Mensah, M. Y. (2015). Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. *Waste Management*, *46*, 15–27. https://doi.org/10.1016/j.wasman.2015.09.009
Ministry of Foreign Affairs and Local Development [MoFALD]. (1999). *Local self-governance act, 2055 (1999)*. Ministry of Federal Affairs and Local Development. Retrieved from http://www.mofald.gov.np/sites/default/files/Resources/docs_25.pdf
Ministry of Foreign Affairs and Local Development [MoFALD]. (2017). Home. Retrieved November 4, 2017, from http://municipality.gov.np/en
Ministry of Local Development. (1996). *Solid waste management national policy 2053 (1996)*.
Minton, A. P., & Rose, R. L. (1997). The effects of environmental concern on environmentally friendly consumer behaviour: An exploratory study. *Journal of Business Research*, *40*(96), 37–48. https://doi.org/10.1016/S0148-2963(96)00209-3
Misra, R., Roy, R., & Hiraoka, H. (2003). *On-farm composting methods.* Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).
Mitchell, R. C., & Carson, R. T. (1989). *Using surveys to value public goods: The contingent valuation method*. Washington, D.C.: Resources for the Future.
Mutz, D., Hengevoss, D., Hugi, C., & Gross, T. (2017). *Waste-to-energy options in - municipal solid waste management: A guide for decision makers in developing and emerging countries*. Bonn, Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from

https://www.giz.de/en/downloads/GIZ_WasteToEnergy_Guidelines_2017.pdf
Nepal Rastra Bank. (2017). Foreign exchange rates. Retrieved September 1, 2017, from https://www.nrb.org.np/fxmexchangerate.php?YY=2017&MM=08&DD=31&B1=Go
Nkansah, E., Dafor, N. K., & Essel-Gaisey, F. (2015). Willingness to pay for improved solid waste disposal in Tema metropolis. *UDS International Journal of Development*, *2*(1), 116–127.
Noehammer, H. C., & Byer, P. H. (1997). Effect of design variables on participation in residential curbside recycling programs. *Waste Management & Research*, *15*(4), 407–427. https://doi.org/https://doi.org/10.1006/wmre.1996.0096
Ogwueleka, T. C. (2013). Survey of household waste composition and quantities in Abuja, Nigeria. *Resources, Conservation and Recycling*, *77*, 52–60. https://doi.org/10.1016/j.resconrec.2013.05.011
Ojeda-Benítez, S., Vega, C. A., & Marquez-Montenegro, M. Y. (2008). Household solid waste characterization by family socioeconomic profile as unit of analysis. *Resources, Conservation and Recycling*, *52*(7), 992–999. https://doi.org/10.1016/j.resconrec.2008.03.004
Organisation for Economic Co-operation and Development [OECD]. (2014). *Greening household behaviour: Overview from the 2011 survey - Revised edition* (OECD Studies on Environmental Policy and Household Behaviour). Paris: OECD Publishing. https://doi.org/10.1787/9789264214651-en
Organisation for Economic Co-operation and Development [OECD]. (2016). Municipal waste. In *OECD factbook 2015-2016: Economic, environmental and social statistics* (pp. 142–143). Paris: OECD Publishing. https://doi.org/http://dx.doi.org/10.1787/factbook-2015-en
Organization for Security and Co-operation in Europe [OSCE]. (2009). *Gender and environment: A guide to the integration of gender aspects in the OSCE's environmental projects*. Vienna: OSCE. Retrieved from https://www.google.fi/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjms6WYjM3NAhVSSZoKHRyOBuUQFggfMAA&url=http%3A%2F%2Fwww.osce.org%2Fgender%2F36360%3Fdownload%3Dtrue&usg=AFQjCNGJii5XuGIfmDSZhZr9TP0_vIoBpA&sig2=uarPBTcQiLgYFKNpYi1lnw&bvm=bv.12580152
Oribe-Garcia, I., Kamara-Esteban, O., Martin, C., Macarulla-Arenaza, A. M., & Alonso-Vicario, A. (2015). Identification of influencing municipal characteristics regarding household waste generation and their forecasting ability in Biscay. *Waste Management*, *39*, 26–34. https://doi.org/10.1016/j.wasman.2015.02.017
Oteng-Ababio, M. (2010). Solid waste management in Ghana: Willingness-to-pay for improved services. *Ghana Journal of Geography*, *2*, 85–107.
Otitoju, T. A. (2014). Individual attitude toward recycling of municipal solid waste in Lagos, Nigeria. *American Journal of Engineering Research*, *3*(7), 78–88.
Padeco Co. Ltd., & Consultants, M. (2010). *Volume 3: Solid waste management. Nepal: Preparing the secondary towns integrated urban environmental improvement project* (Vol. 3). Asian Development Bank. Retrieved from https://www.adb.org/sites/default/files/project-document/67548/36188-01-nep-tacr-03.pdf
Padi, A., Addor, J. A., & Nunfam, V. F. (2015). An econometric model of factors influencing households' willingness to pay for improved solid waste management service within the Sekondi–Takoradi metropolis in the western

