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Asia-Pacific Network for Global Change Research

Using CDM Opportunities to Mitigate the Release of Greenhouse Gases by Improving Waste Management Practices

Final report for APN project: ARCP2007-18NSY

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Final Report submitted to APN

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Overview of project work and outcomes

Non-technical summary

Improper solid waste disposal is a serious environmental problem and also a major source of GHG emission in Nepal. To address this issue, Nepal Development Research Institute (NDRI) with a financial support from the Asia Pacific Network for Global Change Research (APN) initiated a project entitled "Using CDM opportunities to mitigate the release of GHG by improving waste management practices". The project aimed to address the issue of GHG, waste recycling, CDM and capacity building together. Results from the field survey revealed that more than two thirds of the total waste generated originates from the kitchen indicating a strong potential of composting. As a part of the project activities, a five days workshop was convened in Kathmandu, Nepal during 14-20 December, 2007. Preparation of document essential for the project proposals to be submitted for CDM funding was the major focus of the event. Although composting was found a feasible option for solid waste disposal, the emission estimation indicated that there could be a barrier of scale economy for putting the individual projects under CDM framework. Similarly, the institutional capability and political willingness were additional issues identified as major bottlenecks. Bundling of the composting projects of two or more municipalities could still be considered for CDM funding.

Objectives

The main objectives of the project were:

1. to evaluate the extent of reduction of GHGs as of the improvement in waste management practices
2. to assess the opportunities under Clean Development Mechanism (CDM) framework for co-financing of waste management in the municipalities and
3. to develop a protocol of proposal templates in the form of Project Information Notes (PIN)

Amount received and number years supported

2007/08: USD 39,845 (One year)

Activity undertaken

Major project activities undertaken were

- Review of literature
- Collection of data and information from 15 municipalities of Nepal and 8 areas of Indonesia
  - Household survey to find out composition of solid waste
  - Household questionnaire survey
  - Interview with municipal authorities regarding current solid waste management practices
- Estimation of the rates of GHG emission
- Organization of workshop
  - Preparation of templates of Project Idea Notes (PIN)
- Study of show-cases which utilize solid waste for bio-gas generation and composting

Results

Key Results are given below:

- Per capita waste generation ranged from 0.12 to 0.325 kg and waste generation was found up to 65 ton per day in the municipalities
- Kitchen waste, a major contributor of organic fraction ranged from 51 to 87 % in municipalities (average 72%)
- A significant daily variation was observed during the weekends which may affect the quantity of waste available for composting.

- Annual GHG emission rates ranged from 708 ton CO_{2e} (Ilam) to 20,925 ton CO_{2e} (Biratnagar)
- Although composting was found to be a feasible option for waste disposal, scale economy could be a barrier for project implementation under CDM framework.
- PINs on the following topics were prepared during the workshop
  - Establishment and operation of a solid waste composting facility under CDM framework
  - Establishment and operation of a bio-gas plant using municipal organic waste under CDM framework
  - Establishment and operation of a solid waste recycling & composting facility under CDM framework
- Show-cases of various small scale disposal options including bio-gas plants were studied.

Relevance to APN's Science Agenda and objectives

The project envisioned to assess a feasibility study for waste management using composting technology and utilizing funds available under CDM initiative. The activity was considered relevant to APN topics in three basic ways. Firstly, the proposed activity envisioned its major focus on GHGs and climate change, and efforts to reduce the emissions. Secondly, the project linked its results to sustainable development by addressing the CDM and waste recycling themes. Capacity building and awareness aspect in specific relation to the municipal authorities and development practitioners is the third important element of the project.

Self evaluation

This project executed by NDRI was first one funded through APN. Involvement of NDRI as an institution and other staff as individuals in the project has been considered as highly productive and beneficial to the growth of both. The project has significantly and meaningfully contributed in enhancing the capacity of NDRI and involving the researchers. Nineteen out of 58 municipalities in Nepal and 8 municipalities in Indonesia participated on the project activities. They are now aware on the innovative solid waste management options and the funds available under CDM initiative. Awareness level of policy makers, municipal authorities and development practitioners was also enhanced through the project activities. The analysis and investigations indicated a need of further empirical research on a few aspects covered under this project. Inspired by the project activities, Solid Waste Management and Resource Mobilization Center (SWMRMC), an apex body in Nepal, is planning to organize a similar kind of workshop in which representatives from all 58 municipalities are expected to participate. Similarly, Public-Private Partnerships for Urban Environment (PPPUE), Nepal has initiated a baseline survey of "Exploring prospects of Clean Development Mechanism (CDM) project for Municipal Solid Waste Management (MSWM) in Nepal and preparing the information package related to it". Thus in conclusion, the achievements made by the project have been evaluated as satisfactory and helped to add a value in various aspects.

Potential for further work

This study has opened the door for the further work in various sectors. In the solid waste management sector, research studies focused on more detailed empirical findings can be initiated. Likewise, estimation of greenhouse gases can also be calculated with various scenarios. The study findings will be useful for exploring funding opportunities under CDM framework for other sectors such as biogas generation, community forest management, agriculture and micro-hydro electricity generation projects.

Publications

A few publications are in progress.

References

Acknowledgments

Project team would like to extend sincere thanks to Department of Human Ecology, the University of Tokyo; Institute of Ecology, Padjadjaran University, Indonesia; Solid Waste Management and Resource Mobilization Center (SWMRMC), Kathmandu, Nepal; Winrock International in Nepal and Biogas Sector Partnership (BSP), Nepal for their support and participation in the project activities. The contribution and support of chief executive officers and junior officers of the municipalities is also highly appreciated.

PREFACE

This technical report titled 'Using CDM Opportunities to Mitigate the Release of Greenhouse Gases by Improving Waste Management Practices' provides an overview of a research project executed by Nepal Development Research Institute (NDRI) and funded by Asia-Pacific Network for Global Change Research. The findings of the report are based on the primary and secondary information collected from selected municipalities in Nepal and Indonesia. The report also includes a few small scale show-cases which utilise the solid waste to generate bio-gas and compost fertiliser. It is expected that the report in present form will be useful for future research studies.

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Project Leader

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CHAPTER I

INTRODUCTION

1.1 Background

Nearly 15% of the population in Nepal reside in the cities. According to 2001 census, the urban population is concentrated in 58 municipalities of the country. The population in these municipalities range from close to 10,000 to 700,000. Despite such a high population pressure in the urban areas and rapid growth, municipal solid waste management is yet to be prioritised in development agenda. Previous studies have indicated that the municipal authorities collect only 42% (average of 58 municipalities) of total solid waste generated in urban areas. The collected urban waste in most of the cases are either randomly dumped in open space or disposed at a poorly engineered landfill site. In the existing landfill too there is no provision for collection and utilization of gases generated from the landfill site. Therefore, it can be said that the fate of collected or uncollected waste is anaerobic decomposition which leads to emission of greenhouse gases (GHGs).

Municipal Solid Waste (MSW) constitutes 61.95% of organic matter with an average per capita waste generation of 0.25kg/person/day (IDI, 2004). The study indicated that there is a lack of comprehensive approach to solid waste management in all the municipalities. Slow burning together with uncontrolled dumping on the rivers, hillsides and forest are the most common methods practiced for solid waste disposal.

The organic matter under anaerobically decomposing condition produces mainly methane (CH_4) and carbon dioxide (CO_2) along with insignificant quantities of other gases. Emission of methane and carbon dioxide from landfill site are considered to be one of the several anthropogenic factors that causes greenhouse gas effect and lead to global climate change. Methane has a more potential on global warming because, it has a relative effect of 21 times greater than carbon dioxide together with atmospheric residence time of over 100 years. Atmospheric methane concentration has been reported to increase at an average rate of about 1 to 2 % per year. It is estimated that methane has a total contribution of approximately 18 % towards global warming. Disposal of MSW through composting in household level is a traditional practice in Nepal. However, there are not any large scales composting facilities used for the MSW management in Nepal.

In contrast to the anaerobic decomposition of MSW, aerobic composting is a low GHG emitting process which reduces the release of GHGs and helps sequester carbon and other nutrients to the soil. During the aerobic composting process, CO_2, a lower global warming potential gas compared to the methane, is emitted into the atmosphere.

In addition to these GHG emissions, municipalities have very limited resources for MSW management. Hence, it is urgent to investigate non-traditional funding sources to tackle the problems of solid waste management in Nepal. Clean Development Mechanism (CDM) framework not only provides source of fund but also contributes to the global effort in managing the environment. With these issues in mind, this study was envisioned and a funding request was made to Asia Pacific Network (APN) for Global Change Research. The project was approved in May, 2007 and the project activities were then duly started. A description of the project activities and its outcome is explained in the subsequent chapters.

1.2 Objective of the study

This research project aimed at carrying out a feasibility study in assessing the impact of better waste management in the municipalities of Nepal through proper collection and aerobic composting.

The specific objectives of the study included the followings:

- Review, analysis and assessment of the relevant research literature on gaseous emissions from composting and anaerobic waste decomposition, and latest development on CDM framework implementation
- Collection of secondary data and information on waste characteristics, generation rates, collection and disposal, and development of a comprehensive overview of data and knowledge on waste management in the municipalities of Nepal
- Carry out a questionnaire survey in selected municipalities in Indonesia to understand the current waste management practices and potential of composting for the waste disposal
- Identification of strategically important knowledge gaps and verification of the data and information through field visits to the case study cities and interaction with the stakeholders
- Development of an analytical framework on waste management focusing on aerobic composting and identifying the system factors
- Estimation of the rate of GHGs during aerobic composting and anaerobic decomposition, and preparation of simplified estimation guidelines
- Assessment of capacities of the municipalities in project preparation and implementation through the data analysis and workshop
- Preparation of templates of Project Information Notes (PIN) describing the utilisation of funds available under CDM framework for co-financing of waste management in the municipalities. These documents are required by agencies such as Japan Carbon Finance Limited and the World Bank.

1.3 Literature review

UNFCCC (1998) stated that the Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment (called Annex 1 countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. A crucial feature of an approved CDM carbon project is that it has established that the planned reductions would not occur without the additional incentive provided by emission reductions credits, a concept known as "additionally". The CDM allows net global greenhouse gas emissions to be reduced at a much lower global cost by financing emissions reduction projects in developing countries where costs are lower than in industrialized countries. The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC). This project for mitigation of the release of methane into the atmosphere through composting of municipal solid waste will be an effort to reduce the GHGs. The emission reduction can be possible through composting or through flaring of the methane to CO_2 (a GHG with less global warming potential).

The study team reviewed various research works, magazines, journals, reports and books. Summary of some of the reviewed literature is given below.

El-Fadel et al. (2000) described the solid waste management practices in Lebanon, estimated the corresponding current and future greenhouse gas emissions from this sector, and proposed mitigation alternatives to reduce these emissions.

IDI Pvt. Ltd (2004) provides a summary of the factual information of the state of solid waste management in the 58 municipalities of Nepal which covers background information on the municipalities, waste generation and collection, treatment of solid wastes, management aspects of solid wastes and future prospects.

Alamgir et al. (2005) conducted study on integrated management and safe disposal of municipal solid waste in least developed Asian countries based on storage and separation of wastes at a source/family level, reuse and recycling, primary collection, on-site storage in a hygienic way, efficient collection and transportation, appropriate waste treatment and safe disposal of residual wastes.

Shrestha et al. (2005) mentioned that CDM is becoming a key instrument for limiting GHG emission and promoting sustainable development. The author provides illustration in estimating the baseline for various GHG emission reduction cases and project emission for various potential projects.

The IPCC Guidelines for National Greenhouse Gas Inventories methodology for estimating CH_4 emissions from SWDS 2006 is based on the First Order Decay (FOD) method. This method assumes that the degradable organic component (DOC) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are formed. If conditions are constant, the rate of CH_4 production depends solely on the amount of carbon remaining in the waste. The emission of CH_4 from waste deposited in a disposal site is highest in the first few years of deposition, and then gradually declines as the degradable carbon in the waste is consumed by the bacteria responsible for the decay.

1.4 Organization of the report

In this study, the first chapter begins by highlighting the GHG emission from anaerobic decomposition of municipal solid waste and CDM opportunities to mitigate the release of GHGs by improving waste management practices in 15 municipalities of Nepal. It further explains the relevant literatures from different authors in literature review section.

Further, the second chapter provides an overview of methodology applied in the study.

Similarly, the third chapter focuses on findings from national and international context which includes findings from household survey to know the waste composition and findings from questionnaire survey to gather information on waste generation, collection and management in the study area. The chapter also presents some examples of waste generation and composition in Indonesia. A section on this chapter is devoted to the baseline emission scenario in study area from the anaerobic decomposition of municipal solid waste for the year 2007. It also highlights the procedure to be followed to approve as CDM project. This chapter also provides the show cases of waste management by implementing biogas plant and composting in study area.

Chapter four provides the summary of key findings and conclusion drawn from the analysis of data and information.

CHAPTER II

METHODOLOGY

The major activities of study were executed during August, 2007 to October, 2008 period. Field investigation in 15 municipalities of Nepal was the major component of the study. A detailed description of the methodology followed is discussed in this chapter.

2.1 Selection of municipalities

The distribution of the municipalities as per the geography of Nepal is given on Table 2.1 which shows that the municipalities are concentrated on eastern and central development regions and in the Terai rather than the Hilly areas. Further, the number of municipalities located in the Terai region is greater than that in the hilly region. Out of 58 municipalities of Nepal, 31 municipalities are located in the Terai region and the remaining 27 municipalities are in the Hilly region. The far western development region has only 3 municipalities in the Terai region in comparison to the eastern development region with 10 municipalities. Similarly, the Hilly area in the central development region has ten municipalities whereas the same region in the mid-western development region has only two municipalities despite of its greater geographical coverage. The largest municipality in terms of covered area is Biratnagar located in Terai region and the smallest one is Amargadhi in Hilly region.

Table 2 .1 Geographical distributions of the municipalities

Development Region	Location	Municipality	Municipality selected for the study
Eastern Development Region	Terai	Damak, Inaruwa, Bhadrapur, Itahari, Siraha, Biratnagar, Rajbiraj, Lahan, Dharan, Mechinagar	Damak, Biratnagar
	Hill	Ilam, Dhankuta, Triyoga, Khandbari	Ilam
Central Development Region	Terai	Malangawa, Bharatpur, Hetauda, Janakpur, Gaur, Ratnanagar, Birgunj, Kalyaiya, Jaleshowr, Kamlamai	Bharatpur
	Hill	Panauti, Kirtipur, Madhyapur-Thimi, Bidur-Nuwakot, Banepa, Bhimeshowr, Dhulikhel, Kathmandu, Bhaktapur, Lalitpur	Madhyapur-Thimi, Bidur
West Development Region	Terai	Butwal, Kapilbastu, Ramgram, Siddharthanagar	Kapilbastu
	Hill	Putalibazar, Lekhnath, Gorkha, Vyas, Waling, Pokhara, Tansen, Baglung	Putalibazar, Baglung
Mid-western Development Region	Terai	Gularia, Nepalgunj, Tulsipur, Tribhuwannagar	Gulariya, Nepalgunj
	Hill	Birendranagar, Narayan	Birendranagar
Far-western Development Region	Terai	Mahendranagar, Dhanghadi, Tikapur	Mahendranagar
	Hill	Amargadhi, Dasharathchand, Dipayal	Amargadhi, Dipayal

Total Terai = 31; Total Hill = 27

To have a representative sampling, 15 municipalities were selected from all five development regions and the two geographical regions, i.e., hills and Terai. The selected municipalities are also shown in the table 2.1.

2.2 Collection of primary data

The number of wards in selected municipalities ranged from 9 in Ilam to 22 in Biratnagar sub-metropolitan City. In each selected municipality, four wards were selected to get the representative data, two from urban area and two from rural area. After identification of representative wards, five households with different living criteria were selected as shown in Table 2.2 and each family was supplied with two buckets, one for kitchen wastes (green colour) and second one for low degradable organic and inorganic wastes (red colour). The green-bucket waste included hay, raw vegetables, fruit barks, left over rice, left over pulses, vegetables, meat, bones and others and the red-bucket waste contained papers, plastic, metal, glass and inert materials. During the distribution of two buckets, the household's owners and family members were requested to store the wastes separately. For simplicity, a list characterizing the wastes written in Nepali was pasted on each bucket (Annex 1). The green bucket waste was daily segregated and measured according to provided data sheet. The content of red bucket was measured on the day third and day seventh or whenever found filled with wastes. In the first day of each survey in the wards, address, name of respective household owner and family size were also collected.

Table 2.2 Household categories and their selection criteria

Category of HH_S	Criteria of selection
A	Independent bungalow type of home, with at least a vehicle, ample parking space, not rented in general; at least a servant is present
B	Independent home, with at least a vehicle, few rooms of the building could be on rent
C	A building having most of rooms on rent
D	Family owning a flat on rent
E	Family staying in a flat but sharing rooms with others

2.3 Questionnaire survey

Altogether 100 structured questionnaire sheets were divided based on pre-identified strategies: 'face to face survey' and 'leave and collect'. First 80 randomly selected HHs were surveyed using the former strategy and remaining 20 sheets of questionnaire were distributed to HHs where buckets were distributed to get the data on composition, generation and daily variation of household waste using the later strategy. Then altogether 100 households were visited to collect the data. During the survey, researchers asked the respondents about the various options of managing the solid waste (Annex 2). Public opinion was also collected on the issues of managing the solid waste within the municipality with the structured questionnaire. Finally, their opinions were tabulated. Please refer Annex 2 for structured questionnaire.

Similarly, a questionnaire survey was also conducted in the municipalities (Annex 3). During the field visit, the responsible staff (engineer or head of environment section) was consulted and requested to fill the questionnaire.

2.4 Collection of secondary data

This study is based on both primary and secondary data. Secondary data and information were collected from the office of municipalities through the questionnaire (Annex 3) whereas primary data on physical composition and generation of household waste were collected through survey of 20 households of each municipality.

2.5 Interaction with stakeholders

Project team made an interaction meeting with the different stakeholders like Solid Waste Management and Resource Mobilization Centre (SWMRMC), Ministry of Local Development (MoLD), Winrock International Nepal, Biogas Sector Partnership-Nepal, Ministry of Environment, Science and Technology (MoEST), municipal authorities and UN-Habitat on the issues of CDM in municipal solid waste management. During the interaction meeting with the stakeholders it was emphasized that funds available under CDM initiative should be utilized in municipal solid waste management. The stakeholders were also oriented and informed about the emerging new concept of utilisation of globally available funds for local initiatives in Nepal.

2.6 Organization of a workshop

NDRI arranged a workshop titled "Municipal Solid Waste Management: Prospects for Innovative Options and Financing" during January 14, 2008 to January 18, 2008 in Kathmandu. The objective of the workshop was to offer a forum for the concerned stakeholders. In addition, brainstorming on the documentation essential for project proposals to be submitted for CDM funding was also the major focus of the event. More than 70 participants representing government authorities, municipalities, international institutions, private sectors, academic institutions and national and international non-governmental organizations attended the first day of the event. Refer Annex 4, Annex 5 and Annex 6 for list of participants, program schedule and presentation slides respectively.

The first day of the workshop on 14th Jan, 2008 started with the opening ceremony followed by the technical sessions. During the opening ceremony Dr. Tara Nidhi Bhattarai, President of NDRI served as a chairman and delivered a welcome address on behalf of NDRI. Dr. Nawa Raj Khatiwada, Executive Director of NDRI and Team Leader of the project made an informative presentation regarding the workshop. The workshop was inaugurated by Hon'able Mr. Rama Kanta Gauro, Member of National Planning Commission (NPC) who also delivered inaugural address. The opening ceremony continued with the keynote address by keynote speaker Mr. Suman Basnet, Director, Winrock International Nepal. The presentation was followed by the floor discussion and closing of the session. Ms. Sriju Sharma, Research Associate of NDRI served as a Master of Ceremony throughout the workshop.

There were two technical sessions in the first day and a total of 4 papers were presented. Speakers of the first session were Mr. Saroj Rai, Executive Director, Biogas Sector Partnership-Nepal and Prof. Muhammed Alamgir, Khulna University of Engineering and Technology (KUET), Bangladesh. The session was chaired by Prof. Bishal Nath Upreti, Dean, Institute of Science and Technolgy (IOST), Kirtipur and co-chaired by Dr. Punya Prasad Regmi, Program Coordinator, NDRI. Similarly, Dr. Sunardi, Institute of Ecology, Padjadjaran University, Indonesia and Mr. Mahesh Babu, IL&FS Ecosmart Limited, Chanakyapuri, New Dehli made their deliberations during the second technical session. Each technical session was followed by a floor discussion. Many participants expressed their views and provided a feedback during the discussion.