region of Ghana. *Journal of Economics and Sustainable Development*, *6*(16), 15–29.
Palanivel, T. M., & Sulaiman, H. (2014). Generation and composition of municipal solid waste (MSW) in Muscat, Sultanate of Oman. *APCBEE Procedia*, *10*, 96–102. https://doi.org/10.1016/j.apcbee.2014.10.024
Parikh, S. J., & James, B. R. (2012). Soil: The foundation of agriculture. *Nature Education Knowledge, 3*(10), 2.
Perrin, D., & Barton, J. (2001). Issues associated with transforming household attitudes and opinions into materials recovery: A review of two kerbside recycling schemes. *Resources, Conservation and Recycling*, *33*(1), 61–74. https://doi.org/10.1016/S0921-3449(01)00075-1
Pokhrel, D., & Viraraghavan, T. (2005). Municipal solid waste management in Nepal: Practices and challenges. *Waste Management*, *25*(5), 555–562. https://doi.org/10.1016/j.wasman.2005.01.020
Practical Action Nepal. (2008). *Best practices on solid waste management of Nepalese cities*. Kathmandu, Nepal: Practical Action Nepal.
Premakumara, D. G. J. (2013). *Community-based solid waste management system in Saankhu city, Nepal*.
Qu, X., Li, Z., Xie, X., Sui, Y., Yang, L., & Chen, Y. (2009). Survey of composition and generation rate of household wastes in Beijing, China. *Waste Management*, *29*(10), 2618–2624. https://doi.org/10.1016/j.wasman.2009.05.014
Ramesh, R., & SivaRam, P. (2017). *Composting kitchen waste: Basic questions and answers.* Hyderabad: National Institute of Rural Development & Panchayati Raj, Ministry of Rural Development.
Ranabhat, R. (2015). Life cycle assessment of municipal solid waste management system in Kathmandu, Nepal. *Journal of Advanced College of Engineering and Management*, *1*.
Rosato, C. (2016, 5 3). *Balancing soil using organic minerals*. Retrieved from woodleaffarm.com: https://woodleaffarm.com/enlivening-soil/
Rosen, C. J., Bierman, P. M., & Eliason, R. D. (2016). *Soil test interpretations and fertilizer management for lawns, turf, gardens and landscape plants.* Minnesota: Regents of the University of Minnesota.
Roy, A. T., & Deb, U. (2013). Households willingness to pay for improved waste management in Silchar municipal area: A case study in Cachar District, Assam. *IOSR Journal of Humanities and Social Science*, *6*(5), 21–31.
Sankoh, F. P., Yan, X., & Conteh, A. M. H. (2012). A situational assessment of socioeconomic factors affecting solid waste generation and composition in Freetown, Sierra Leone. *Journal of Environmental Protection*, *3*, 563–568. https://doi.org/10.4236/jep.2012.37067
Schall, J. (1992). *Does the solid waste management hierarchy make sense?: A technical, economic and environmental justification for the priority of source reduction and recycling*. Yale University.
Schübeler, P., Wehrle, K., & Christen, J. (1996). *Conceptual framework for municipal solid waste management in low-income countries* (No. 9). Retrieved from http://www.worldbank.org/urban/solid_wm/erm/CWG folder/conceptualframework.pdf
Senzige, J. P., Makinde, D. O., Njau, K. N., & Nkansah-Gyeke, Y. (2014). Factors influencing solid waste generation and composition in urban areas of Tanzania: The case of Dar-es-Salaam. *American Journal of Environmental Protection*, *3*(4),

172–178. https://doi.org/10.11648/j.ajep.20140304.11
Shrestha, M. E. I., Sartohadi, J., Ridwan, M. K., & Hizbaron, D. R. (2014). Converting urban waste into energy in Kathmandu Valley: Barriers and opportunities. *Journal of Environmental Protection*, *5*, 772–779. https://doi.org/10.4236/jep.2014.59079
Shrestha, S. L. (2015). *Final report on implementation of solid waste management plan in Sankhu city*.
Singh, R. K., Yabar, H., Mizunoya, T., Higano, Y., & Rakwal, R. (2014). Potential benefits of introducing integrated solid waste management approach in developing countries: A case study in Kathmandu city. *Journal of Sustainable Development*, *7*(6), 70–83. https://doi.org/10.5539/jsd.v7n6p70
Society for Environment and Economic Development Nepal [SEED Nepal]. (2009). *Baseline study report on assessment of current waste agricultural biomass management system and practices at national and local level at Madhyapur Thimi municipality*. Kathmandu, Nepal.
Solid Waste Management and Resource Mobilization Center [SWMRMC]. (2004). *A diagnostic report on state of solid waste management in municipalities of Nepal*. Kathmandu, Nepal: SWMRMC.
Solid Waste Management and Resource Mobilization Center [SWMRMC]. (2008). *Baseline study on solid waste management in municipalities of Nepal*. Kathmandu, Nepal: SWMRMC.
Solid Waste Management Technical Support Center [SWMTSC]. (1992). Solid Waste Management and Resource Mobilization Act, 1987. Retrieved October 15, 2015, from http://swmtsc.gov.np/sites/default/files/policy/SWMRMC Act, 1987.pdf
Song, Q., Wang, Z., & Li, J. (2016). Residents' attitudes and willingness to pay for solid waste management in Macau. *Procedia Environmental Sciences*, *31*, 635–643. https://doi.org/10.1016/j.proenv.2016.02.116
Soukopová, J., Struk, M., & Hřebíček, J. (2016). Population age structure and the cost of municipal waste collection. A case study from the Czech Republic. *Journal of Environmental Management*, 1–9. https://doi.org/10.1016/j.jenvman.2016.03.030
Steuteville, R. (1995). The state of garbage in America. *BioCycle*, *4*, 54–63.
Subhan, M., Ghani, A. B. A., & Joarder, M. H. R. (2014). Urban community willingness to pay for improved solid waste management in Malaysian municipality: A choice modeling approach. *Asian Social Science*, *10*(18), 122–136. https://doi.org/10.5539/ass.v10n18p122
Sujauddin, M., Huda, S. M. S., & Hoque, A. T. M. R. (2008). Household solid waste characteristics and management in Chittagong, Bangladesh. *Waste Management*, *28*(9), 1688–1695. https://doi.org/10.1016/j.wasman.2007.06.013
Sumukwo, J., Kiptui, M., & Cheserek, G. J. (2012). Economic valuation of improved solid waste management in Eldoret municipality. *Journal of Emerging Trends in Economics and Management Sciences*, *3*(6), 962–970.
Suthar, S., & Singh, P. (2015). Household solid waste generation and composition in different family size and socio-economic groups: A case study. *Sustainable Cities and Society*, *14*(1), 56–63. https://doi.org/10.1016/j.scs.2014.07.004
Tai, J., Zhang, W., Che, Y., & Feng, D. (2011). Municipal solid waste source-separated collection in China: A comparative analysis. *Waste Management*, *31*(8), 1673–1682. https://doi.org/10.1016/j.wasman.2011.03.014
Taiwo, A. M. (2011). Composting as a sustainable waste management technique in