One technical session and a panel discussion were also organized on second day of the workshop on 15 Jan, 2008. Mr. Niwas Chandra Shrestha, General Manager of SWMRMC, Ministry of Local Development served as a session chair and Dr. Nawa Raj Khatiwada, Executive Director NDRI served as a session co-chair. Speakers included Mr. Vinod Sharma, Research Associate, NDRI and Dr. Ai Hiramatsu, University of Tokyo, Japan. There was a panel discussion in the second half of the day in which Mr. Dinesh Raj Manandhar, Managing Director,D-Net served as a moderator and the panelists included Prof. Muhammed Alamgir, Dr. Sanjay Nath Khanal, Kathmandu University and Mr. Surya Man Shakya, Director, School of Environmental Management and Sustainable Development (SchEMS).

Participants of the workshop enjoyed the field trip on the third day of the workshop. In the morning, they visited Okharpauwa landfill site and in the afternoon they visited premises of a private operator of solid waste collection and disposal in Koteshwor and a community composting plant in Thimi.

Fourth day started with the presentation by Mr. Prem Sagar Subedi, Micro Finance Specialist, Winrock International Nepal. Then there was a group formation and group discussion about the Project Idea Notes (PIN) among the participants

In the final day of the workshop, there was a presentation on the outcomes of each group. The workshop concluded with the closing ceremony. Dr. Punya Prasad Regmi, NDRI was chairman for the ceremony. Dr. Nawa Raj Khatiwada gave brief overview of the workshop. Mr. Prem Raj Joshi, Executive Ofiicer, Bharatpur Municipality, delivered a speech representing all participants of the workshop. Ms. Meena Khanal, Joint Secretary, Ministry of Environment, Science and Technology (MoEST) and Mr. Bishnu Nath Sharma, Joint Secretary, Ministry of Local Development (MoLD) also made their deliberations during the closing ceremony. Finally the program concluded with certificate distribution to the participants by our guests and closing remarks by Dr. Punya Prasad Regmi, Coordinator of NDRI.

2.7 Desk analysis and report writing

Field study and desk analysis were performed to visualize the solid waste management issues. Literatures and research papers were reviewed in a team to extract major information and methodologies relevant to the study objectives. Collected primary and secondary data were analyzed by using MS Excel. Information and findings from Indonesia and Japan were also analysed and included in the report. In addition to this, workshop was organized in Kathmandu, Nepal by inviting municipal authorities in order to brainstorm on the solid waste issues, the estimation of baseline GHG emission and CDM initiative for waste management.

CHAPTER III

RESULTS AND DISCUSSION

3.1 Current status of solid waste management

3.1.1 General

Population and households: The lowest and the highest population in the selected municipalities were 16,246 in Ilam and 166,674 in Biratnagar which is shown in the Table 3.1. Similarly, table 3.1 shows that there is no correlation between covered area and population. Municipalities like Nepalgunj, Biratnagar and Madhyapur Thimi have high population density. Where as the municipalities like Amargadhi, Ilam, Baglung and Putalibazzar have low population density. The highest and the lowest population density are found in Nepalgunj with 51.67 persons per hectare in Nepalgunj and of 1.61 persons per hectare in Amargadhi respectively. Similarly, the household size was observed to be lowest for Baglung with 4.3 persons while it was the highest in Bharatpur with 7.65 persons per house.

Table 3.1: Background information

Municipality	No. of wards	Total covered area (ha)	Total Population	No. of Households (HHs)	HH Size	Population density (Pers./ha)
Amargadhi	11	13,895	22,378	3,976	5.63	1.61
Baglung	11	1,923	20,852	4,847	4.30	10.84
Bharatpur	14	7,500	130,000	17,000	7.65	17.33
Bidur	11	3,455	22,273	4,234	5.26	6.45
Biratnagar	22	5,990	166,674	33,678	4.95	27.83
Birendranagar	12	3,600	31,694	7,335	4.32	8.80
Damak	19	7,513	58,590	9,039	6.48	7.80
Dipayal Silugadhi	14	7,390	24,013	4,637	5.18	3.25
Gulariya	14	9,119	48,875	8,622	5.67	5.36
Ilam	9	2,700	16,246	3,231	5.03	6.02
Kapilvastu	14	3,083	37,385	5,365	6.97	12.13
Madhyapur-Thimi	17	1,147	47,751	10,051	4.75	41.63
Mahendranagar	19	19,640	80,839	13,738	5.88	4.12
Nepalgunj	17	1,314	67,891	10,565	6.43	51.67
Putalibazar	13	7,014	30,000	6,675	4.49	4.28

In terms of total number of households the highest of 33,678 are observed in Biratnagar followed by 17,000 in Bharatpur. Ilam Municipality has the lowest household number 3,231. Biratnagar constitutes 23.55% of total households in all of the municipalities followed by Bharatpur with 11.89%, while Ilam has the lowest 2.26% percentage share of total households among the municipalities.

Non-domestic sectors: The non domestic sector also plays a significant role in waste generation. The Table 3.2 below shows the number of non-domestic sector in study area. Commercial sector comprises of hotels, lodges, restaurants and shops, institutional sector includes schools, colleges, governmental and nongovernmental offices and industrial sector includes big, small and cottage industries. Special waste arises from different places such as hospital, clinic, and slaughter house.

Table 3.2: The number of non-domestic sector in study area

Municipality	Commercial	Institutional	Industrial	Special waste		Construction /demolition
				Hospitals / Clinics / Laboritories	Slaughter house	
Amarghadhi	474	168	25	2	1	60
Baglung	2225	100	193	49	NA	140
Bharatpur	4956	98	375	138	NA	100
Bidur	1088	26	103	118	3	150
Biratnagar	NA	NA	NA	NA	NA	NA
Birendranagar	1228	238	72	36	1	100
Damak	1720	44	236	NA	NA	100
Dipayal	230	29	64	17	NA	150
Gularia	NA	40	NA	17	NA	85
Ilam	NA	NA	NA	NA	NA	NA
Kapilvastu	1095	71	180	2	NA	140
Madhyapur-Thimi	NA	NA	NA	NA	NA	NA
Mahendranagar	2081	265	369	46	NA	855
Nepalgunj	NA	69	NA	NA	3	NA
Putalibazaar	1459	124	410	3	NA	30

Coverage and built-up area: Mahendranagar covers the largest area (19,640 ha) with its 19 wards followed by Amargadhi (13,895 ha) with 11 wards. However Madhyapur Thimi (1147 ha), and Nepalgunj (1314 ha) both with 17 wards, are two small municipalities. The average built-up area of all municipalities studied is 6352 ha. There is a significant difference between the built-up area occupied by the municipalities and the number of wards contained. Biratnagar has built up area of 5,990 ha with 22 wards whereas Amargadhi with only 11 wards consists of 13895 ha of built-up area. This indicates a high variation in population density among the study sites. Though there are 17 wards, the area covered by the municipalities is very less in Madhyapur Thimi (1,147 ha) and Nepalgunj (1,314ha) and the average ward numbers are 14.

Urban versus rural area: Study on the number of wards and the population density of the municipalities found higher number of rural wards. For example, Birendranagar municipality has only one urban ward with the rest 11 falling in rural section. However, in contrast to this Bidur, Biratnagar, Nepalgunj and Putalibazaar municipalities have a higher number of urban wards in their territory. Biratnagar sub-metropolitan city has the largest part in urban area in comparison to the other municipalities studied.

3.1.2 Findings from household survey

The waste generation and collection practices, characteristics of municipal solid waste was found by conducting household survey which is described in the following section.

Waste generation and collection: Figure 3.1 shows the waste generation and collection obtained by household survey in the study areas. A survey on per-capita household waste generation conducted in 20 households in each case study municipality gives an average household waste generation rate of 0.166 kg/person/day. The representative households in each municipality were selected mainly based on various socio-economic criteria and household size. As per survey results, the per-capita household waste generation rate was ranged from 0.108 kg/day (Mahendranagar) 0.325 kg/day (Biratnagar).

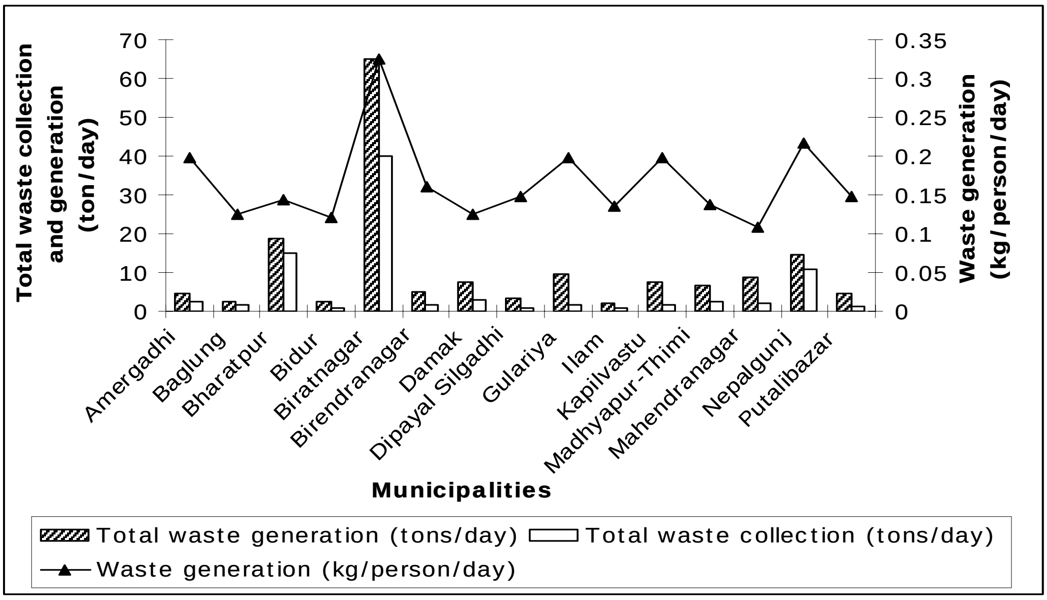

Figure 3.1: Waste generation and collection

It is remarkable that the households surveyed in some of the municipalities such as Mahendranagar, Bidur, Damak and Baglung were found to reuse most of the kitchen waste generated for different purposes, e.g. feeding the pigs, pigeons, cattle etc. thus resulting in lower waste generation rate compared to the municipality average.

Based on this per-capita waste generation rate and estimated population for the year 2001, the total municipal waste generation and the current collection coverage achieved by municipal service in each case study municipality has been calculated and represented. Regarding the collection coverage, it was higher for the Bharatpur (80%) and Nepalgunj (75%) municipalities and lower for the municipalities like Gularia, Kapilbastu and Mahendranagar with the collection coverage of 16%, 20 % and 23% of the total waste generated respectively. The average collection coverage from fifteen municipalities was found to be low which is 42%.

Physical composition of household waste

Physical analysis of waste sample collected from the households during the survey was carried out to determine the composition of waste. The average values for different waste fraction in terms of percentage composition by wet weight were obtained. Average physical composition in case study municipalities revealed three major waste components i.e. kitchen (green bucket), recyclable and inert (red bucket) is shown in the Figure 3.2.

The three major waste components (i.e. kitchen, recyclable and inert) play a vital role in treatment and recycling/resource recovery of solid waste management. Kitchen waste is comprised of organic materials and therefore has a significant potential to produce compost fertiliser. The fraction of kitchen waste varied from 51% (Amargadhi) to about 87% (Nepalgunj), with an average value of about 72% in the study area. It shows that household waste of studied municipalities, in general is qualitatively viable for producing compost.

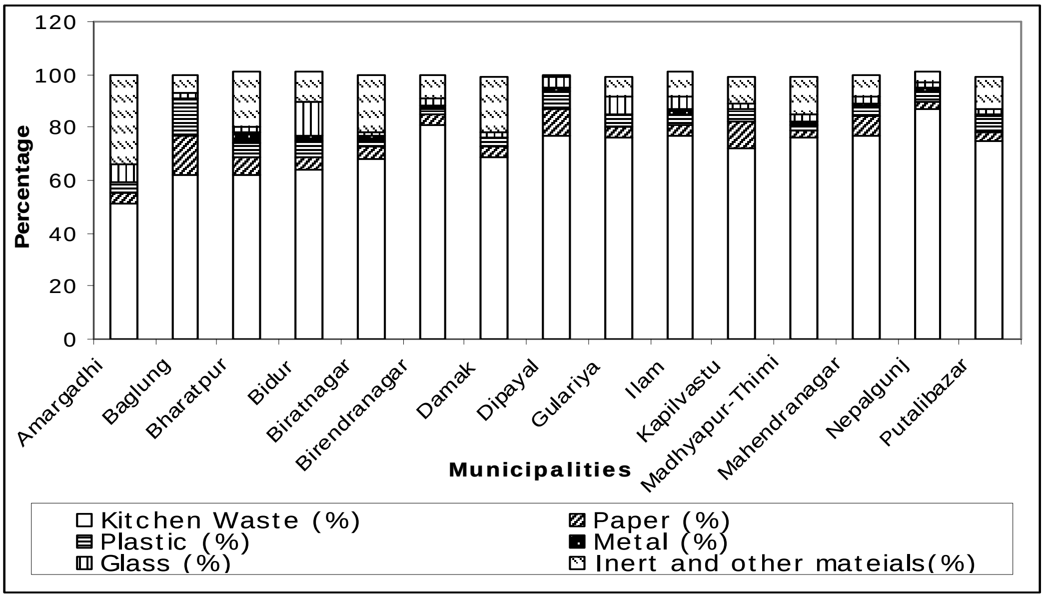

Figure 3.2: Physical composition of household waste in study area

The content of recyclable materials (i.e. paper) varies from 3 % (Nepalgunj, Putalibazar) to 15 % (Baglung), with an average value of 6 %. As far as the plastic waste is concerned, it has created a major waste disposal problem in each municipality studied. The content of plastic materials ranged from 2% (Biratnagar, Birendranagar and Madhyapur) to 14 % (Baglung), with an average value of 5% and metal and glass had an average value of 1% and 4 % respectively. This shows that endorsement of waste recycling activity may act as an important measure for the minimization of waste problems.

Municipal solid waste disposal

Comprehensive approach to solid waste management in case study municipalities was almost absent. Inappropriate types of disposal methods were being practiced in most of the municipalities. Slow burning and uncontrolled dumping on river, hillsides and forests or improperly planned and temporarily developed disposal sites were the common methods practiced for solid waste disposal. It was observed that the Kapilbastu Municipality had the largest disposal area (1.35 hectare) followed by Putalibazar (1.3 hectare). The Biratnagar sub-metropolitan city, Damak and Kapilbastu municipality had its disposal sites at the bank of Shingiya, Ratuwa and Jamuhar rivers respectively whereas Ilam, Bidur, Madhyapur- Thimi, Bharatpur, Baglung, Putalibazar, Birendranagar, Nepalgunj, Gulariya, Dipayal-Silgadhi, Amarghadi and Mahendranagar municipalities found to use the temporary open pile system for the disposal of solid waste as shown in Table 3.3. It was interesting to note that collected waste was being dumped at the premises of Mahendranagar municipality office.

It was found that the selected municipalities neither have appropriate landfill site nor engineered incineration facilities. Open burning of municipal solid waste was found as a common practice in the centre of city at Mahendranagar and Madhyapur-Thimi municipalities. In most of the municipalities, a state of conflict on many SWM issues was noticed between local people and municipal authorities. In some cases political interference regarding the disposal of waste was also observed. This shows that there is lack of appropriate waste management technique in the study area.

Table 3.3: Municipal Solid Waste Disposals

Municipality	Disposal site
Amargadhi	Temporary open pile, Ward no 8 (Kueli)
Baglung	Public land (temporary)
Bharatpur	Temporary open piles
Bidur	Temporary open piles
Biratnagar	River side (Shingiya river)
Birendranagar	Temporary open piles, riverside, (temporary)
Damak	Ratuwa River side
Dipayal Silgadhi	Temporary open piles, road/stream side
Gulariya	Temporary open piles
Ilam	Temporary open piles
Kapilvastu	Jamuhar Khola
Madhyapur-Thimi	Temporary pile, open spaces (ward no 8,1)
Mahendranagar	Temporary open piles
Nepaljung	Temporary open piles, (ward no 10,17 Bulbulia)
Putalibazar	Temporary open piles

Resource allocation: A comparison was made between the quantities of waste generated per unit area and the hectare of land served per staff members of the municipality. Area of land served per staff members was observed to be higher in Amarghadi, Dipayal Silgadi, Putalibazar and Gulariya. However, when comparing the total quantity of waste generated from the municipality and the area of land served by a staff member a relatively less man power was observed in Mahendranagar and Gulariya.

A comparison of annual budget allocated for MSW management in the municipalities was made and shown in Table.3.4. Biratnagar was found to have an annual budget of NRs. 10 million which was the highest among the selected municipalities. Whereas, Bidur municipality had the lowest annual budget allocated Rs 2,50000. Similarly, by analysing the amount of budget allocated per kg of waste generated, the highest of Rs 18 was for Ilam municipality and the lowest of Rs 0.17 was allocated for Gulariya which is shown in Figure3.3

Table 3.4: Budget allocation for solid waste management in study area

Municipality	Staff in SWM	Budget for SWM (NRs in million)
Amargadhi	8	0.6
Baglung	14	1.392
Bharatpur	62	5
Bidur Municipality	16	0.25
Biratnagar Sub-Metropolitan City	114	10
Birendranagar	14	3.266
Damak	30	1.098
Dipayal Silgadhi	11	0.325
Gulariya	10	0.6
Ilam	16	15
Kapilvastu	16	1
Madhyapur-Thimi	20	1.6
Mahendranagar	27	2
Nepalgunj	103	2.75
Putalibazar	10	8

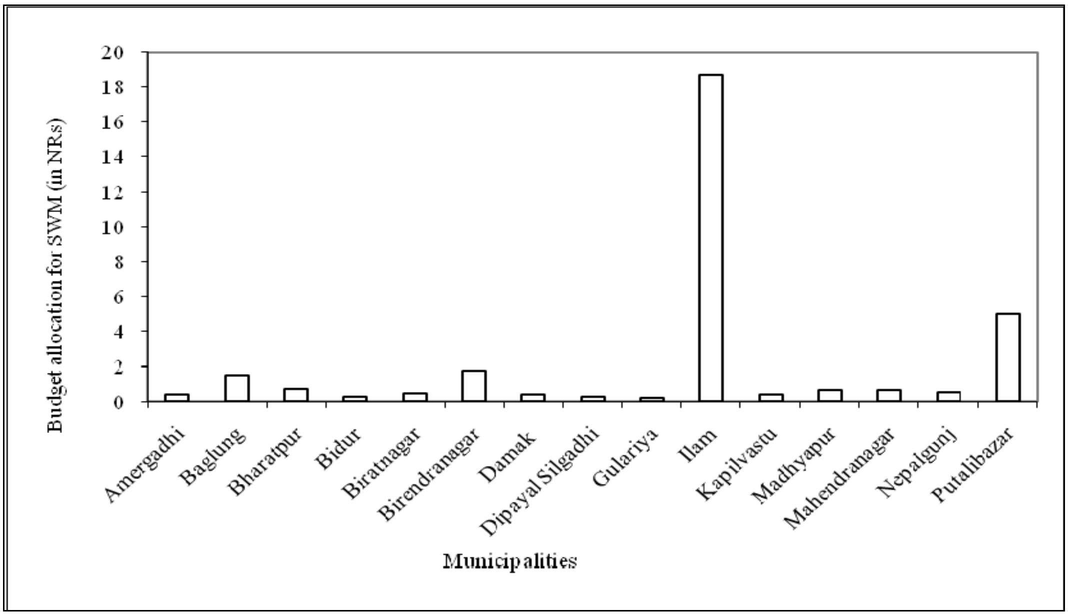

Figure 3.3: Budget allocated per kg of waste management generated

Problems identified during survey

The municipalities studied reported that they are facing many complications and difficulties at both managerial and implementation level to achieve their goal of solid waste management.