developing countries. *Journal of Environmental Science and Technology*, *4*(2), 93–102. https://doi.org/10.3923/jest.2011.93.102
Thapa, G. B. (1998). Lessons learned from solid waste management in Kathmandu, Nepal. *Habitat International*, *22*(2), 97–114. https://doi.org/10.1016/S0197-3975(97)00030-1
The World Bank. (2016). Urban solid waste management. Retrieved July 21, 2016, from http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/EXTUSWM/0,,menuPK:463847~pagePK:149018~piPK:149093~theSitePK:463841,00.html
The World Bank. (2017). GDP (current US$). Retrieved August 7, 2017, from https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=NP&view=chart
Tonglet, M., Phillips, P. S., & Bates, M. P. (2004). Determining the drivers for householder pro-environmental behaviour: Waste minimisation compared to recycling. *Resources, Conservation and Recycling*, *42*(1), 27–48. https://doi.org/10.1016/j.resconrec.2004.02.001
Trang, P. T. T., Dong, H. Q., Toan, D. Q., Hanh, N. T. X., & Thu, N. T. (2017). The effects of socio-economic factors on household solid waste generation and composition: A case study in Thu Dau Mot, Vietnam. *Energy Procedia*, *107*, 253–258. https://doi.org/10.1016/j.egypro.2016.12.144
Tuladhar, B. (2003). *Home compost bins.* Retrieved May 6, 2016, from http://www.sswm.info/sites/default/files/reference_attachments/TULADHAR%202003%20Home%20Compost%20Bins.pdf
Tuladhar, B. (2007). *Solid Waste Management: Issues and Challenges in Asia.* Tokyo: Asian Productivity Organization.
Tuladhar, B., & Spuhler, D. (2016, 5 10). *(Co-) composting (Small-scale)*. Retrieved from Sustainable Sanitation and Water Management (SSWM): http://www.sswm.info/content/co-composting-small-scale
United Nations Environment Programme [UNEP]. (2010). *Waste and climate change: Global trends and strategy framework*. Japan: UNEP.
United Nations Environment Programme [UNEP]. (2011). Waste: Investing in energy and resource efficiency. In *Towards a green economy: Pathways to sustainable development and poverty eradication* (pp. 285–327). United Nations Environment Programme.
United States Environmental Protection Agency (EPA). (2017). Household Hazardous Waste (HHW). Retrieved September 1, 2017, from https://www.epa.gov/hw/household-hazardous-waste-hhw
United States Environmental Protection Agency [EPA]. (2002). *Solid waste management: A local challenge with global impacts*. Washington, DC, U.S.A. Retrieved from http://www.epa.gov/osw/nonhaz/municipal/pubs/ghg/f02026.pdf
Vázquez, M., & Soto, M. (2017). The efficiency of home composting programmes and compost quality. *Waste Management, 64*, 39–50.
WaterAid in Nepal. (2008). *Solid waste management in Nepal*. Nepal. Retrieved from www.wateraid.org/nepal
Whynes, D. K., Frew, E. J., & Wolstenholme, J. L. (2005). Willingness-to-pay and demand curves: A comparison of results obtained using different elicitation formats. *International Journal of Health Care Finance and Economics*, *5*(4), 369–

386. https://doi.org/10.1007/s10754-005-4014-2
Williams, R. (2015). Heteroskedasticity. Retrieved July 15, 2016, from https://www3.nd.edu/~rwilliam/stats2/l25.pdf
Wooldridge, J. M. (2012). *Introductory econometrics: A modern approach* (5th ed.). Mason, USA: Cengage Learning.
Xu, L., Lin, T., Xu, Y., Xiao, L., Ye, Z., & Cui, S. (2016). Path analysis of factors influencing household solid waste generation: A case study of Xiamen Island, China. *Journal of Material Cycles and Waste Management*, *18*(2), 377–384. https://doi.org/10.1007/s10163-014-0340-0
Xu, L., Ling, M., Lu, Y., & Shen, M. (2017). External influences on forming residents' waste separation behaviour: Evidence from households in Hangzhou, China. *Habitat International*, *63*, 21–33. https://doi.org/10.1016/j.habitatint.2017.03.009
Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). New York: Harper and Row.
Yau, Y. (2010). Domestic waste recycling, collective action and economic incentive: The case in Hong Kong. *Waste Management*, *30*(12), 2440–2447. https://doi.org/10.1016/j.wasman.2010.06.009
Zafar, S. (2015, 12 29). *Introduction to Composting*. Retrieved from EcoMENA: Echoing Sustainability: http://www.ecomena.org/tag/vermicomposting/
Zhang, H., & Wen, Z.-G. (2014). Residents' household solid waste (HSW) source separation activity: A case study of Suzhou, China. *Sustainability*, *6*(9), 6446–6466. https://doi.org/10.3390/su6096446
Zorpas, A. A., Lasaridi, K., Voukkali, I., Loizia, P., & Chroni, C. (2015). Household waste compositional analysis variation from insular communities in the framework of waste prevention strategy plans. *Waste Management*, *38*(1), 3–11. https://doi.org/10.1016/j.wasman.2015.01.030
Zurbrugg, C. (2002). *Solid waste management in developing countries*.