Table 3.5: Problem identified for solid waste management

Environmental	Financial	Social	Technical	Institutional
-Bad odours in disposal site	-Lack of budget	-Lack of awareness of resource reuse, reduce and recycle -Rapid urban growth	-Lack of adequate equipment/ vehicles/technology. -Lack of permanent dumping or sanitary landfill site -Lack of transfer station	-Necessity of strengthening of public private partnership -Lack of skilled and trained manpower -Increased dependency on others -Lack of physical Infrastructure -Lack of separate unit for waste management -Absence of monitoring in solid waste management activities

In the recent years, the management problems are becoming complicated and their magnitudes have been increased by many folds. The haphazard disposal of solid waste in densely populated areas, environmentally sensitive areas, riverbanks and heritage sites has resulted many adverse impacts on the public health and environment which puts a negative externality in anticipated improvement on the quality of life of people. Most common and frequently cited problems of the solid waste management in the municipalities are listed in the table 3.5.

3.1.3 Institutional arrangement

Organizational structure: Most waste management units in the selected municipalities were found under the Planning/Urban Development Section or Community Welfare Section of the municipalities. All solid waste management activities within the municipalities are executed and supervised by non-technical officer or staff. MSW management is an essential service for public health and even tourism therefore it would be desirable for all municipalities to have a separate unit to deal with SWM related issues. In smaller municipalities, this can be incorporated as a part of the Community Welfare or Urban Development Section. However, in the larger cities, this should be a separate entity in itself because of the two basic reasons, handling of large quantity of the wastes including inorganic and hazardous wastes and the requirement of non-governmental management including commercial and enterprenual intervention.

Resource allocation for solid waste management: Solid Waste management is a difficult task for all municipalities therefore it requires use of substantial human and financial resources. However, mostly because of financial constraints, municipalities are not able to provide adequate as well as efficient services. Furthermore, due to technical and managerial inefficiencies, the available resources are often utilized ineffectively. The quantity and type of financial as well as human resources allocated for waste management practices vary distinctly from municipality to municipality. Table 3.6 shows human resources in waste management of the case study municipalities. For instance, municipalities such as Amargadhi, Gulariya, Putalibazar and Dipayal Silgadhi have only 8 to 11 solid waste management staffs but large cities like Biratnagar and Nepalgunj have 114 and 103 SWM staffs involved. In terms of resource intensity or number of people served per SWM staff, municipalities like Biratnagar and Nepalgunj have one SWM staff for serving 1,462 and 659 people respectively. However, Gulariya, Putalibazar and Amargadhi have one SWM staff serving 4,887, 3,000 and 2,800 people respectively

Table 3.6: Human resources in waste management

Municipality	SWM Staff	Person served per staff
Amargadhi	8	2797
Baglung	14	1489
Bharatpur	62	2096
Bidur	16	1392
Biratnagar sub-metropolitan city	114	1462
Birendranagar	14	2263
Damak	30	1953
Dipayal Silgadhi	11	2183
Gulariya	10	4887
Ilam	16	1015
Kapilbastu	16	2336
Madhyapur- Thimi	20	2387
Mahendranagar	27	2994
Nepalganj	103	659
Putalibazar	10	3000

3.1.4 Findings from household questionnaire survey

Waste collection practice: Regarding the waste collection practices, figure 3.4 shows that more than 50% of the residents at Kapilvastu were found to collect their waste in open places. Majority (about 30%) of the respondents in Amargadhi, Birendranagar, Dipayal, Gulariya, Mahendaranagar and Nepalgunj were found to follow similar waste collection practice. More than 30% of the respondents, except Mahendranagar and Putalibazar, collect their waste in container. The waste collection in container was found to be higher (more than 50%) in Baglung, Bidur, Biratnagar and Madhyapur-Thimi. Further, the percentage of respondents collecting their waste in plastic bags ranged from less than 5% in Kapilvastu to more than 50% in Putalibazar.

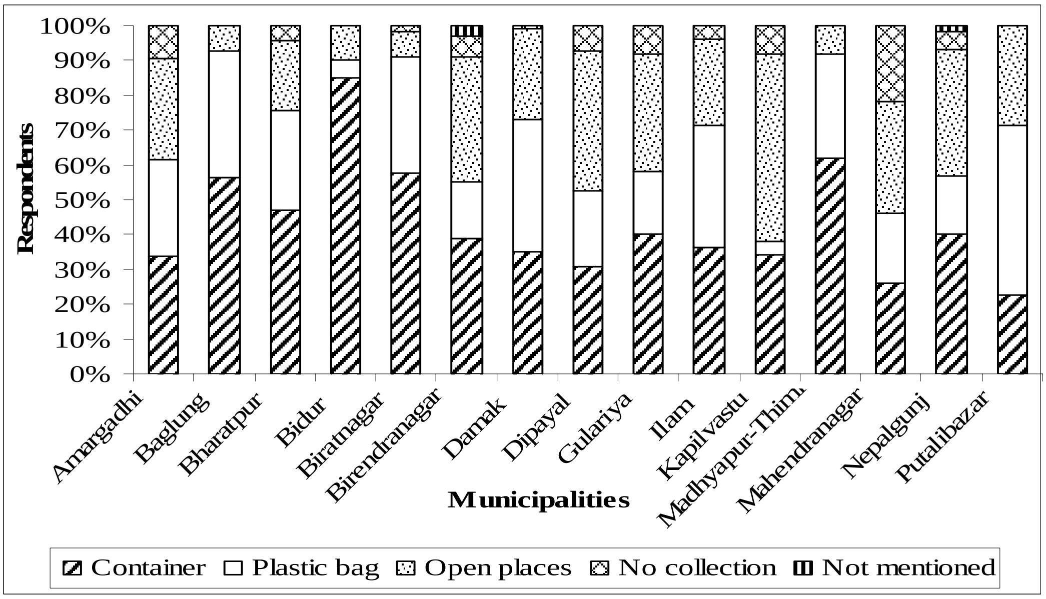

Figure 3.4: Waste collection practice

Container type for waste collection in home: The plastic dustbin was the most preferred in study area. Baglung had 90% of waste collection in plastic dustbin (Figure 3.5).

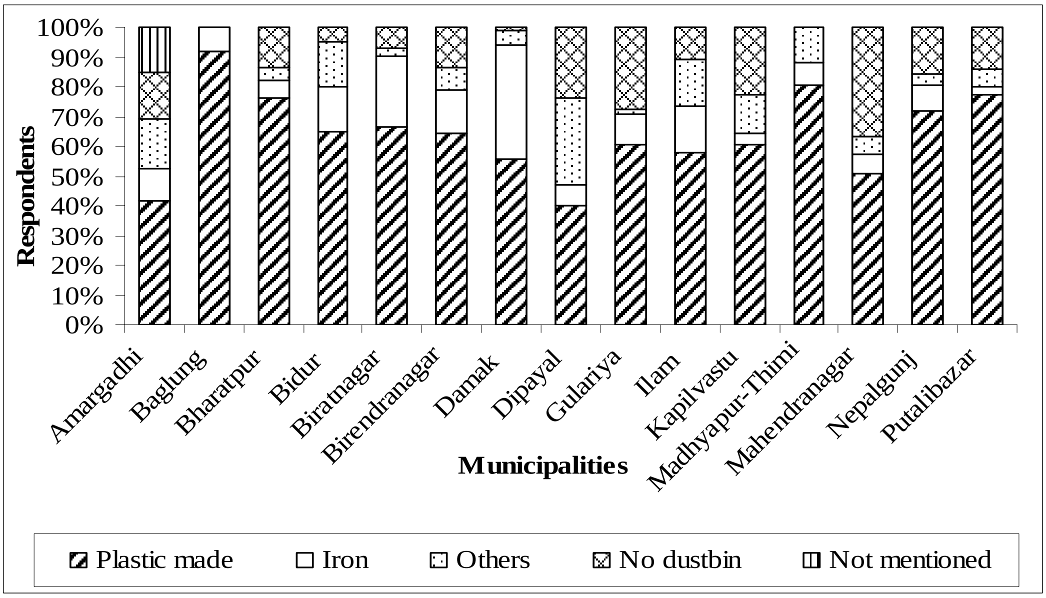

Figure 3.5: Container type for waste collection in home

Price of the waste container used: Figure 3.6 shows the price of the waste container used in study area. About 45% of the respondents in Bidur were paying more than NRs. 100 per dustbin. Most of the respondents were paying less than NRs. 50 ranging, from 25% in Amargadhi to 85% in Baglung.

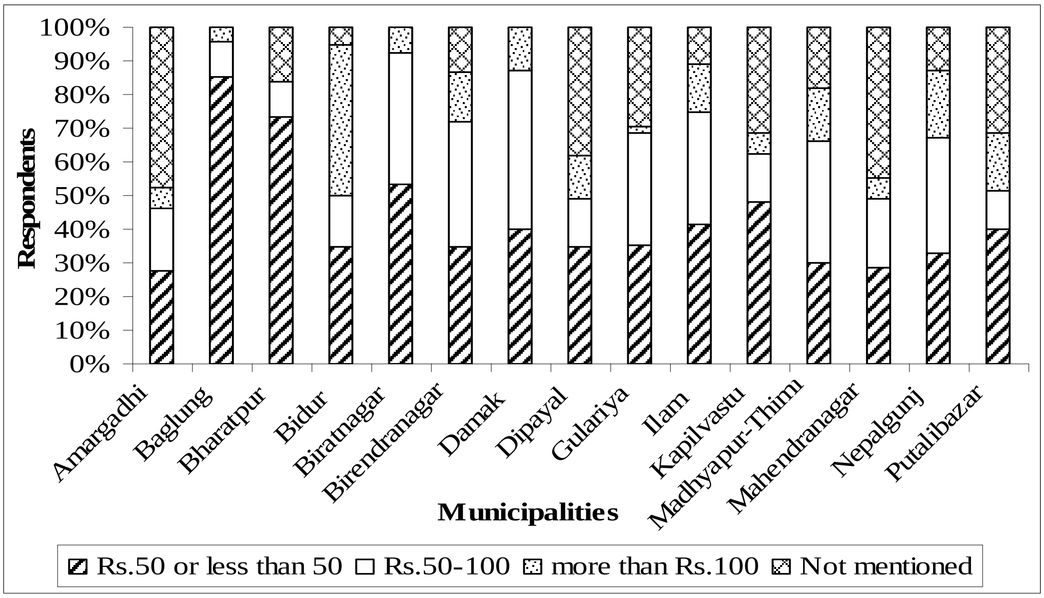

Figure 3.6: Price of the waste container used

Waste segregation at home: In 12 municipalities, most of the respondents accepted that their current practice was to mix all kinds of wastes for disposal. Among them, Bidur municipality had the highest of response (90%). The other 3 municipalities; Biratnagar, Bharatpur and Ilam had 60, 65 and 65 % response about segregating their wastes before disposal (Figure 3.7). Amongst the reusable materials such as beverage bottles and old utensils, most of the households in all the 15 municipalities responded to sell it, highest in Bharatpur with almost 80% response as shown in the Figure 3.7. While in Bidur and Baglung, a larger section (60% & 68%) of the people were disposing them together with other wastes.

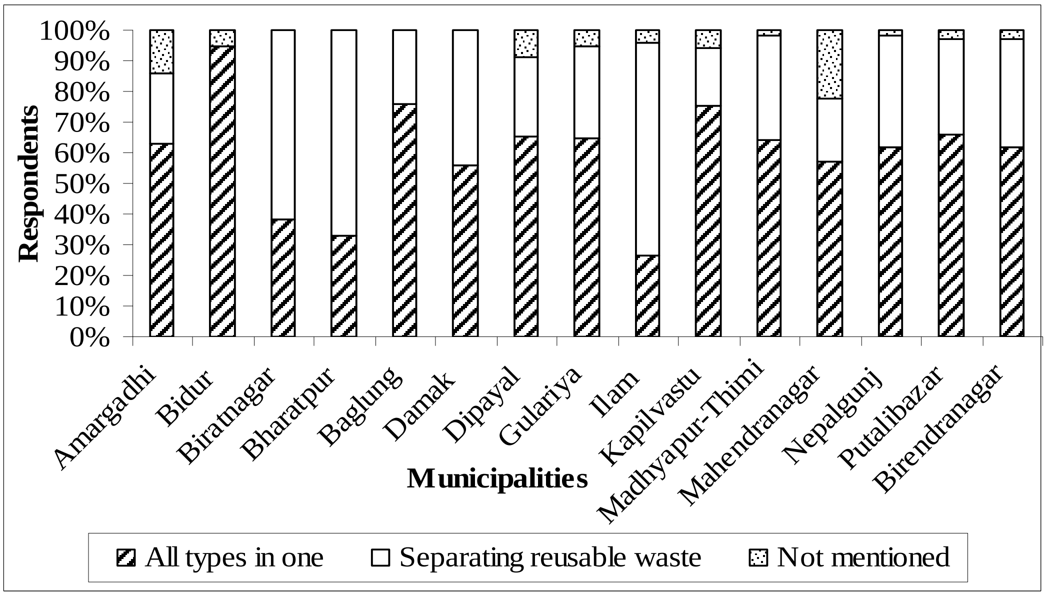

Figure 3.7: Waste segregation at home

Methods for disposing used utensils and bottles: A larger portion of the respondents in all the case study municipalities answered that they do not segregate plastic materials before dumping their waste. Similarly, respondents mentioned that it ranged from a maximum of 100% in Baglung to a minimum of 60% in Ilam (Figure 3.8). There were also small percentage of people who mixed the plastic wastes with the sewage and this amount was 10% in Biratnagar, Ilam and Birendranagar.

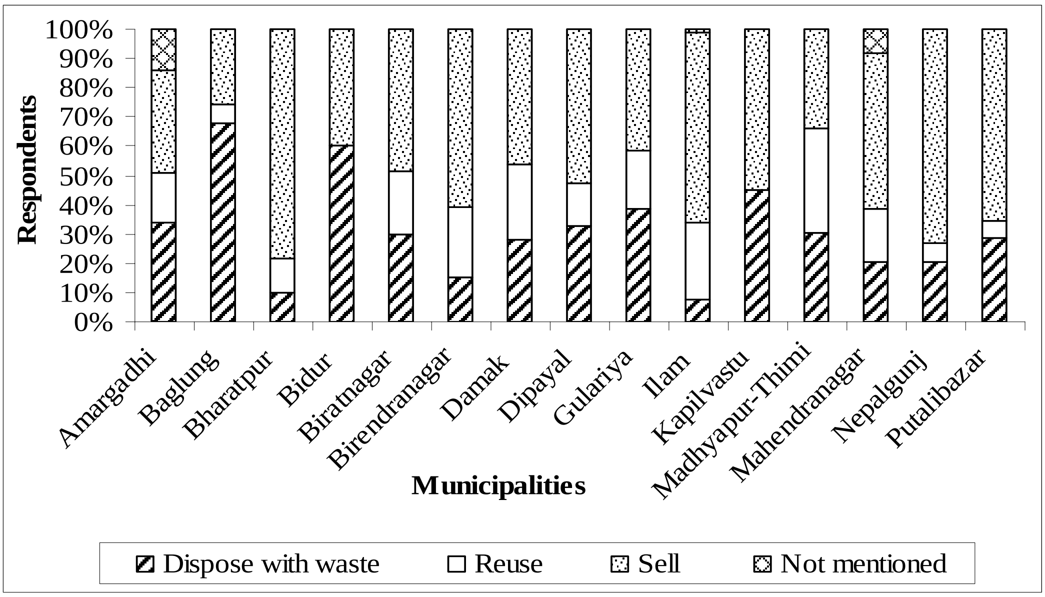

Figure 3.8: Methods for disposing used utensils and bottles

Fate of used plastics: Figure 3.9 shows that people in Bharatpur and Baglung, 65% and 55% of people stored the waste in plastic bags and rest of the municipalities stored waste directly in dustbins varying from 80% in Bidur to 30% in Amargadhi .

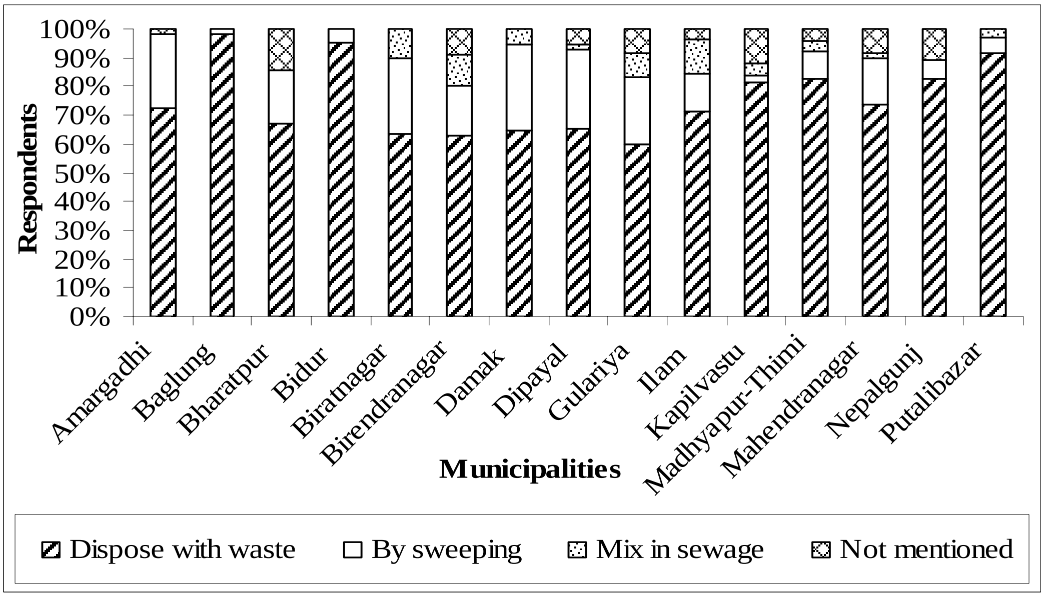

Figure 3.9: Fate of used plastics

Methods for storing wastes: Disposal of waste batteries along with other waste was found to be greater in number in all the municipalities except in Biratnagar, Bharatpur, Ilam and Nepalgunj. The mixing practice ranged from 100% in Bidur to approximately 50% in Amargadhi, Gulariya, Dipayal and Birendranagar (Figure 3.10). Ilam had the highest response 50% about selling the used batteries while Baglung had only about 10%.

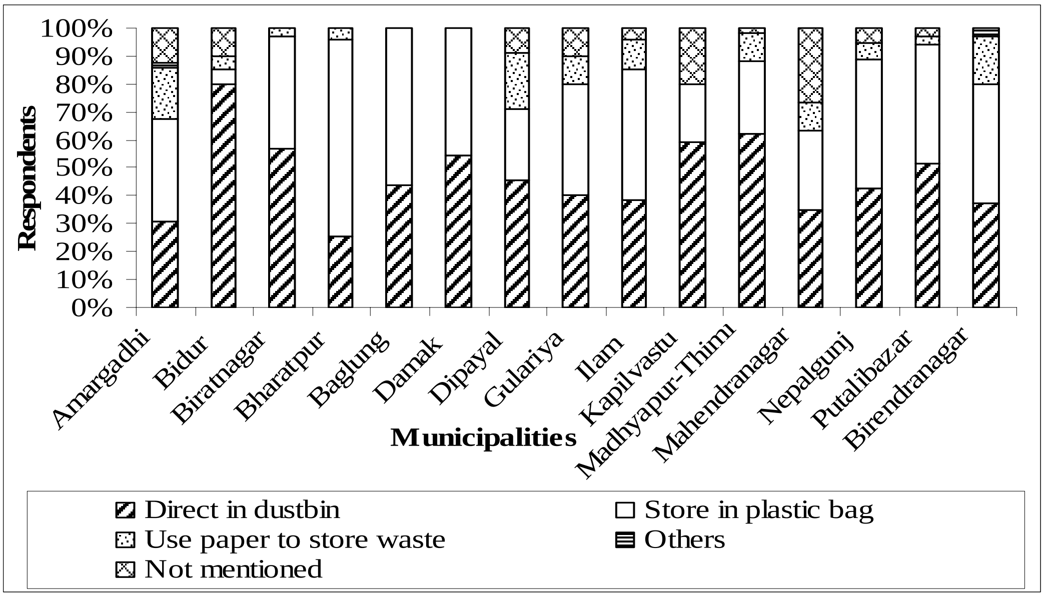

Figure 3.10: Methods for storing wastes

Methods of disposing waste batteries and bottles: Majority of the respondents in all the case study municipalities were found to dispose waste batteries and bottles along with the waste (Figure 3.11). The situation was nearly 50% or more in all study area except Bharatpur, Biratnagar, Ilam and Nepalgunj. The respondents who disposed separately ranged from less than 10% in Putalibazar to 50% in Bharatpur. The respondents making money out of the waste ranged form about 10% in Baglung to about 45% in Ilam.