Appendix 1: Compost quality test report from Nepal Environmental & Scientific Services (P) Ltd.

1. Sample A:

NESS **Nepal Environmental & Scientific Services (P) Ltd.** Page 1 of 6
G.P.O. Box: 7301, Thapathali, Kathmandu, Nepal
Phone : +977-1-4244989, 4241001, Fax No.: +977-1-4226028, Email: ness@mos.com.np
http://www.nessltd.com

QS Test Report / Certificate

NS Accreditation No. Pra. 01/053-54

Entry No.	: NCL - 418(Ft) (6) - 03 - 2016	Date Received	: 03 - 03 - 2016
Sample	: Organic Fertilizer (Sample A)	Date Complete	: 17 - 03 - 2016
Client	: Bijan Maskey	Sampled By	: Client
Location	: Gorkha Municipality		

S. N.	Parameters	Test Methods	Observed Values	Nepal Standard for Organic & Bio Fertilizer Protocol, 2068 B.S.
1.	Moisture, (%)	Oven Drying, IS: 6092 Part VI	35.68	20 - 30
2.	Total Nitrogen, (%)	Modified Kzeldahl, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	2.69	1.5, min
3.	Total Phosphorous as P_2O_5 (%)	Vanadomolybdophosphoric acid, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	2.74	0.5, min
4.	Total Potassium as K_2O (%)	AAS, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	3.08	1.5, min
5.	Organic Matter, (%)	Modified Walkley & Black, USDA Agricultural Handbook 60	38.54	10 - 20
6.	C:N Ratio	Calculation	8.27	20
7.	*pH @ 21^{0}C (1:5)	Electromeric, Methods of Manure Analysis USDA	8.4	6.5 - 7.5
8.	*Cadmium, (μg/g)	Wet Digestion, AAS US EPA, 1986. Method 3050	39.28	5 - 10
9.	*Lead, (μg/g)		31.42	100, max

**: Non accreditated parameters*

Note: Except moisture the analysis was carried out in oven dried sample.
AAS - Atomic Absorption Spectrophotometer; USDA: United State Department of Agriculture; FAO: Food and Agriculture Organization; IS: Indian Standard.

***Remarks:** The observed values for moisture, organic matter, pH and cadmium were found greater than 30%, 20%, 7.5 and 10 μg/g respectively, whereas, the observed value for C:N ratio was found lesser than 20.*

(Analyzed By) (Checked By) (Authorized Signature)

Note:
1. This report/certificate is in reference to Laboratory Quality Control Manual, QS (006), section OPT.
2. The result listed refer only to the tested samples & applicable parameters. Endorsement of products is neither inferred nor implied.
3. Liability of our institute is limited to the invoiced test parameters & amount only.
4. Samples will be destroyed after one month from the date of issue of test certificate unless otherwise specified.
5. This report is not to be reproduced wholly / partially & cannot be used as an evidence in the Court of Law & should not be used in any advertizing media without our permission in writing.
6. The clients are requested to take back their hazardous samples along with the report/certificate.

2. Sample B:

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NS Accreditation No. Pra. 01/053-54

Entry No.	: NCL - 418(Ft) (6) - 03 - 2016	Date Received	: 03 - 03 - 2016
Sample	: Organic Fertilizer (Sample B)	Date Complete	: 17 - 03 - 2016
Client	: Bijan Maskey	Sampled By	: Client
Location	: Gorkha Municipality		