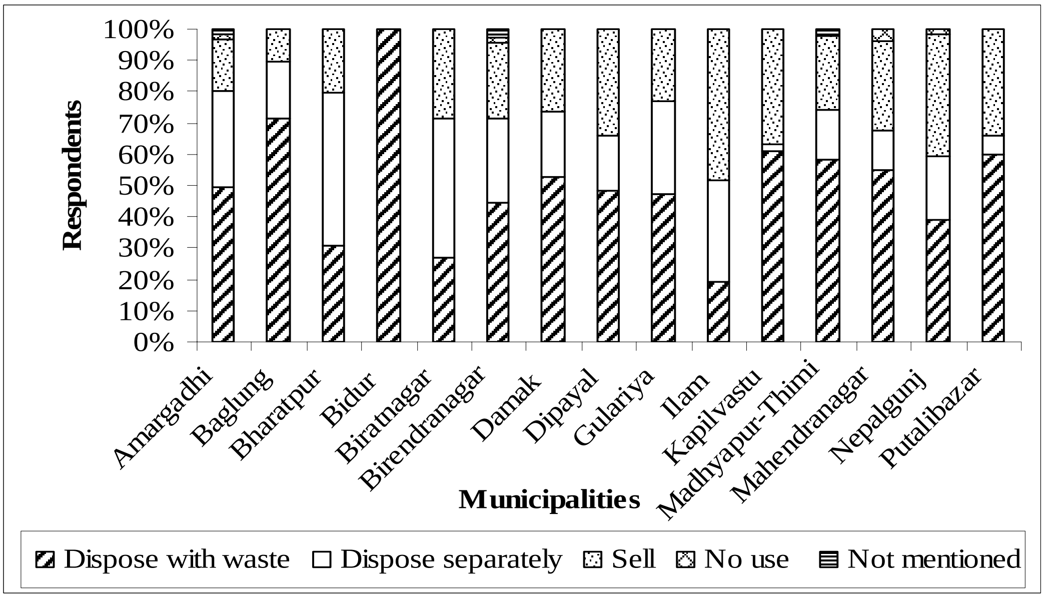

Figure 3.11: Methods of disposing waste batteries and bottles

Type of dustbin preferred: In11 municipalities(except Bidur, Damak, Dipayal and Ilam), higher preference (80% in Madhyapur to 40% in Amargadhi) was given to a round shaped dustbin(Figure 3.12). About (65%) in Bidur preferred an iron dustbin while in Damak 45% of people preferred rectangular one.

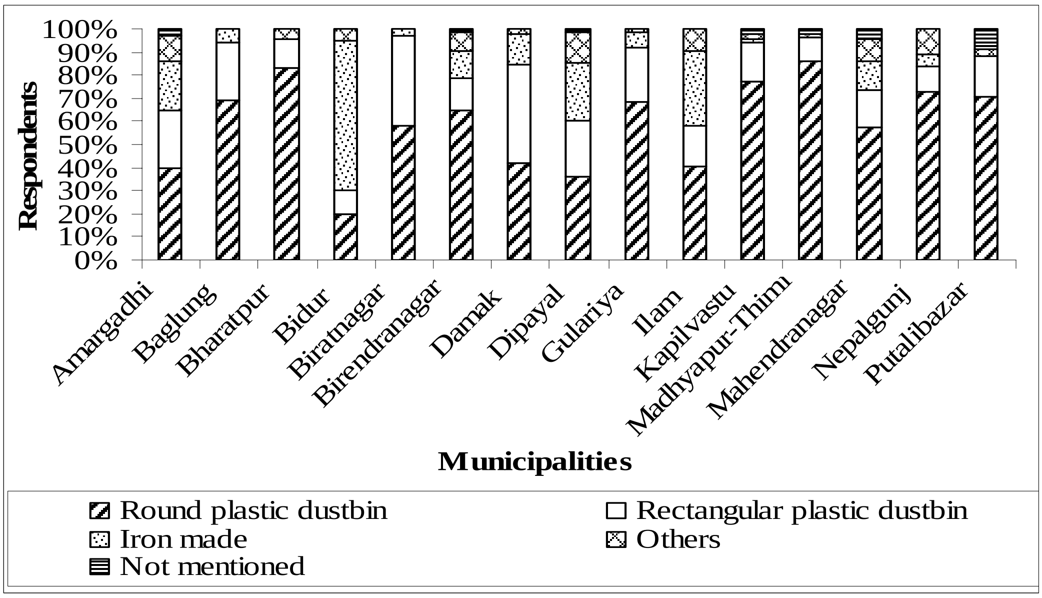

Figure 3.12: Type of dustbin preferred

Perception regarding dustbin containers lid: Figure 3.13 shows the perception regarding the dustbin containers' lid. Concerning the type of the lid of the container majority of the respondents replied that either an automatic one (Kapilvastu 90%) or the ones easy to use (Madhyapur 85%) would be better. Least preference was given to an open one. The preference for an open container was found to be highest in Birendranagar (30%).

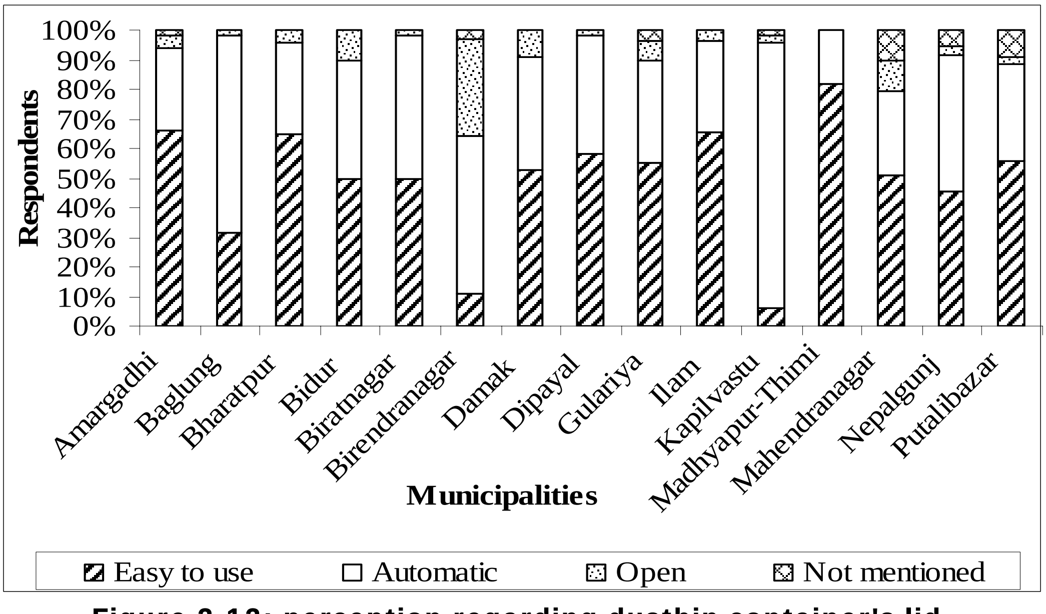

Figure 3.13: perception regarding dustbin container's lid

Person responsible for waste disposal: In all the municipalities most (ranging from100% in Bidur to 65% in Nepalgunj) disposed their waste either by themselves or through their servant, in contrast to this, whereas 15% of people in Ilam had door to door collection as shown in the (Figure 3.14).

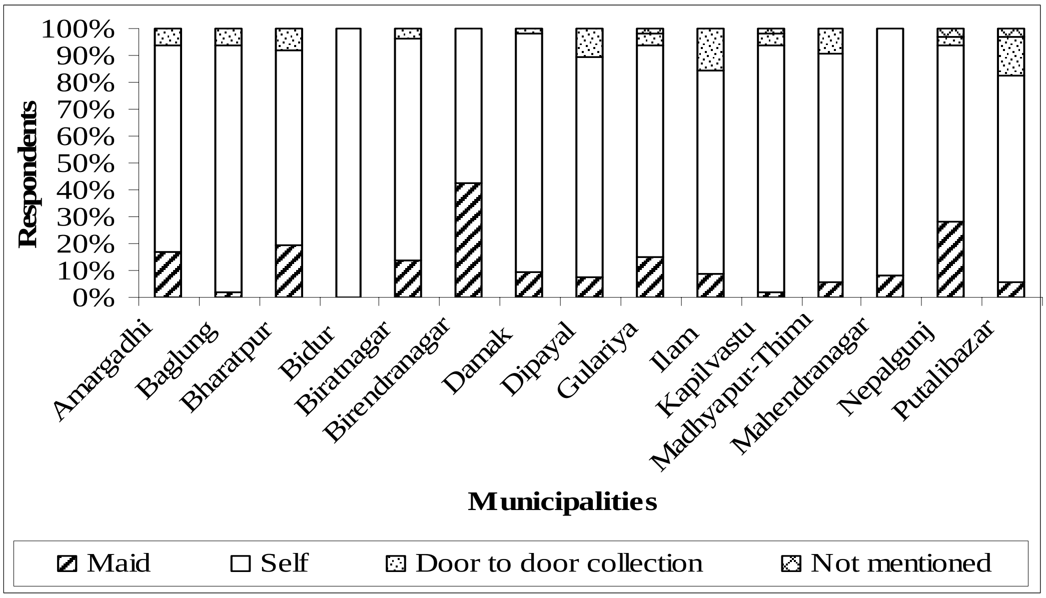

Figure 3.14: Person responsible for waste disposal

Disposal of municipal solid waste: Regarding the waste disposal, 90% of people in Bidur disposed their waste in dustbin whereas 75 % in Baglung managed by door to door service. However, in Damak and Kapilvastu, 60% and 55% disposed MSW either in sewage or in open place (Figure 3.15) respectively.

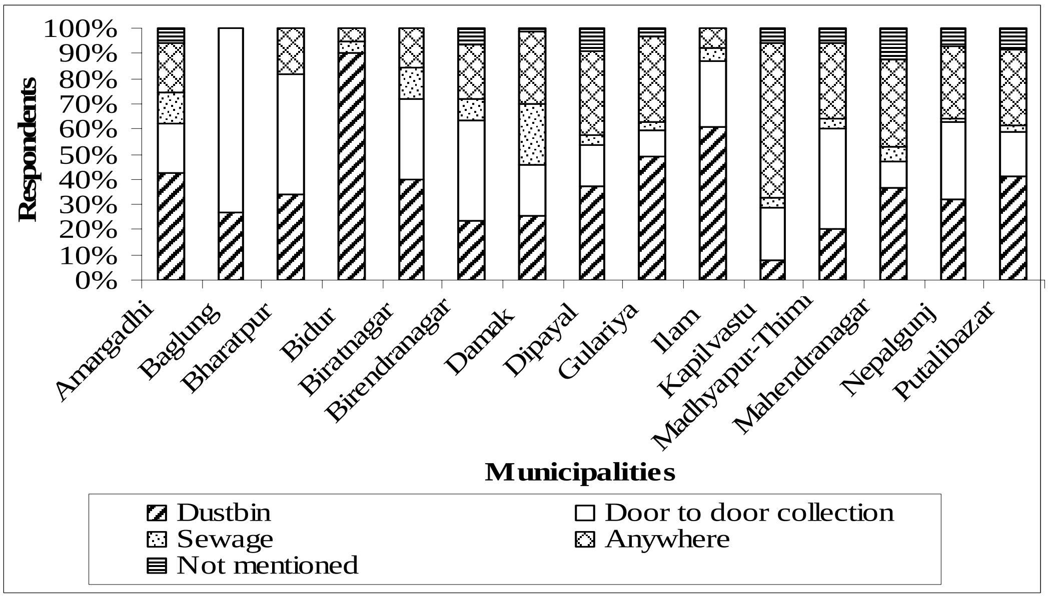

Figure 3.15: Disposal of municipal solid waste

Present expenditure for waste disposal: Figure 3.16 shows that in 13 of the 15 municipalities, more than 50% of the households did not spend even a single rupee for waste disposal which ranged from 90% in Kapilvastu to 57% in Amargadhi. In rest of two municipalities, Baglung showed 65% respondents paying Rs 25 to 50, while in Bharatpur 45% paid Rs 25 to 50 and 5% paid Rs 50-100 per month.

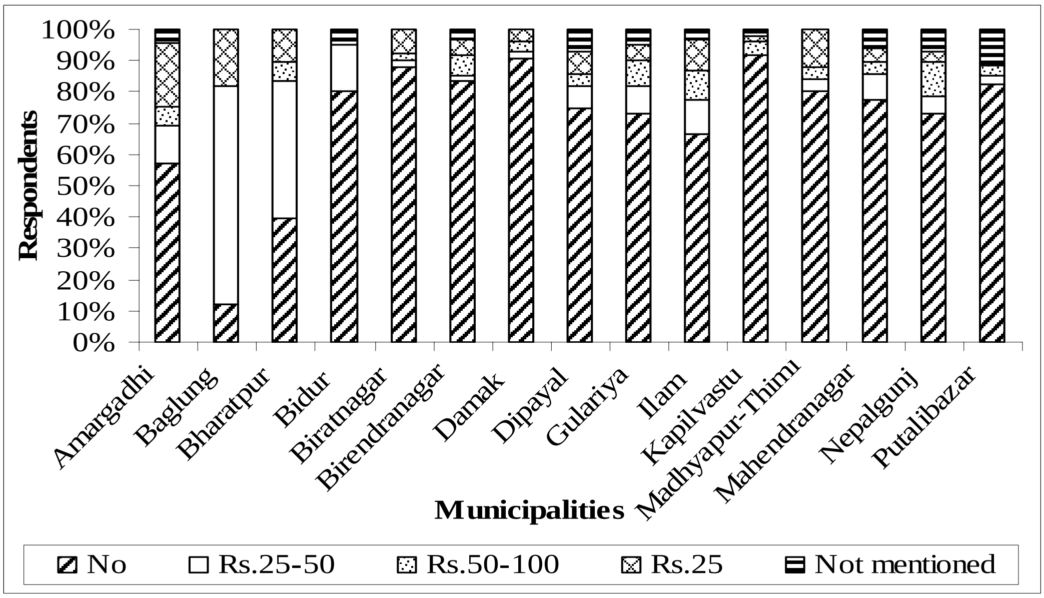

Figure 3.16: Present expenditure for waste disposal

Perception regarding willingness to pay for door to door waste collection system: In 14 municipalities most of the respondents were found to be willing to pay for door to door waste collection service. The number of respondents ranged 90% in Damak and Ilam to 55% in Bidur. In Birendranagar, 65% of the response opposed to make such expenditure.

Amount willing to spend for solid waste management: Percentage of respondents willing to pay less than NRs 25/month for solid waste management ranged from 20% in Putalibazar to 100% in Bidur. In contrast to this, 90% of the respondents were willing to pay more than NRs 100/month for solid waste management (Figure 3.17).

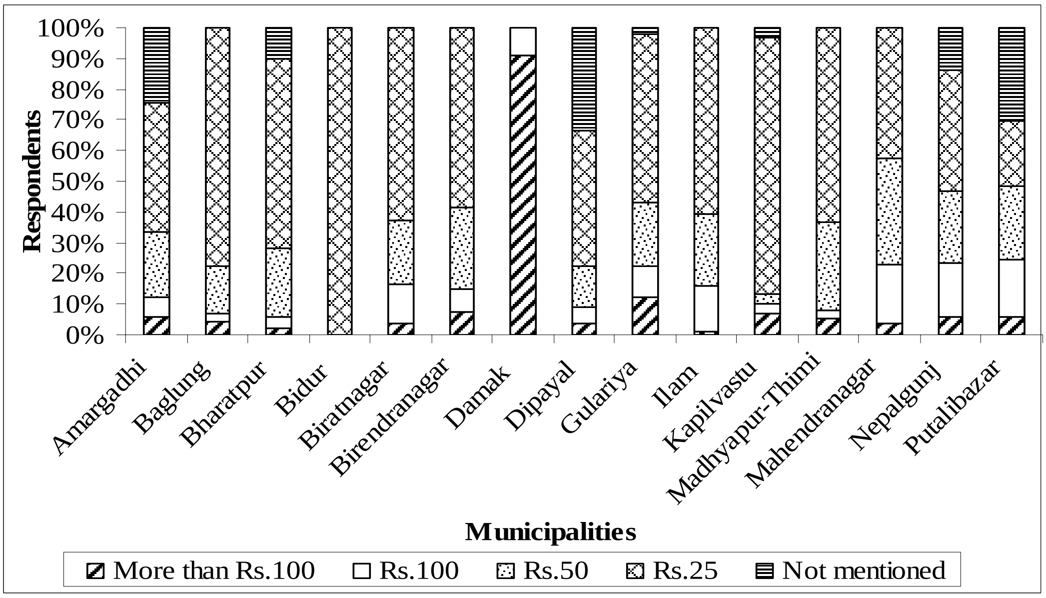

Figure 3.17: Amount willing to spend for solid waste management

Financial cause for not willing to pay: The households that were not willing to pay for the waste management services constitutes about 50% in 7 municipalities (Amargadhi, Biratnagar, Damak, Dipayal, Gulariya, Madhyapur and Nepalgunj) who considerd financial problem as a reason for the opposition. In Ilam and Kapilvastu, 80% of the opposing people said it was not their financial condition for their denial (Figure 3.18).

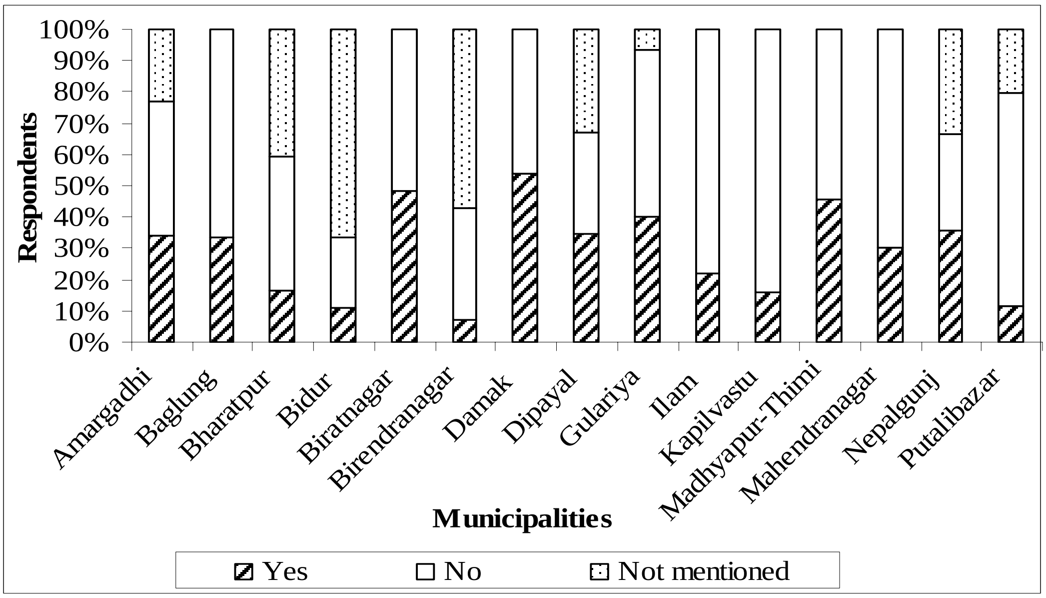

Figure 3.18: Financial cause for not willing to pay

Presence and absence of city waste container: In the survey conducted regarding the presence or absence of the city container in their locality majority of respondents mentioned about its absence. Among them Baglung, Damak, Madhyapur, Mahendranagar & Nepalgunj had more than 90% respondents. At Bidur 80% of the respondents stated the presence of city containers near to their localities. Similarly 55% of the Amargadhi respondents reported presence of such containers.

Distance of the city waste container from residence: Among the respondents who said city waste container was present in their locality ranged from 70% in Gulariya and Ilam to 5% in Nepalgunj (Figure 3.19).

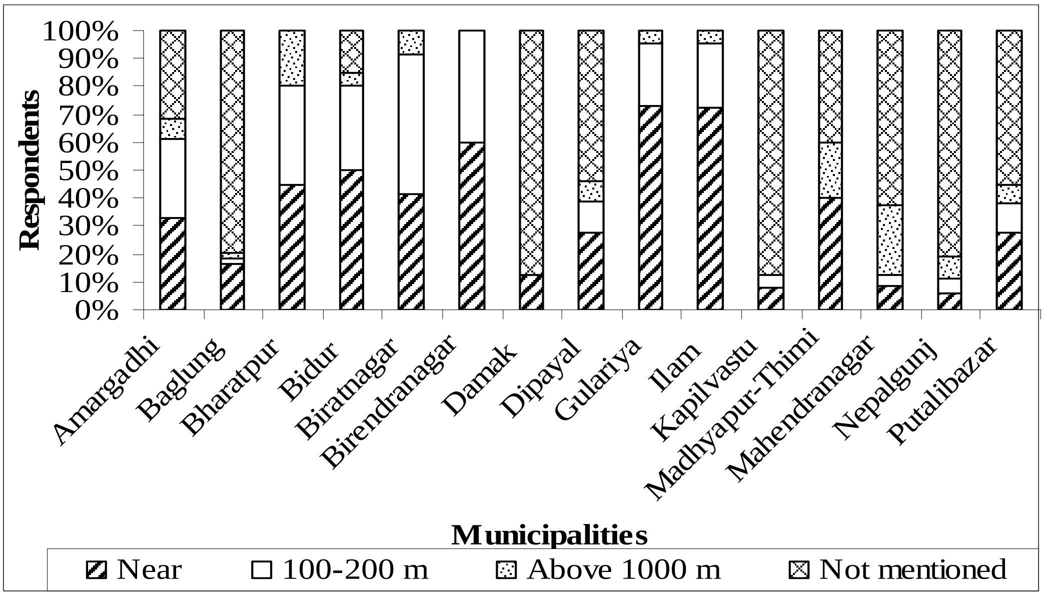

Figure 3.19: Distance of the city waste container from residence

The respondents with presence of city waste container at a distance of 100 to 200m ranged from 40% in Biratnagar and Birendranagar to 0% in Damak. While amongst those who said it was more than 1000m constituted 20% in Bharatpur and Madhyapur to 0% in Damak and Kapilvastu.

Waste disposal system: Door to door collection was the most preferred waste disposal system in all the municipalities (Figure 3.20). This type of waste disposal system was supported by more than 50% of the respondents in all the municipalities. Similarly, more than 70% of the respondents were in the support of door to door collection in the municipalities like Damak, Ilam and Mahendranagar. The second most preferred system of waste disposal was the disposal in waste container and which was almost equal to 50% in the municipalities like Gulariya, Kapilvastu, Mahendranagar and Putalibazar.

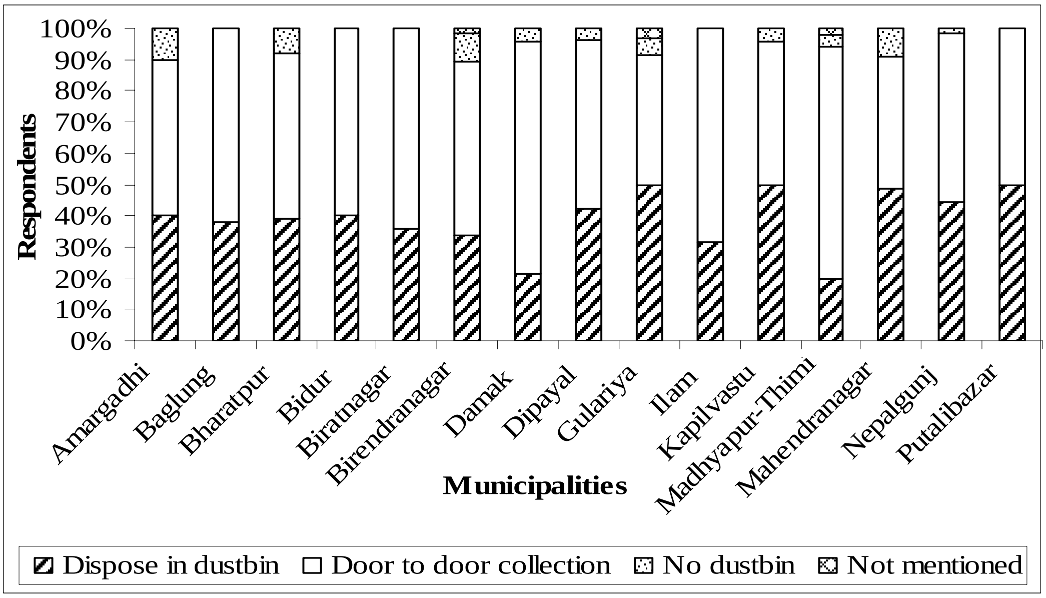

Figure 3.20: Type of waste disposal system preferred by the respondents

Suitable waste collection time: The respondents were asked about the suitable time for waste collection from their home.

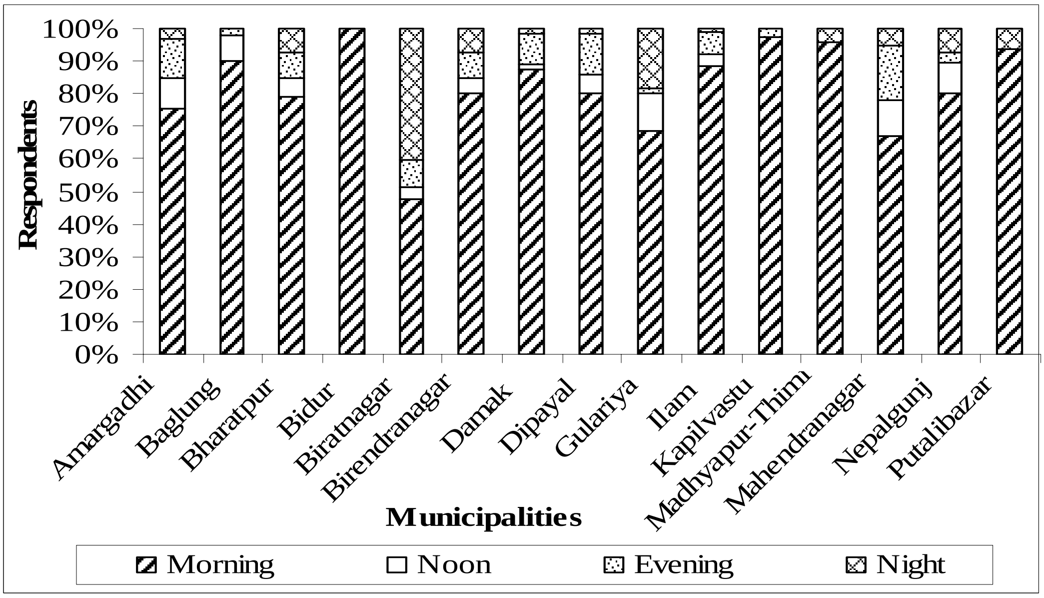

Figure 3.21: Suitable waste collection time

Morning was found to be the most preferred time for solid waste collection from their home. In Bidur municipality, 100% of the respondents preferred morning time. At least 70% of the respondents preferred morning time in all the fifteen municipalities except Biratnagar municipality where about 40% of the respondents preferred night time for collection of waste from their home. In the municipalities like Bharatpur, Baglung, Damak, Dipayal, Ilam, Kapilvastu, Madhyapur, Nepalgunj, Putalibazar and Birendranagar, more than 80% of the respondents were in the favour of morning time for the collection of waste from their home. Night time was also preferred by some of the respondents but it was negligible as compared to the morning time waste collection and was notable in the case of Biratnagar municipality only. Similarly, evening was the most suitable time for waste collection for some respondents. However, it was lower than 20% in all the fifteen municipalities. The collection of waste in the noon time was not supported by more than 10% of the respondents in all sampled municipalities (Figure 3.21).

Preferred frequency of waste collection: The respondents were further asked about the number of times the waste to be collected. More than 50% of the respondents in all the fifteen municipalities (except Biratnagar and Baglung) municipality responded that the waste should be collected at least once a day (Figure 3.22). In case of Biratnagar and Baglung municipalities also, 40-50% of the respondents were of the opinion that the waste should be collected at least once a day.

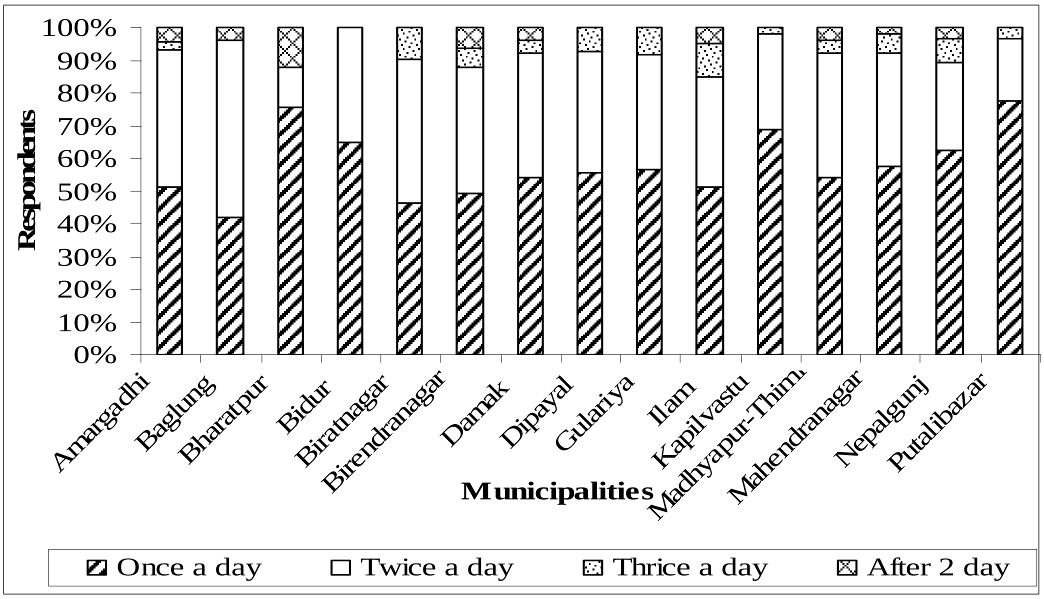

Figure 3.22: Preferred frequency of waste collection

Trend of waste collection: Figure 3.23 shows that the regularity in waste collection is very poor in all the municipalities. The regular waste collection practice was comparatively higher in the Damak municipality. However, it is only in the range of 30-40% followed by Madhyapur Thimi municipality (30%). However, most of the municipalities have less than 30% regularity in waste collection.

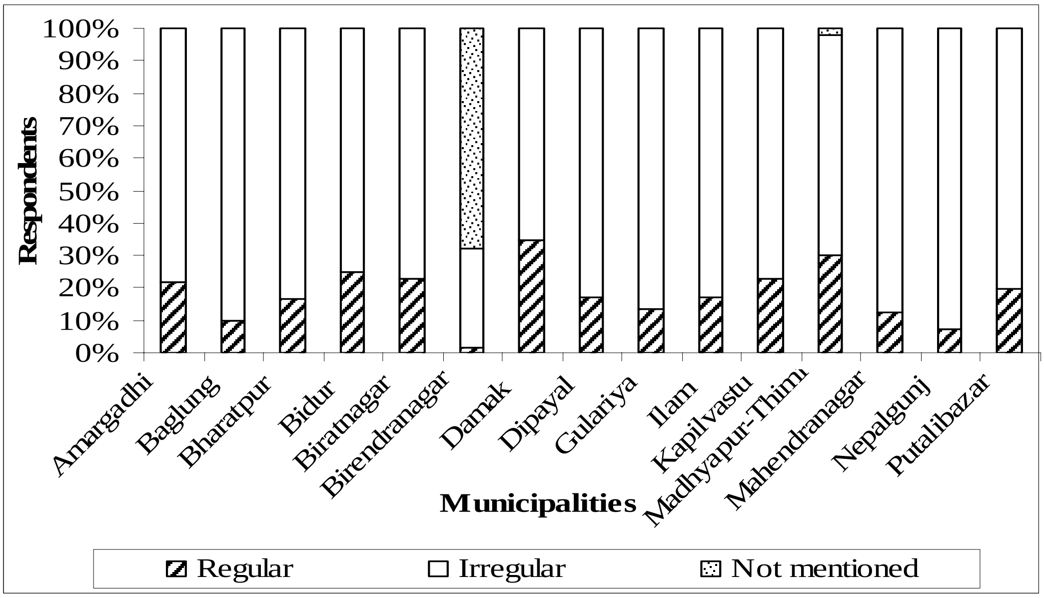

Figure 3.23: Waste collection trend

Cleaning activities of waste: The cleaning activities of waste during the daytime are the highest for the Amargadhi municipality. However, it was only in the range of 40-50%. For most of the municipalities, it is in the range of 20-30%. In the Bidur and Kapilvastu municipality, it was less than 10% as shown in the figure 3.24.

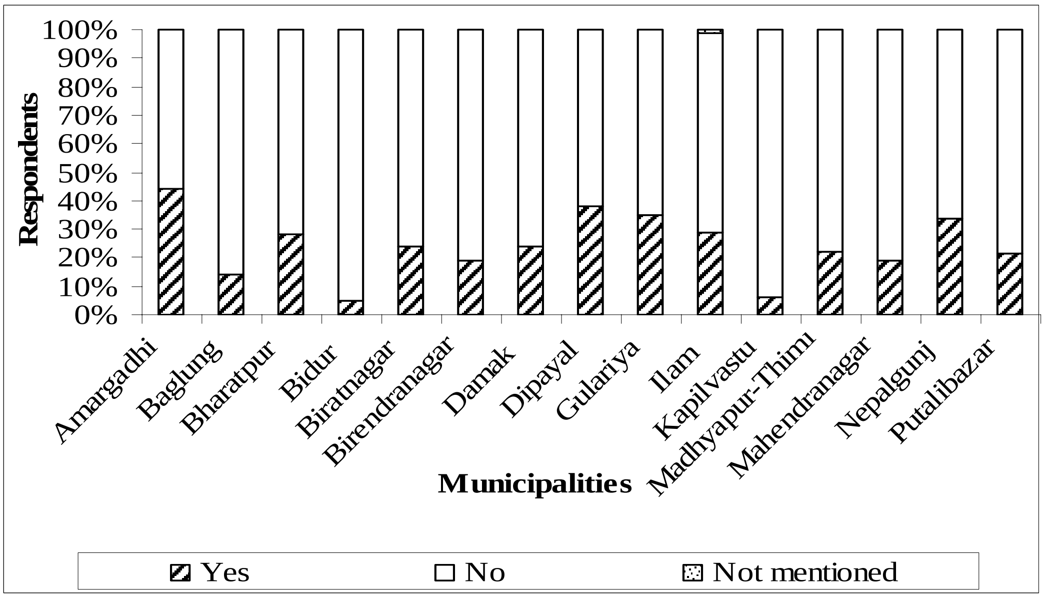

Figure 3.24: Cleaning activity at day time

Extent of knowledge towards solid waste management disposal: In response to a questionnaire about ultimate disposal of solid waste, most of the respondents were unaware of it (Figure 3.25).The respondents who were aware about the ultimate disposal of waste were less than 50% in majority of the municipalities. However, awareness level was higher for Bidur municipality (greater than 80%) and Baglung municipality (almost 70%).

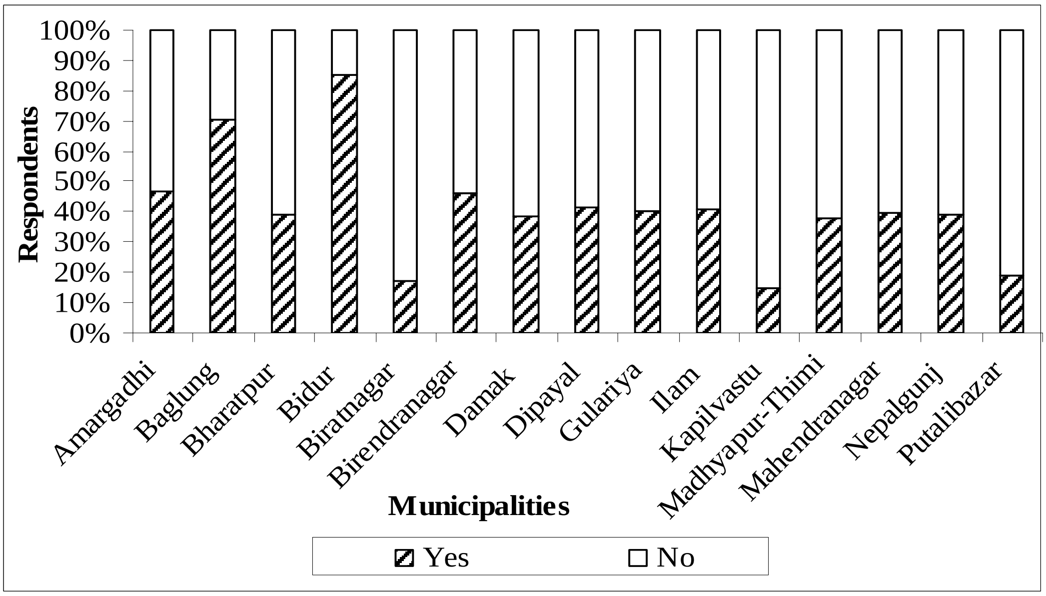

Figure 3.25: Awareness regarding ultimate disposal of solid waste

People perception towards the site of solid waste disposal: The respondents were asked whether the disposal of solid waste at open place is good or not. Majority of the respondents were not in the favour of disposing solid waste at open places. Figure 3.26 indicates that not more than 30% of the respondents were in the support of open dumping of waste.

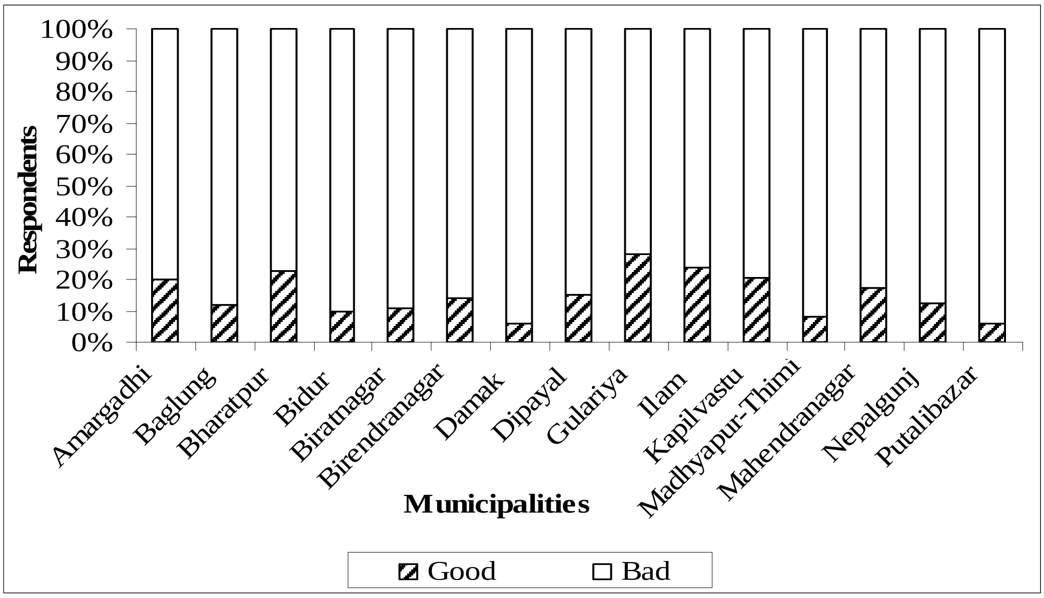

Figure 3.26: Perception regarding open dumping of solid waste by municipality

Awareness towards the environmental pollution from the open dumping of solid waste: The respondents were further asked whether they are aware of open dumping of solid waste or not. There was high awareness among the respondents about the open dumping of solid waste and its dumping in open places (Figure 3.34). The awareness level was comparatively lower in the case of Amargadhi municipality (almost 50%). However, it was very high for any other municipalities but higher in other municipalities.