Accreditation No. Pra. 01/053-54

S. N.	Parameters	Test Methods	Observed Values	Nepal Standard for Organic & Bio Fertilizer Protocol, 2068 B.S.
1.	Moisture, (%)	Oven Drying, IS: 6092 Part VI	33.74	*20 - 30*
2.	Total Nitrogen, (%)	Modified Kzeldahl, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**1.47**	*1.5, min*
3.	Total Phosphorous as P_2O_5 (%)	Vanadomolybdophosphoric acid, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	0.83	*0.5, min*
4.	Total Potassium as K_2O (%)	AAS, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**1.23**	*1.5, min*
5.	Organic Matter, (%)	Modified Walkley & Black, USDA Agricultural Handbook 60	17.76	*10 - 20*
6.	C:N Ratio	Calculation	6.97	*20*
7.	*pH @ 21^0C (1:5)	Electromeric, Methods of Manure Analysis USDA	8.7	*6.5 - 7.5*
8.	*Cadmium, (µg/g)	Wet Digestion, AAS US EPA, 1986. Method 3050	35.94	*5 - 10*
9.	*Lead, (µg/g)		11.98	*100, max*

**: Non accreditated parameters*

Note: Except moisture the analysis was carried out in oven dried sample.
AAS - Atomic Absorption Spectrophotometer; USDA: United State Department of Agriculture; FAO: Food and Agriculture Organization; IS: Indian Standard.

***Remarks:** The observed values for moisture, pH and cadmium were found greater than 30%, 7.5 and 10 µg/g respectively, whereas, the observed value for C:N ratio was found lesser than 20. Similarly, the observed values of total nitrogen and total potassium as K_2O did not comply the prescribed standards for organic & bio fertilizer protocol, 2068 B.S.*

(Analyzed By) (Checked By) (Authorized Signature)

Note:
1. This report/certificate is in reference to Laboratory Quality Control Manual, QS (006), section OPT.
2. The result listed refer only to the tested samples & applicable parameters. Endorsement of products is neither inferred nor implied.
3. Liability of our institute is limited to the invoiced test parameters & amount only.
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3. Sample C:

Nepal Environmental & Scientific Services (P) Ltd.

NESS

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QS Test Report / Certificate

NS Accreditation No. Pra. 01/053-54

Entry No.	: NCL - 418(Ft) (6) - 03 - 2016	Date Received	: 03 - 03 - 2016
Sample	: Organic Fertilizer (Sample C)	Date Complete	: 17 - 03 - 2016
Client	: Bijan Maskey	Sampled By	: Client
Location	: Gorkha Municipality		

Accreditation No. Pre. 01/053-54

S. N.	Parameters	Test Methods	Observed Values	Nepal Standard for Organic & Bio Fertilizer Protocol, 2068 B.S.
1.	Moisture, (%)	Oven Drying, IS: 6092 Part VI	7.32	*20 - 30*
2.	Total Nitrogen, (%)	Modified Kzeldahl, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	2.69	*1.5, min*
3.	Total Phosphorous as P_2O_5 (%)	Vanadomolybdophosphoric acid, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	2.16	*0.5, min*
4.	Total Potassium as K_2O (%)	AAS, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**1.10**	*1.5, min*
5.	Organic Matter, (%)	Modified Walkley & Black, USDA Agricultural Handbook 60	47.54	*10 - 20*
6.	C:N Ratio	Calculation	10.20	*20*
7.	*pH @ 21^{0}C (1:5)	Electromeric, Methods of Manure Analysis USDA	8.4	*6.5 - 7.5*
8.	*Cadmium, (µg/g)	Wet Digestion, AAS US EPA, 1986. Method 3050	31.86	*5 - 10*
9.	*Lead, (µg/g)		3.98	*100, max*

**: Non accreditated parameters*

Note: Except moisture the analysis was carried out in oven dried sample.
AAS - Atomic Absorption Spectrophotometer; USDA: United State Department of Agriculture; FAO: Food and Agriculture Organization; IS: Indian Standard.

***Remarks:** The observed values for organic matter, pH and cadmium were found greater than 20%, 7.5 and 10 µg/g respectively, whereas, the observed values for moisture and C:N ratio were found lesser than 30% and 20 respectively. Similarly, the observed values of total potassium as K_2O did not comply the prescribed standards for organic & bio fertilizer protocol, 2068 B.S.*

(Analyzed By) (Checked By) (Authorized Signature)

4. Sample D:

NESS
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QS Test Report / Certificate

NS Accreditation No. Pra. 01/053-54

Entry No.	: NCL - 418(Ft) (6) - 03 - 2016	Date Received	: 03 - 03 - 2016
Sample	: Organic Fertilizer (Sample D)	Date Complete	: 17 - 03 - 2016
Client	: Bijan Maskey	Sampled By	: Client
Location	: Gorkha Municipality		