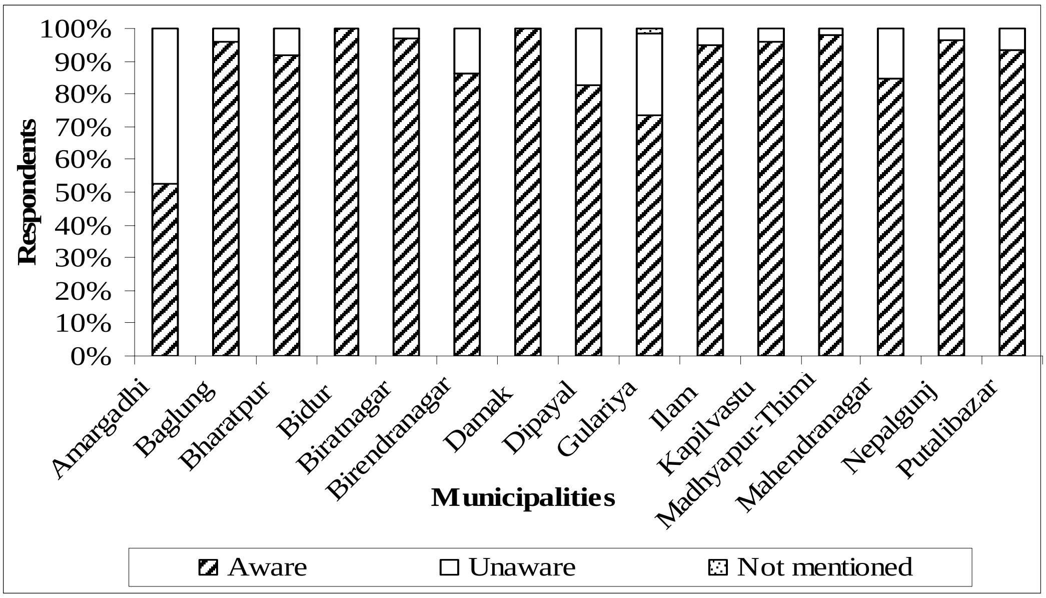

Figure 3.27: Awareness concerning environmental pollution from open dumping

Reuse or sell behaviour of the respondents: On average, metals were the most reused materials (31%) or to be sold followed by plastic (24%), paper (22%), rubber/leather (10%) and cloth (6%) (Figure 3.28).

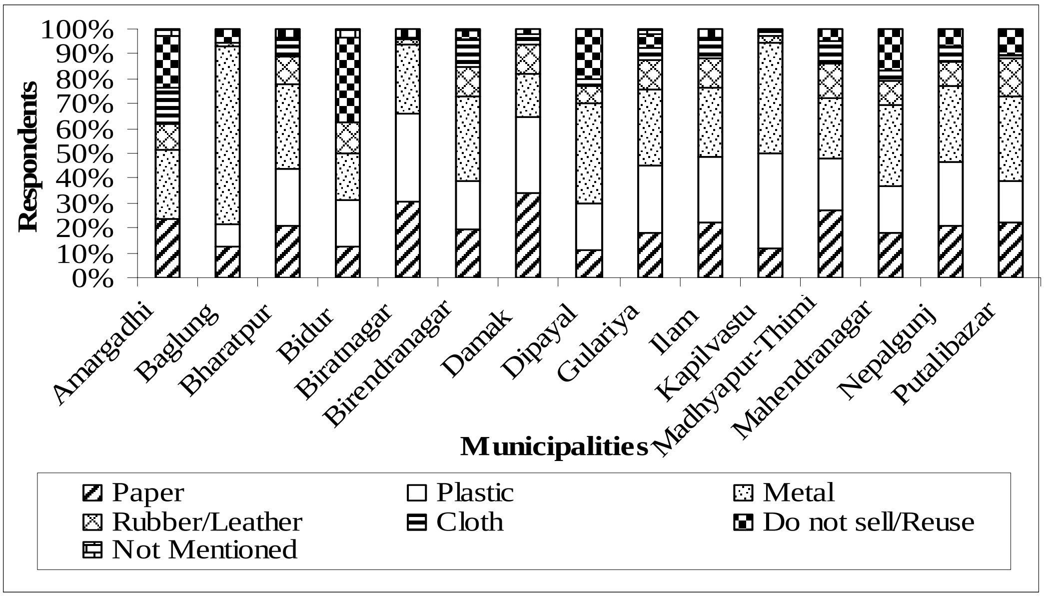

Figure 3.28: Parts of the waste reused / sold

Saving from the recyclable or reusable materials: Out of the total reusable or recyclable materials, 37% of the households sell these materials and save less than Rs 25 in a month. However, the same percentage of households ,i.e., 37% don't sell these materials. But some households (14%) save Rs 25-50 in a month and some of them (6%) could save above NRs 50 in a month (Figure 3.29).

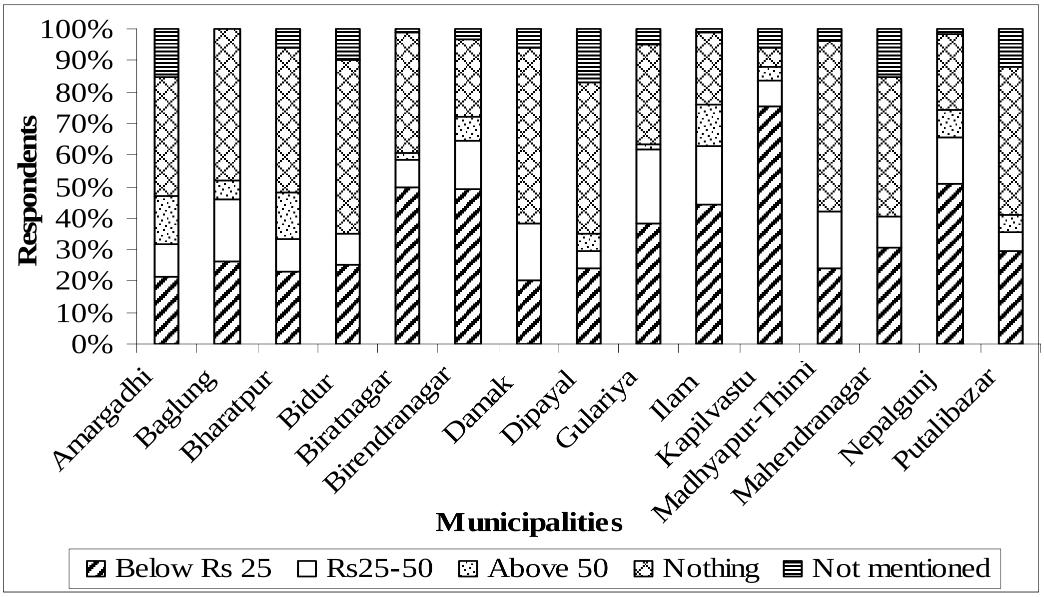

Figure 3.29: Amount saved by selling reusable or recyclable materials

Awareness regarding manufacturing fertilizer from waste: Most of the respondents (more than 50%) were familiar about the compost preparation from the waste in all the municipalities (Figure 3.30). In case of Biratnagar, Baglung, Damak, Dipayal, Gulariya, Ilam, Kapilvastu, Madhyapur, Nepalgunj, Putalibazar and Birendranagar municipalities, the familiarity of compost production from waste was very high (80%).

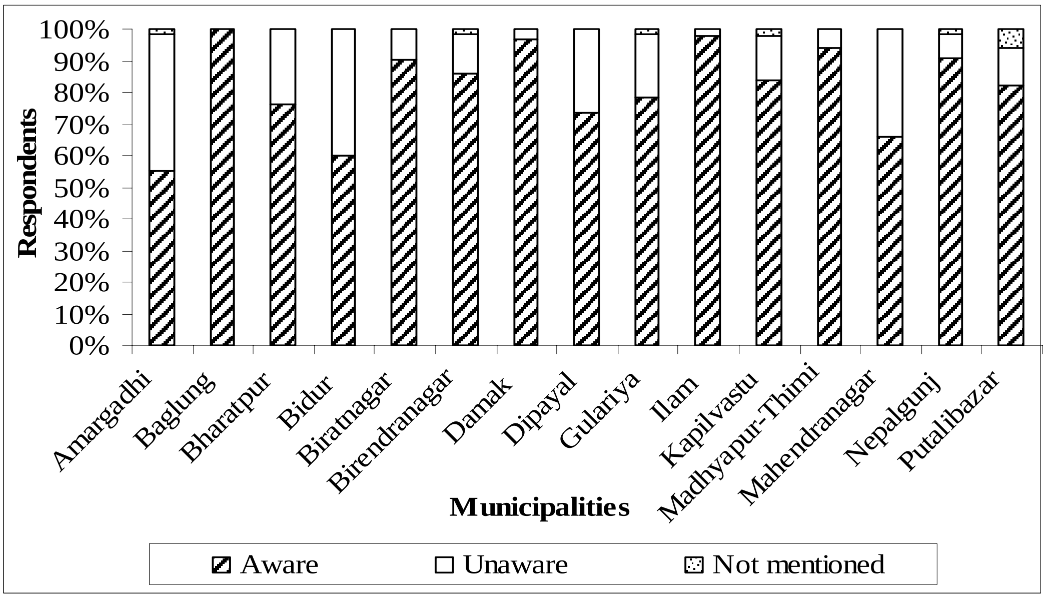

Figure 3.30: Awareness regarding manufacturing fertilizer from waste

Effective means of encouraging use of compost fertilizers: Figure 3.31 shows the percentage of households that were ready to make compost from the waste if provided certain facility to them. On average about 30% of the households responded that they would make fertilizer if someone demonstrates the home made fertilizer. Some respondents were seeking financial assistance for this purpose. About 30% of the respondents expected the encouragement of municipality for the composting process. Many respondents were also ready to use/make fertilizer if the Market is available easily.

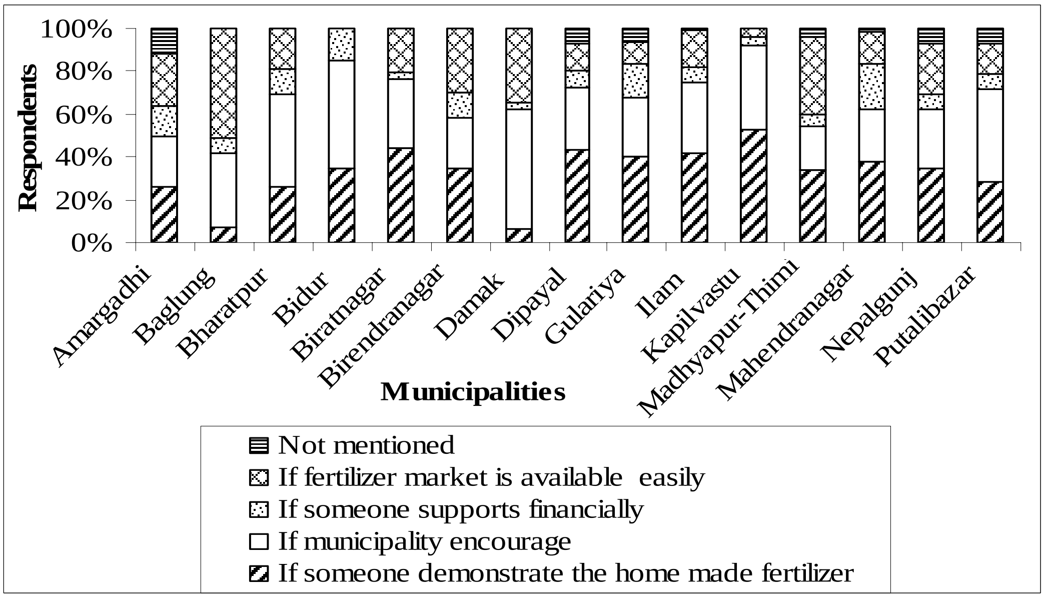

Figure 3.31: Effective means of encouraging use of compost fertilizers

Perception about providing two bins for waste segregation at home: The sampled households were very positive towards segregating the biodegradable and inorganic waste in two dustbins at home (Figure 3.32). More than 70% of the respondents in all the fifteen municipalities rated it as good system for the collection and segregation of waste. But some respondents took it as management problem. However, the percentage of respondents taking it as management problem is relatively lower and is less than 30%.

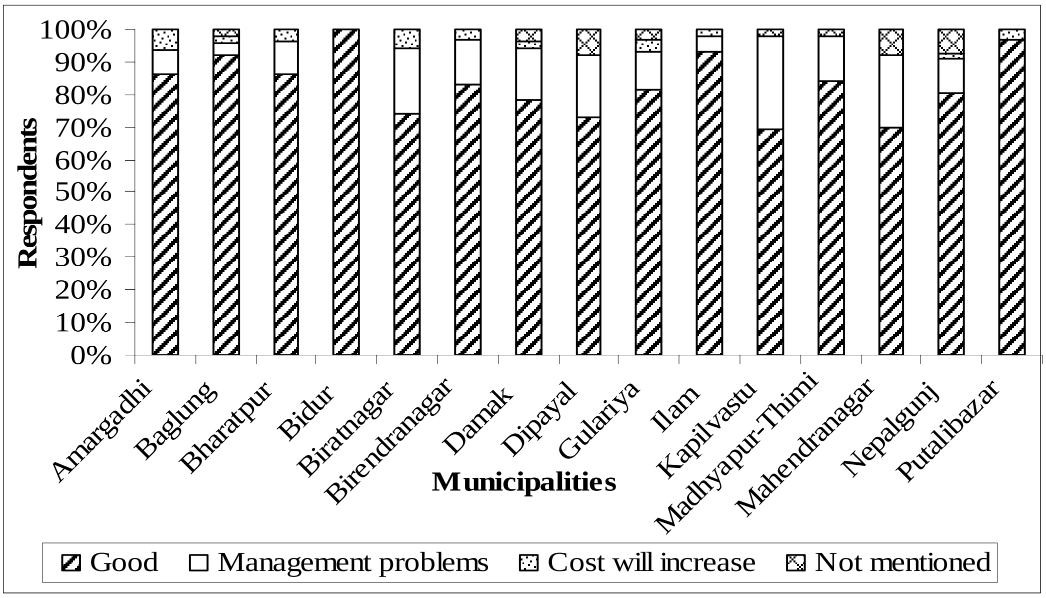

Figure 3.32: Perception about providing two dustbins for waste segregation at home

Perception about present waste management practice: Figure 3.33 shows the perception of the respondents about the present waste management system. Nearly 50% of the respondents were not satisfied with the present waste management system in their area in the municipality like Gulariya and Nepalgunj. The percentage of respondents who were satisfied with the current waste management system was higher in Baglung (85%) followed by Ilam (82%).

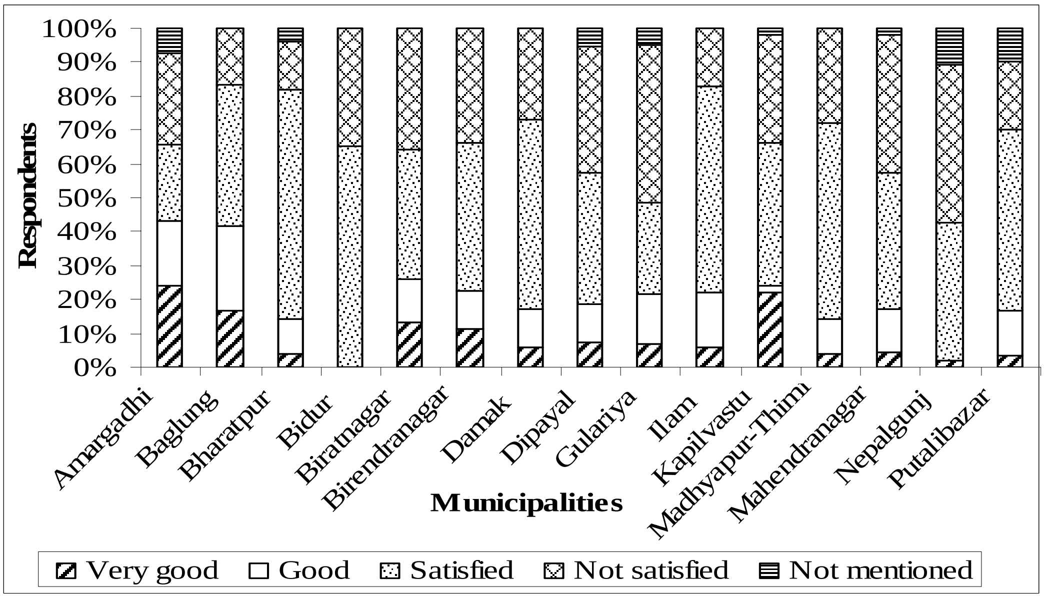

Figure 3.33: Perception about present waste management practice

Cause of present unsatisfactory system of waste management: There was mixed reaction from the respondents about the unsatisfactory system of waste management (Figure 3.34). The major causes of un-satisfaction were lack of proper segregations, type and location of dustbin, steps taken by the city corporation, economical condition and lack of awareness. Most of the respondents in the Kapilvastu municipality were not satisfied with the steps taken by the city corporation (90%).

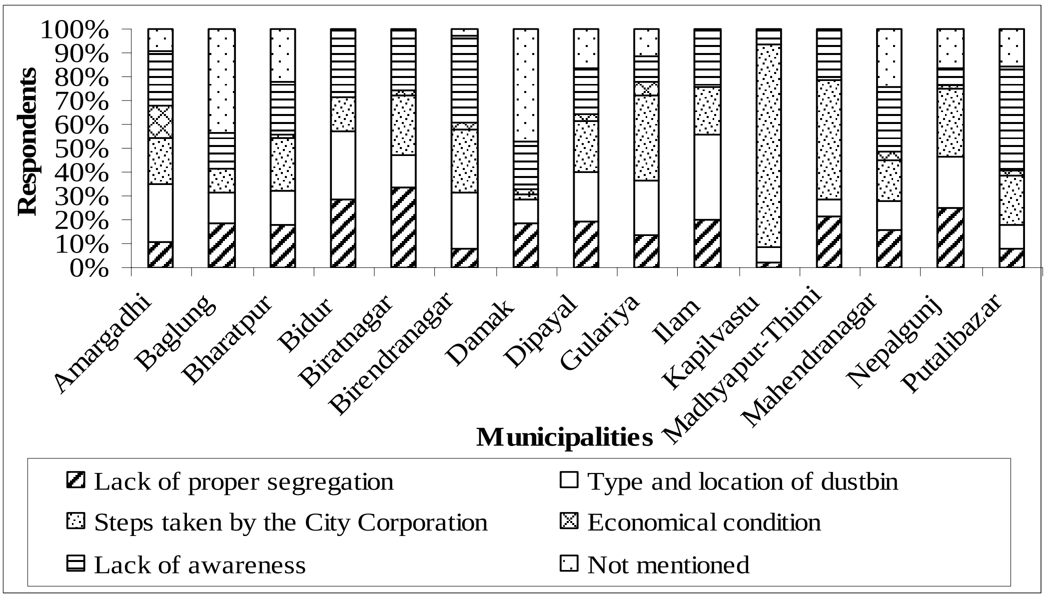

Figure 3.34: Cause of present unsatisfactory system of waste management

Views concerning practice of waste management with no waste: Respondents were highly attracted towards the technology that could clean and reduce the waste in their area .Almost cent percent of the respondents in average welcomed any system from which their area can be free of waste (Figure 3.35).