S. N.	Parameters	Test Methods	Observed Values	Nepal Standard for Organic & Bio Fertilizer Protocol, 2068 B.S.
1.	Moisture, (%)	Oven Drying, IS: 6092 Part VI	10.30	*20 - 30*
2.	Total Nitrogen, (%)	Modified Kzeldahl, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**1.00**	*1.5, min*
3.	Total Phosphorous as P_2O_5 (%)	Vanadomolybdophosphoric acid, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	1.49	*0.5, min*
4.	Total Potassium as K_2O (%)	AAS, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**0.99**	*1.5, min*
5.	Organic Matter, (%)	Modified Walkley & Black, USDA Agricultural Handbook 60	16.92	*10 - 20*
6.	C:N Ratio	Calculation	9.77	*20*
7.	*pH @ 21^{0}C (1:5)	Electromeric, Methods of Manure Analysis USDA	8.9	*6.5 - 7.5*
8.	*Cadmium, (µg/g)	Wet Digestion, AAS US EPA, 1986. Method 3050	35.94	*5 - 10*
9.	*Lead, (µg/g)		19.97	*100, max*

**: Non accreditated parameters*

Note: Except moisture the analysis was carried out in oven dried sample.
AAS - Atomic Absorption Spectrophotometer; USDA: United State Department of Agriculture; FAO: Food and Agriculture Organization; IS: Indian Standard.

***Remarks:** The observed values for pH and cadmium were found greater than 7.5 and 10 µg/g respectively, whereas, the observed values for moisture and C:N ratio were found lesser than 20% and 20 respectively. Similarly, the observed values of total nitrogen and total potassium as K_2O did not comply the prescribed standards for organic & bio fertilizer protocol, 2068 B.S.*

(Analyzed By) (Checked By) (Authorized Signature)

Note:
1. This report/certificate is in reference to Laboratory Quality Control Manual, QS (006), section OPT.
2. The result listed refer only to the tested samples & applicable parameters. Endorsement of products is neither inferred nor implied.
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5. Sample E:

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NS Accreditation No. Pra. 01/053-54

Entry No.	: NCL - 418(Ft) (6) - 03 - 2016	Date Received	: 03 - 03 - 2016
Sample	: Organic Fertilizer (Sample E)	Date Complete	: 17 - 03 - 2016
Client	: Bijan Maskey	Sampled By	: Client
Location	: Gorkha Municipality		

Accredited Laboratory — Accreditation No. Pra. 01/053-54

S. N.	Parameters	Test Methods	Observed Values	Nepal Standard for Organic & Bio Fertilizer Protocol, 2068 B.S.
1.	Moisture, (%)	Oven Drying, IS: 6092 Part VI	8.33	20 - 30
2.	Total Nitrogen, (%)	Modified Kzeldahl, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**1.31**	1.5, min
3.	Total Phosphorous as P_2O_5 (%)	Vanadomolybdophosphoric acid, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	2.24	0.5, min
4.	Total Potassium as K_2O (%)	AAS, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	**1.15**	1.5, min
5.	Organic Matter, (%)	Modified Walkley & Black, USDA Agricultural Handbook 60	32.97	10 - 20
6.	C:N Ratio	Calculation	14.53	20
7.	*pH @ 21°C (1:5)	Electromeric, Methods of Manure Analysis USDA	9.1	6.5 - 7.5
8.	*Cadmium, (µg/g)	Wet Digestion, AAS US EPA, 1986. Method 3050	27.79	5 - 10
9.	*Lead, (µg/g)		N. D.(<0.05)	100, max

*: Non accreditated parameters

N. D.: Not Detected

Note: Except moisture the analysis was carried out in oven dried sample.
AAS - Atomic Absorption Spectrophotometer; USDA: United State Department of Agriculture; FAO: Food and Agriculture Organization; IS: Indian Standard.

Remarks: The observed values for organic matter, pH and cadmium were found greater than 20% 7.5 and 10 µg/g respectively, whereas, the observed values for moisture and C:N ratio were found lesser than 20% and 20 respectively. Similarly, the observed values of total nitrogen and total potassium as K_2O did not comply the prescribed standards for organic & bio fertilizer protocol, 2068 B.S.