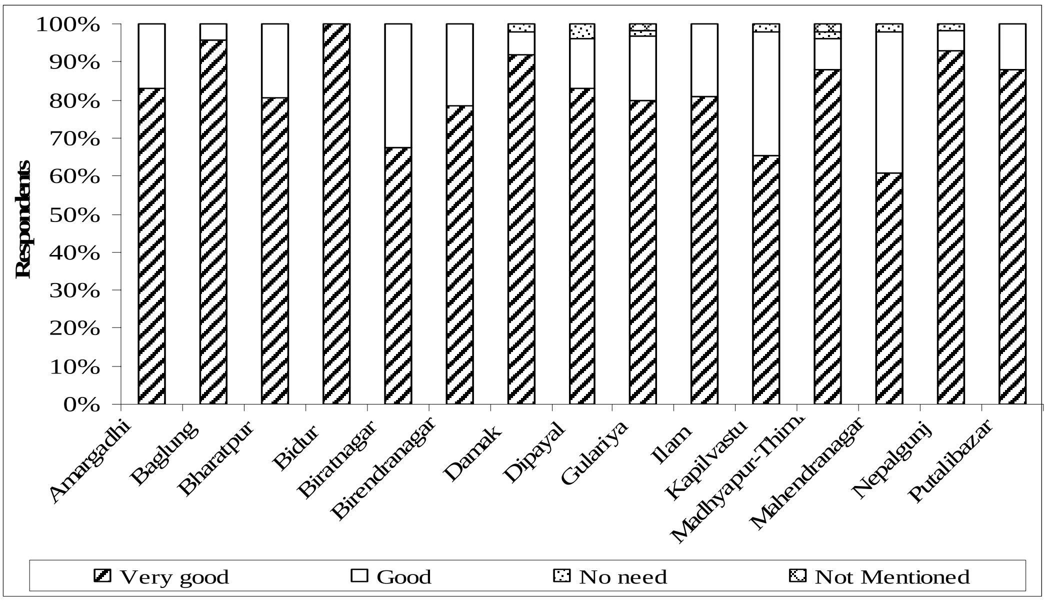

Figure 3.35: Views concerning practice of waste management with no waste

Means of encouragement for people participation in waste management: About 40% of the respondents in all sampled municipalities (except Birendranagar) believed that the personal motivation can be the best way for encouraging people participation in waste management (Figure 3.36). However, more than 30% of the respondents from Amargadhi, Bharatpur, Bidur, Biratnagar, Damak, Ilam, Madhyapur-Thimi, Mahendranagar and Nepalgunj municipalities were in the favour of TV/Radio/Newspaper. Similarly, about 21% of the respondents were in the favour of meeting to encourage people's participation in waste management practices. Small percentage of respondents (less than 5%) did not believe in any means for the encouragement of people participation in this campaign.

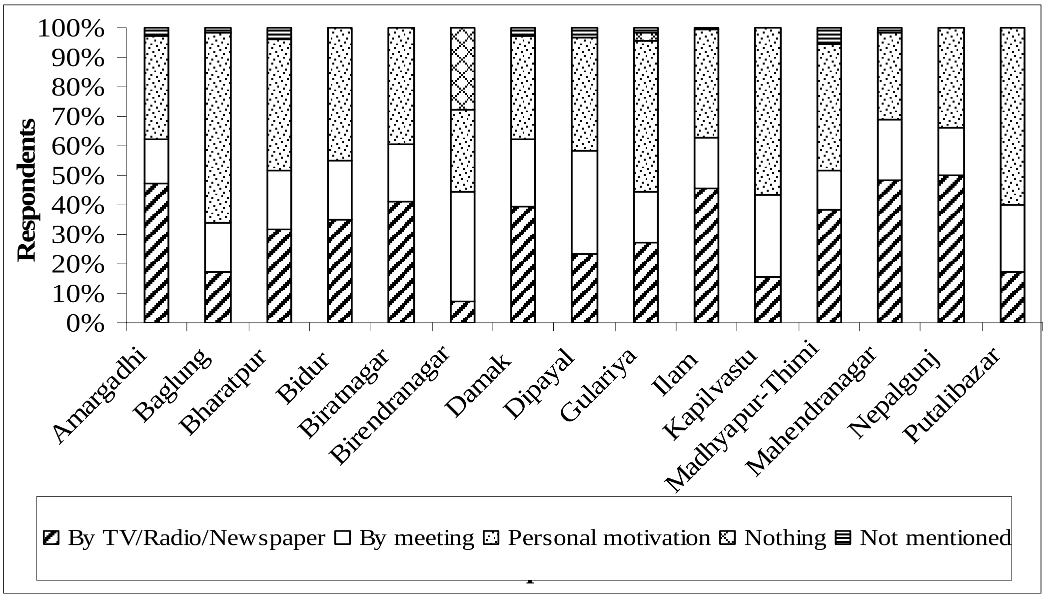

Figure 3.36: Means of encouragement for people participation in solid waste management

In general, the respondents were found to be well aware regarding the problems of solid waste management and the role of stakeholders primarily the municipality. Further, majority of the respondents were ready to pay and improve their behaviour regarding the improvement of waste management related activities if provided some assistance.

3.1.5 Findings from Indonesia

Population and households

Eight areas were selected for the study in Indonesia. The waste management responsibilities in these areas are undertaken by Agency of Public Work (AOPW), Department of Environment (DOE), UPTD Kebersihan (UPTDK), Dinas Kebersihan (Agency of City Cleanliness), Agency of Cleanliness-1(AOC-1), Department of Environment and Sanitary(DOES), Agency of Cleanliness-2(AOC-2), and Cipta Karya Agency(CKA).

It can be seen from the Table 4.1 that the population ranged from approximately 0.5 million in Kebersihan (UPTDK), to approximately 4 million in Agency of Cleanliness-1. There were 1,036,491 number of households in Agency of Cleanliness-1 areas and 953,926 in Dinas Kebersihan (Agency of City Cleanliness) whereas 8005 households were found in the area of Department of Environment. It would be interesting to note that the solid wastes generated per household in the municipalities might vary significantly as of the extreme variation on the no. of household indicated above.

Table 3.7: Background information

Areas Covered by	No. of wards	Total covered area (hectare)	Total population in million	No. of HHS
Agency of Public Work	13	10,378	1.407	359,384
Department of Environment (DOE)	26	1,581	1.008	8005
UPTD Kebersihan (UPTDK)	2	275,030	0.523	174,578
Dinas Kebersihan(Agency of City Cleanliness)	28	307,371	2.861	953,926
Agency of Cleanliness-1 (AOC-1)	45	366,350	4.145	1,036,491
Department of Environment and Sanitary	42	306,519	2.274	568,608
Agency of Cleanliness-2	36	NA	3.542	NA
Cipta Karya Agency	30	3,50147	2.173	NA

The largest area lies in the AOC-1 with 366,350 ha in order to manage the waste from the 1,036,491 households in 45 wards of its area. Similarly, UPTDK municipal area is responsible to manage waste from 2 wards which has lowest population with 523,734.

3.5.2. Waste generation/collection

Table 4.2 shows that huge amount of waste generated from AOC-1 is responsible to collect19.64% solid waste out of 9000 m^3/day generation where as remarkably in contrast, DOE had 100% solid waste collection ratio out of 1632 m^3/day generation. Similarly, UPTDK has waste generation per capita 0.0036m^3 waste /day where as DKACC has lowest value with 0.0011 m^3/day.

Table 3.8: Waste generation/collection

Waste handled by	Waste generation per capita(m^3/day)	Total waste generation (m^3/ day)	Total waste collection (m^3/day)
Agency of Public Work	0.0025	3520	2358
Department of Environment (DOE)	0.0016	1632	1632
UPTD Kebersihan (UPTDK)	0.0036	1342	1285
Dinas Kebersihan(Agency of City Cleanliness) DKACC	0.0011	3200	2080
Agency of Cleanliness-1 (AOC-1)	0.0022	9000	1768
Department of Environment and Sanitary	NA	NA	NA
Agency of Cleanliness-2	0.0014	5000	2000
Cipta Karya Agency (CKA)	0.0087	1900	566

3.5.3. Physical composition of municipal waste

In Indonesia, the municipal solid waste is categorized into 4 broad areas which includes inert (sand, dust, ashes, stone etc), compostable materials (kitchen/garden vegetable waste, leaves, straw, animal excreta etc), reusable/recyclable waste (plastic, paper, leather, bone, metal, rubber, glass etc) and others as shown in Figure 3.37.

Compostable, recyclable and inert play a vital role in treatment and recycling/resource recovery aspects of waste management. The content of compostable waste material has potential to produce compost fertilizer, the waste collected by fro Agency of public works and Cipta Karya Agency consist of 64% and 79 % of compostable waste respectively and rest of other lies with in this range. Therefore, it shows that municipal waste of each area is qualitatively viable for producing compost.

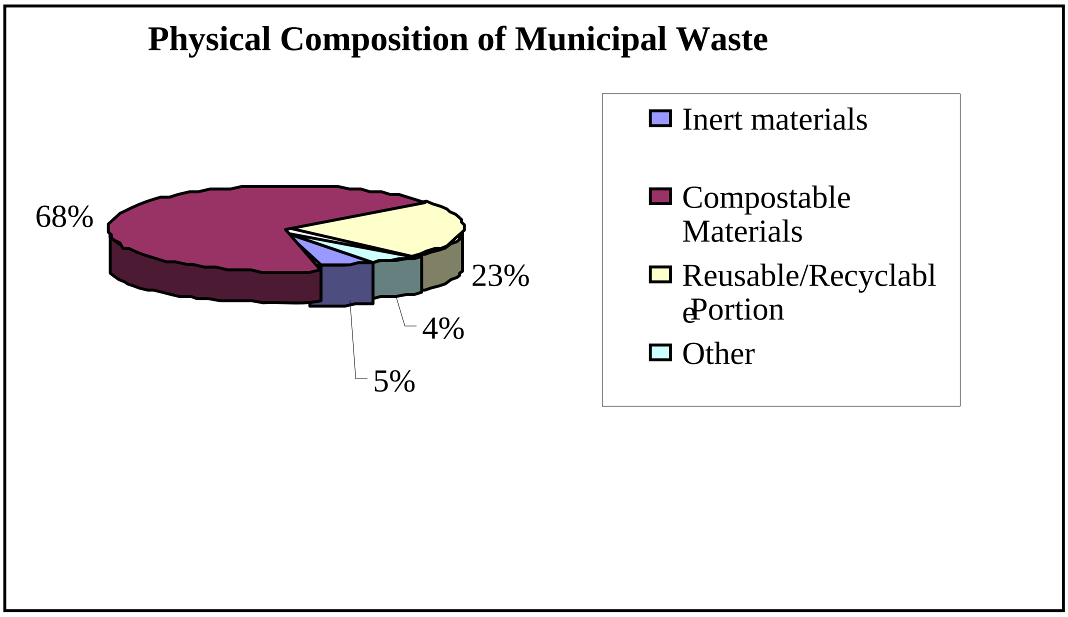

Figure 3.37 Physical composition of municipal waste

The content on inert materials (i.e. neither compostable nor recyclable) varies from 1.7 % to 11%, with an average value of about 5 %. The content on recyclable/reusable materials varies from 5.4 % to 31.3 %, with an average value of about 23 %.

3.2 Emission scenario and CDM documentation

3.2.1 Greenhouse Gas (GHG) Emission

Global climate change through GHG emission has been one of the major environmental concerns confronting policy makers of both developed and developing countries. Solid waste is considered a source of greenhouse gas emission as microbial decomposition of organic materials takes place at the disposal sites. In the absence of oxygen (anaerobic conditions), the decomposition process produces mainly methane (CH_4) and carbon dioxide (CO_2) and insignificant quantities of other gases. The quantity of these emissions is highly dependent on waste composition, climatic conditions and waste management practices. CH_4 alone produced at solid waste disposal sites contribute approximately 3-4 percent to the annual global anthropogenic greenhouse gas emissions. Emission from solid waste disposal area expected to increase with increasing population and GDP. Over the past 100 years, there is considerable increase in the concentration of greenhouse gases in the atmosphere. GHG act as a blanket that retains solar heat in the atmosphere. This creates higher global temperature or more commonly known as "Global Warming". As a consequence, the planet is experiencing changes in weather patterns, rise in sea level and melting of glaciers.

3.2.2 Baseline Scenario

With the Kyoto protocol, the Clean Development Mechanism (CDM) is becoming a key device for limiting greenhouse gas emission (GHG) and promoting sustainable development for both developing and developed countries. Any CDM projects should results in "measurable" reductions in GHG. The concept of "measurable" reduction is based on a comparison with some defined level of GHG emissions. This comparative level, against which the reduction of GHG emissions due to CDM project are measured, is termed a "baseline". The proposed CDM project will result in reduction of GHG emission only if the GHG emissions from the proposed CDM project are lower than the baseline. Human activities that causes the emission of GHG in to the atmosphere in the absence of a CDM project activity is commonly referred to as the baseline scenario. For example, consider a proposed CDM project for composting from a municipal solid waste (MSW) disposal landfill site. Disposal of MSW in landfills results in emission of methane, which is a GHG. In the absence of CDM project, no action is expected to be taken to reduce the methane from MSW landfill site. Therefore, the baseline scenario represents the quantity of methane generated from MSW in the landfill without the any measures. As discussed elsewhere this study envisaged to assess a feasibility study of solid waste and to evaluate the viable option under CDM framework. The current waste management scenario has been discussed in chapter III. The scenario indicated that majority of the municipalities are disposing their waste in non-engineered sites leading to anaerobic decomposition and generation of methane gas. The baseline scenario for existing waste management practices in the case study municipalities would indicate the emission of GHGs either with business as usual scenario or disposal in a planned /engineered landfill sites. The baseline emission, for the case study municipalities is calculated using the IPCC recommended methane estimation method, is given in Table 3.9.

However, baseline emission is estimated as minimum value of 708 tCO_{2e} /year (Ilam Municipality) to a maximum value of 20,925 tCO_{2e} /year (Biratnagar Sub-Metropolitan City). It is expected that after implementation of biological treatment process such as composting, emission reduction from solid waste of Biratnagar Sub-Metropolitan City would be around 16, 000 tCO_{2e}. Thus, at the current market rate for trading of US$ 6 per ton of CO_2 for carbon trading, a rough estimate can be made for total revenue generation with the implementation of composting facilities. The figures for Biratnagar and Ilam would be NRs 6 million and 0.2 million only. Thus for majority of the municipalities, scale economy can be barrier in implementing CDM framework. So, this aspect needs to be considered in making a further strategy. Building of the projects in preparing the project documents such as PIN and PDD is recommended. Please refer Annex 7, 8 and 9 for estimation methods of baseline emissions, project emissions from composting and emissions reduction respectively.

Table 3.9 Household waste generation and baseline emission of case study municipalities

Municipality	Total Population[1]	Total Household Waste Generation (ton/day)	Collection Efficiency %	* Baseline Emission for year 2007 (tCO_{2e})
Amergadhi	22378	4.43	56	1426
Baglung	20852	2.6	65	837
Bharatpur	130210	18.72	80	6026
Bidur Municipality	22273	2.67	30	860
Biratnagar	166674	65	61	20925
Birendranagar	31694	5.1	30	1642
Damak	58590	7.3	41	2350
Dipayal Silgadhi	24013	3.52	29	1133
Gulariya	48875	9.67	16	3113
Ilam	16246	2.2	46	708
Kapilvastu	37385	7.4	20	2382
Madhyapur-Thimi	47751	6.5	39	2092
Mahendranagar	80839	8.73	23	2810
Nepaljung	67891	14.6	75	4700
Putalibazar	30205	4.4	32	1416

[1] Population as of 2001 census

* calculated using the IPCC recommended methane estimation method

3.2.3 Project Idea Note (PIN)

The procedure for applying a CDM projects start with the conceptualisation of the project and activities which would lead to reduction in GHG emission. A PIN basically consists of approximately 5 pages providing information on the type and size of the project and its location. The first step to put a project under CDM framework is to develop a project idea note (PIN). Figure 3.38 describes the general procedure to be followed for a CDM project.

During the workshop, project idea note (PIN) on the following topics were prepared by the participate municipalities.

- Establishment and operation of a solid waste composting facility under CDM framework
- Establishment and operation of a bio-gas plant using municipal organic waste under CDM framework
- Establishment and operation of a solid waste recycling & composting facility under CDM framework

Among the prepared PIN, participated municipalities such as Nepalgunj, Gularia, Birendranagar and Tribhuvannagar had prepared the PIN on "Establishment and operation of a solid waste composting facility by using carbon financing under CDM frame work"(Refer Annex 10).

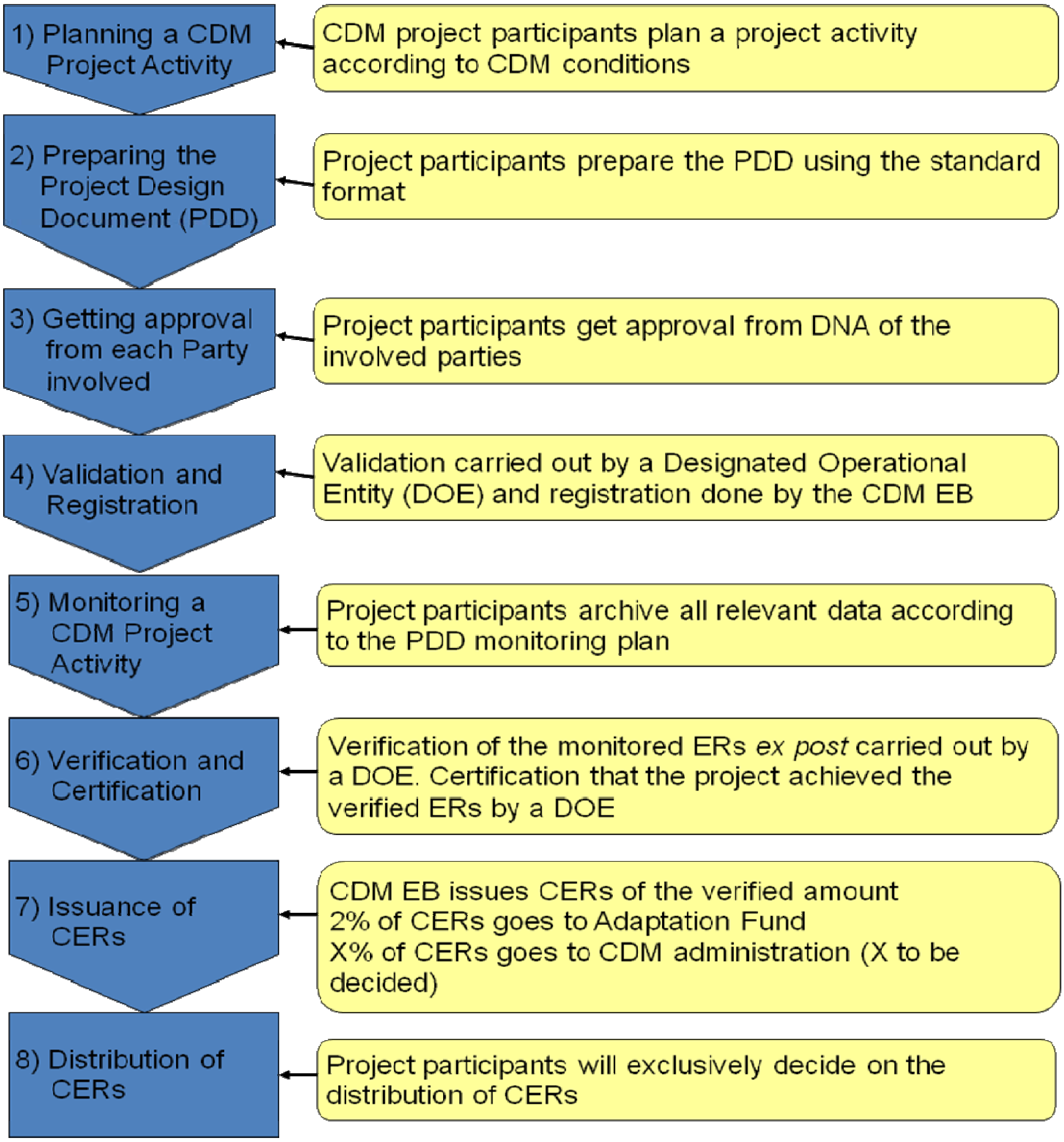

Figure 3.38 Process flow diagram for CDM project

3.3 Relevant solid waste management show-cases

This chapter outlines an overview of various initiatives areas related to solid waste management and GHG emission being implemented in the case study.

3.3.1 Biogas plant at WEPCO

Women Environment Preservation Committee (WEPCO) is a NGO constituting a group of middle class female entrepreneurs. They have been working in managing the MSW since 1992 at the community level. It is located at the left bank of Bagmati River in the Lalitpur District. The organization has 14 staff which includes seven labors (six for waste collection, transportation & segregation and one for waste to generate biogas). They manage the MSW collected from 1500 households of ward number 1 of the Lalitpur Sub-metropolitan city.

WEPCO has been operating a square shaped biogas plant (Figure 3.39) aimed mainly for research purpose since 2006. The $6m^3$ plant has length, breadth and height of 2m, 2m and 1.5m respectively. The digester is positioned above 0.68m high brick platform along with a slurry tank. The slurry outlet tank with 500L of capacity is constructed at the same level as that of the digester. In addition to this, the digester is fitted with four valves located at the bottom for water outlet. This metal digester is wrapped by 1 cm thick foam to trap the heat produced during the anaerobic decomposition so that favorable environment for methane production is maintained. The foam is wrapped completely by black coloured plastic and tied with nylon rope to support the tank walls against explosion from internal pressure. The plant was initially fed with 2 tons of food waste along with 400kg of animal dung and 8kg of sugar molasses. Since then the digester has been supplied with 30kg of household food waste and 30L of water per week. A half inch polythene pipe is used for supplying the gas top the cooking stove. The gas produced from the process is being used for cooking 4 hour/day. Slurry generated from the plant is used as an activator for aerobic composting of solid wastes. The plant of this size substitutes 1 LPG cylinder in every two months.