(Analyzed By) (Checked By) (Authorized Signature)

Note:
1. This report/certificate is in reference to Laboratory Quality Control Manual, QS (006), section OPT.
2. The result listed refer only to the tested samples & applicable parameters. Endorsement of products is neither inferred nor implied.
3. Liability of our institute is limited to the invoiced test parameters & amount only.
4. Samples will be destroyed after one month from the date of issue of test certificate unless otherwise specified.
5. This report is not to be reproduced wholly / partially & cannot be used as an evidence in the Court of Law & should not be used in any advertizing media without our permission in writing.
6. The clients are requested to take back their hazardous samples along with the report/certificate.

6. Sample F:

Nepal Environmental & Scientific Services (P) Ltd. Page 6 of 6

G.P.O. Box: 7301, Thapathali, Kathmandu, Nepal

Phone : +977-1-4244989, 4241001, Fax No.: +977-1-4226028, Email: ness@mos.com.np

http:\\www.nesspltd.com

QS Test Report / Certificate

NS Accreditation No. Pra. 01/053-54

Entry No. : NCL - 418(Ft) (6) - 03 - 2016
Sample : Organic Fertilizer (Sample F)
Client : Bijan Maskey
Location : Gorkha Municipality

Date Received : 03 - 03 - 2016
Date Complete : 17 - 03 - 2016
Sampled By : Client

Accreditation No. Pre. 01/053-54

S. N.	Parameters	Test Methods	Observed Values	Nepal Standard for Organic & Bio Fertilizer Protocol, 2068 B.S.
1.	Moisture, (%)	Oven Drying, IS: 6092 Part VI	39.47	20 - 30
2.	Total Nitrogen, (%)	Modified Kzeldahl, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	3.01	1.5, min
3.	Total Phosphorous as P_2O_5 (%)	Vanadomolybdophosphoric acid, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	2.16	0.5, min
4.	Total Potassium as K_2O (%)	AAS, FAO, Fertilizer & Plant Nutrition Bulletin No. 19	3.07	1.5, min
5.	Organic Matter, (%)	Modified Walkley & Black, USDA Agricultural Handbook 60	48.97	10 - 20
6.	C:N Ratio	Calculation	9.44	20
7.	*pH @ 21^0C (1:5)	Electromeric, Methods of Manure Analysis USDA	8.7	6.5 - 7.5
8.	*Cadmium, (μg/g)	Wet Digestion, AAS US EPA, 1986. Method 3050	11.96	5 - 10
9.	*Lead, (μg/g)		<0.05	100, max

: Non accredited parameters

Note: Except moisture the analysis was carried out in oven dried sample.
AAS - Atomic Absorption Spectrophotometer; USDA: United State Department of Agriculture; FAO: Food and Agriculture Organization; IS: Indian Standard.

***Remarks:** The observed values for moisture, organic matter, pH and cadmium were found greater than 30%, 20%, 7.5 and 10μg/g respectively, whereas, the observed value for C:N ratio was found lesser than 20.*

(Analyzed By) (Checked By) (Authorized Signature)

Note:
1. This report/certificate is in reference to Laboratory Quality Control Manual, QS (006), section OPT.
2. The result listed refer only to the tested samples & applicable parameters. Endorsement of products is neither inferred nor implied.
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6. The clients are requested to take back their hazardous samples along with the report/certificate.

Appendix 2: List of publications produced from this research

Peer-reviewed journal article published:

1. Maskey, B., & Singh, M. (2017). Households' Willingness to Pay for Improved Waste Collection Service in Gorkha Municipality of Nepal. *Environments*, *4*(4), 77. https://doi.org/10.3390/environments4040077
2. Maskey, B., & Singh, M. (2017). Household Waste Generating Factors and Composition Study for Effective Management in Gorkha Municipality of Nepal. *Journal of Sustainable Development*, *10*(6), 169–185. https://doi.org/10.5539/jsd.v10n6p169
3. Maskey, B. (2018). Determinants of Household Waste Segregation in Gorkha Municipality, Nepal. *Journal of Sustainable Development*, *11*(1), 1–12. https://doi.org/10.5539/jsd.v11n1p1