The plant has had to face some major setbacks like the corrosion of steel and the second is sedimentation. Unlike a common digester, this plant has used steel materials which can be easily corroded by acid. Considering the risk of the plant blowing up it is planned to shut down after a new one is built. In addition to the corrosion problem, sediment deposition because of improper segregation of the waste also takes place. The sludge with various contaminants is deposited at the bottom of the digester (Refer Annex 11, photos 1-4).

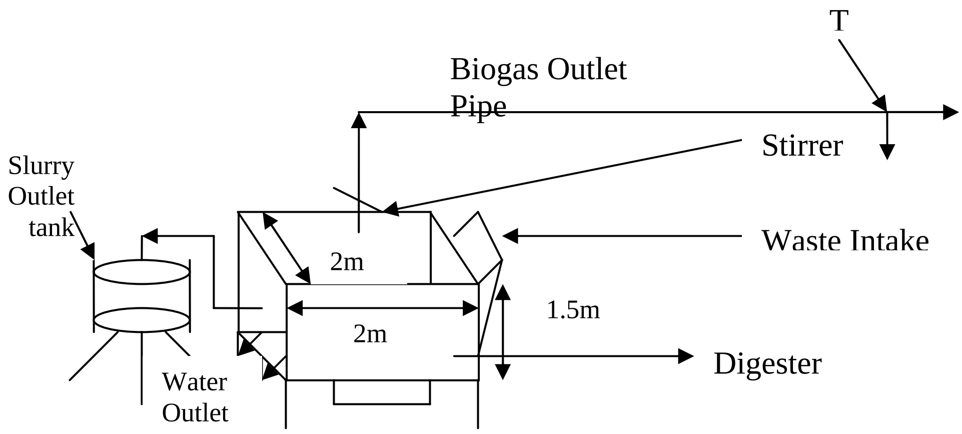

Figure 3.39 Solid waste biogas plants

With the successful operation of $6m^3$ sized biogas plant, WEPCO is constructing another biogas plant with size $8m^3$ which was supposed to operate from September 2008. Unlike the previous plant it is dome shaped and will use black water from the toilet along with the organic matter from municipal solid waste.

The new plant to be constructed will be a GGC 2047 model provided by the Biogas Support Program (Figure 3.40). This model is designed to consume about 4000 kg of dung initially.

After initial dosing a daily feeding of 48 to 60 kg of dung with 48-60L of water is required. With this input, the plant is designed to supply a 1,920L of gas/day which can last for 4.48 hrs if used at the rate of 400L/hr (BSP Year Book 2007).WEPCO is planning to feed the plant weekly with 70 kg of organic MSW.

It has planned to sell the gas produced from MSW to potential consumers like Advanced Engineering College, Nightingale School and restaurants which are located near the area.

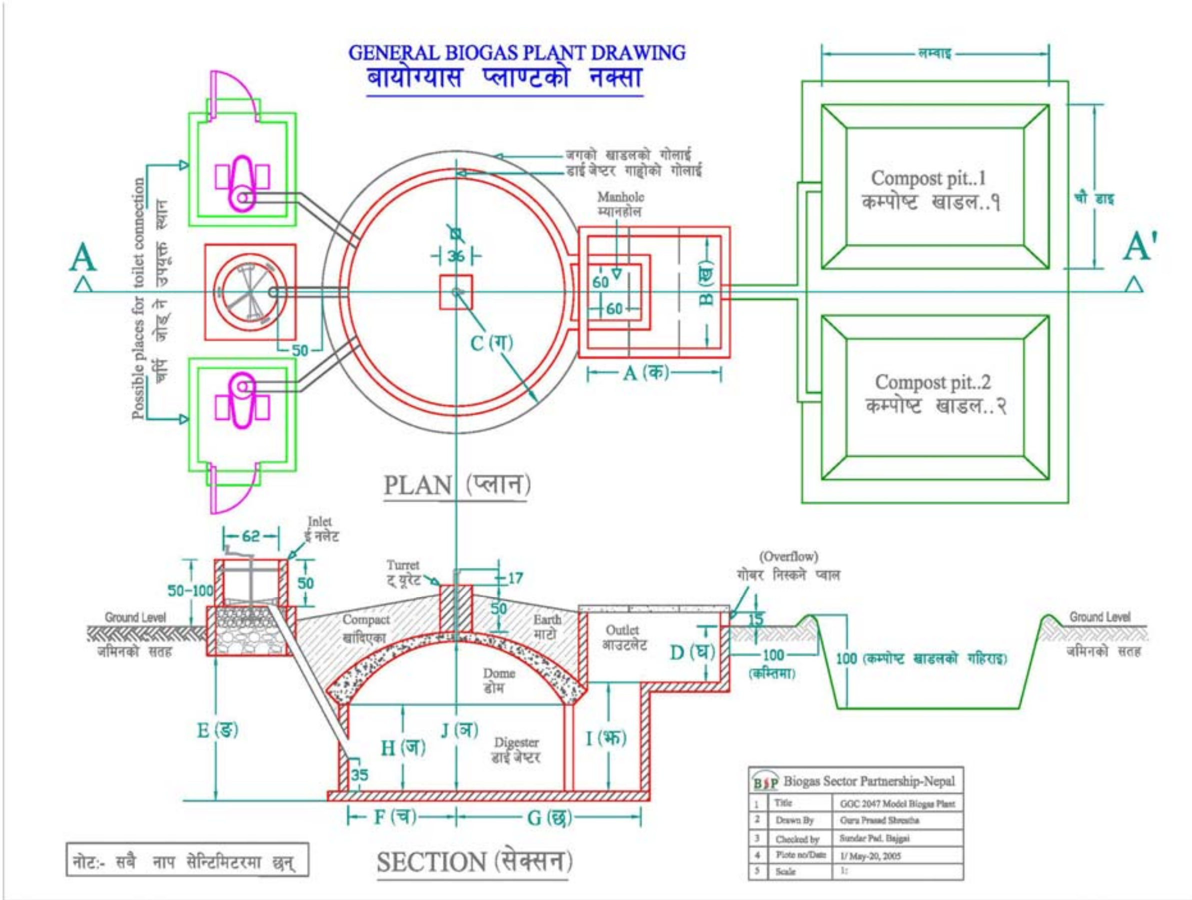

Figure 3.40 GGC 2047 model Biogas Plant (Source: BSP Year Book 2007)

3.3.2 Biogas plant at vegetable market waste in Kalimati

The wholesale fruit and vegetable market located at Kalimati, Kathmandu is the center for collection of fruits and vegetables from different parts of the country. The center supplies fruits and vegetables to Kathmandu valley with 5 municipalities. Kalimati Fruits and Vegetable Market Development Committee (KFVMDC) is a government organized authority that manages the market. It covers an area of 45 ropanis (2.25 ha) of land and is one of the busiest areas of Kathmandu city.

Everyday the market receives 300 metric tons of fruits and vegetables with organic waste output of 20 to 25 tons per day. The biodegradable organic waste is not only creating problem for management authority but also posing the risk of disease outbreak. On one hand unmanaged degrading organic wastes have become a menace for the management authority while on the other it poses a risk of outbreak of disease. Currently, KFVMDC uses 2 tippers with a carrying capacity of 6 and 4 tons to dispose the waste at Okharpauwa landfill site. Okharpauwa is located at a distance of 30km North-West of Kathmandu. Repeated protest from local people against disposing the waste to the landfill site has worsened the problem. The wastes are transported at a monthly expenditure of NRs 4.5 million.

Public-Private Partnership for Urban Environment (PPPUE) program of United Nations Development Program (UNDP) along with KFVMDC have constructed solid waste digester to produce biogas with the objective of managing waste at the source. One person has been trained to operate and manage the plant output.

The plant is of 10m^3 capacity where 1600 kg of organic waste constituting 1400 kg of cabbage and 200 kg of animal dung was used initially. Since then no specific quantity of waste has been added as the amount of gas generated has not been fully utilized. It has two underground digesters with the gas supply through a galvanized pipe to a cooking stove.

According to KFVMDC Executive Director, there are three reasons for not utilizing the gas. Firstly there is no gas refilling technology to transport the gas. Secondly the distance between the production site and commercial consumers is large and is across the road. Thirdly, the unhygienic conditions created by rotting waste next to the plant discouraged potential consumers to use the gas.

According to KFVMDC authority, farmers took initiative on composting to use as manure. They had allocated 25 ropanis of land at Gurjudhara to compost the waste from Kalimati but the locals protested and put it to the end after 30 days of its operation (Refer Annex 11, photo 5).

3.3.3 Biogas plant at slaughter house in Kankeshwori

The initiative of Nepal Khadgi Sewa Samiti (NKSS) together with local participation and financial support from World Vision International, Kathmandu Metropolitan City, National Zoonosis Food Hygiene and Research Centre and technical support of the Ramaniya Sagarmatha Renewable Energy Technology Development Pvt Ltd. have built a biogas plant. The plant is built on the bank of Bishnumati River at ward number 19 in Kankeshwori.

The plant has a capacity of 300m^3 requiring to be fed with 1,800 kg of semi-digested animal wastes and blood everyday and takes 65 days initially to generate gas. It costs NRs 4.51 million in total to construct the plant and will generate 12,000 liter of gas along with 3,000 liter of liquid compost fertilizer (Refer Annex 11, photo 6-7).

The plant is made with the objective to meet the fuel demands of 100 poor household and employment of 30 persons. In this way the plant is expected to mitigate use of 1500L of Kerosene oil. This anaerobic plant is a part of the campaign to construct a Green belt at the banks of River Bishnumati from Shovabhagwati to Teku. The digester will also prevent more or less 2000-kg biological waste, all of which used to be dumped in the banks of River Bishnumati through the slaughtering of 150 buffaloes every day within a span of 100 meters.

3.3.4 Methane recovery

The baseline emission is calculated from the annual mass of organic components in ton added for the production of methane gas. This value is multiplied with the IPCC default values of 0.6 Methane Correction Factor (MCF), 0.18 Degradable Organic Carbon (DOC), 0.77 Degradable Organic Carbon Fraction (DOCF) and 0.5 Fraction of Methane in Landfill Gas (F), 16/12 and 21 Global Warming Potential (GWP) of methane. This calculation gives the baseline emission (BE) of the project in ton of CO_2 equivalent. From this BE certain amount of methane is lost to the atmosphere; known as project emission (PE) which is 10% of BE as per the default value for enclosed flaring. PE is subtracted from the BE to get the annual methane recovered which is then multiplied with the expected \$6/tonCO_2 to derive the total money to be received under the CDM.

The organic substance added to the digester constituted 3.97 tons in the first year and then 1.56 tons/year. This accounts to a baseline emission of 4.62 tCO_2eq for the first year and 1.82 tCO_2 for every year. The baseline emission was calculated from the Methane Factor (MF) 0.056 from IPCC default values, mass of annual organic wastes used and global warming potential 21 for CH_4. From the baseline emission presuming 90% efficiency default value of the enclosed flaring (Annex 13 UNFCC), yearly 0.46 tCO_2eq is released in the first year and 0.18 tCO_2 every year into the atmosphere. In total for the first year 4.16 tCO_2eq and yearly 1.63 tCO_2eq is sequestered. With the presumed market value of \$6/tCO_2 total amount expected to be received by WEPCO adds up to \$24.97 for the first year and then \$9.81 every year (table 3.10).

Table 3.10 Biogas from solid waste at WEPCO

	Solid waste (Tons/Year)	Annual Baseline Emission (tCO_2 eq)	Annual Project Emission (tCO_2eq)	Annual Emission Reduction (tCO_2eq)	Annual $ Received ($6/ton CO_2eq)
First Year	3.97	4.62	0.46	4.16	24.97
Every Year	1.57	1.82	0.18	1.63	9.81

Similarly, for toilet and MSW biogas plant, the mass of waste designed to be added together with the annual human excretion expected from the 14 staff members was used as input. The annual toilet excretion input was derived from an expected value of a person on average defecating once a day. The average mass of defecation is 260g/person (Schouw N. L et al. 2002). Including the defecation and solid waste, total adds to annual mass of 8.97 tons. When the mass is digested, the baseline emission will be 10.44, and 5.79 tCO_2eq for the first year and every year respectively and with the project emission of 10% WEPCO will get $56.39 for the first year and 31.25 per year (Table: 3.11).

Table 3.11 Biogas from MSW & Toilet

Year	Defecation (tons/year)	Solid waste (tons/year)	Total wastes (tons/year)	Annual baseline emission (tCO2)	Annual project emission (tCO2)	Annual emission reduction (tCO2)	Annual $ Received (tCO2)
First year	1.33	7.64	8.97	10.44	1.04	9.40	56.39
Every year	1.33	3.64	4.97	5.79	0.58	5.21	31.25

Table 3.12 Biogas from vegetable waste at kalimati fruit & vegetable market

	Solid wastes (Tons/Year)	Annual Baseline Emission (tCO_2 eq)	Annual Project Emission (tCO_2eq)	Annual Emission Reduction (tCO_2eq)	Annual $ Received ($6/ton CO_2eq)
First Year	1.6	1.9	0.2	1.7	10.1

At Kalimati Fruit & Vegetable Market the total amount of MSW was 1.6ton. Thus, the total amount of CH_4 prevented was equivalent to 1.7 tCo2eq making the project eligible to receive $10(Table 3.12). However, the gas generated is not being used so not further waste has been added and does not qualify to receive any extra amount of money under CDM framework.

The Kankeshwori Abattoir is expected to feed the biogas plant with 6570tons(as shown below in the Table 3.13) of animal waste annually with this amount the BE will be 7649.1 tCo2eq and PE will be 764.9 tCo2eq thus amounting to 6884.2 tCo2eq methane recovery. Thus, the project will qualify to receive $41304.9 per year.

Table3.13 Biogas from slaughter house at Kankeshwori

	Solid wastes (Tons/Year)	Annual Baseline Emission (tCO_2eq)	Annual Project Emission (tCO_2eq)	Annual Emission Reduction (tCO_2eq)	Annual $ Received ($6/ton CO_2eq)
Every Year	6570	7649.1	764.9	6884.2	41304.9

3.3.5 Composting facility at WEPCO

Out of the various waste handling and management methods, WEPCO is using composting technology along with the waste collection, transportation and segregation activities. A strategy of passive windrow composting is applied by WEPCO to biodegradable waste. The process is carried out under controlled aerobic process and is accelerated by microbial populations. After the construction of infrastructure for composting plant in 1995 with the financial support from DANIDA, WEPCO started its operation in1996.

The major source of solid waste for composting is the MSW obtained from the ward no.1 of Lalitpur Sub-metropolitan city. It includes the left over pulses, rice, vegetable waste, paper, straw, tealeaf, rotten meat, garden waste, etc which are biodegradable in nature (Refer Annex 11, photo 8-9). Apart from the household solid waste, cow dung is also used. WEPCO is able to produce 2000 Kg of compost per year from the biodegradable waste. Nurseries and communities are the major customers of the compost with the positive response. Currently, the compost is being sold at the rate of Rs 10 per Kg. The demand of the compost is increasing, so production is not able to fulfil the demand of the consumers. However, the cost of production is higher than selling cost.

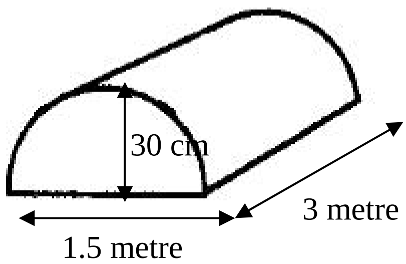

Figure 3.41 Designed shape for piling bio-degradable waste

The technology adopted by WEPCO for composting is the passive windrow composting where production of compost takes place in piles or windrows. The shape of the piles is roughly a half-cylinder with a semi-circular base (Figure 3.41). But the surface of the pile is not uniform, it is irregular in fact. The compost is produced by natural aeration for a long period of time. It is a low and labour approach technology.

Biodegradable solid wastes like left over rice, pulses, vegetable, vegetable waste, straw, rotten meat, tea leaf, garden waste, cover of fruits, etc are piled in open places. Waste rich in carbon and nitrogen is mixed in equal proportion for the production of better quality compost. This process supports the effective action of micro-organisms in degradation of waste. The humus content of the waste should be maintained for composting. In the case of excessive water content, saw dust or ash is added to maintain the normal humus content. Periodic turning of pile is done for aeration which increases the microbial action and degrades the waste rapidly. Soil, compost fertilizer and effective micro-organisms (EM) are also added as catalyst for the effective and rapid degradation of waste. The higher quantity of fat and water increase the acidity. In this case, agricultural lime is added to decrease the acidity. When it is assured that the waste is degraded completely, the well degraded waste which is now compost is separated from the poorly degraded waste. In the process of composting, ten buckets of waste produces about one bucket of compost. The time and duration of composting may vary depending upon the nature of waste. Generally, it takes one and half month to produce compost from the waste. WEPCO is able to manage 1200 kg of waste received daily through composting.

3.3.6 Vermi-composting facility at WEPCO

WEPCO is also promoting vermi-composting technology along with the waste collection, transportation and segregation activities (Refer Annex 11, photo 10). It is actively involved in the conduction of trainings related to vermi-composting. Vermi-composting was started at WEPCO in 2000 and has focused its training campaign in narrow home and the area lacking land for the management of organic wastes produced at the household level and is proved to be effective means of organic waste management. However, it does not use this process for the commercial production of compost at WEPCO. This report will be based on the vermi-composting technology to explore its effect.

The major source of solid waste for vermi-composting include waste produced at the household level such as vegetables, fruits, eggshells, tea bags, garden waste, etc which are biodegradable in nature. For the vermi-composting process, a bin of suitable size is taken. Holes are made at the bottom of the bin. Bedding layer about three inches in thickness of coconut fibre or straw or pieces of paper emerged in water is placed at the bottom of the bean. Again a layer of garden soil mixed with cow dung is spread above the bedding layer. Now the bedding layer and the soil layer are made wet with water. Then the earthworms of compost species are added to the bin. About 500-1000 earthworms are added to the bins depending upon the quantity of the waste and size of the family. Now organic waste produced from the household level such as vegetable waste, rotten fruits, garden waste, etc are kept in the bin. Meat, bones, dairy, fatty or salty food items are avoided. The bin is then closed and kept at normal temperature. Waste is added daily. Regular monitoring of moisture, attack from ants and mouse is also necessary. To separate compost, all compost is kept at a side of the bin and bedding layer is again paced in the left half part of the bin. In this way the separated compost can be used after one month of the separation.

3.3.7 Chamber composting facility in Madhyapur Thimi municipality

Community Development Organization (CDO) is a Community Based Organization (CBO) working at the community level for the collection and management of solid waste in the local level. CDO is using chamber composting technology along with the door to door collection, transportation and segregation activities. Madhyapur Thimi Municipality is assisting CDO financially after the construction of chamber composting plant by World Vision International Nepal, an INGO in 2006 A.D. The chamber composting plant has been basically designed to manage the household solid waste produced from 1000-1500 households.

Currently, CDO is managing Municipal Solid Waste of 305 households from ward number 4, 5 and 6 of the Madhyapur Thimi municipality with the help of three persons involved continuously in the door to door collection, transportation, segregation and operation of chamber composting. It has distributed buckets to all 305 households for the collection of waste. However, it has not provided separate buckets for the collection of biodegradable and non-degradable waste at household level so they are using same bucket for the collection of all kinds of waste. For the collection and transportation of waste, CDO charges certain amount to the households. Apart from that, it receives monthly financial assistance of Rs 90,000 from the Madhyapur Thimi municipality for this purpose.

Thimi Municipality is the pocket area for vegetable production so the amount of discarded vegetable waste is very high in the household waste. The other major source of composting include cabbage leaves, gourd, straw, rotten potato, coriander, brinjal, cucumber, radish, chili, onion, leaves of spinach, etc. Generally, compost can be collected in every two months. However, it has not started commercial production of compost from the waste. It distributes its compost to the community and farmers free of cost.

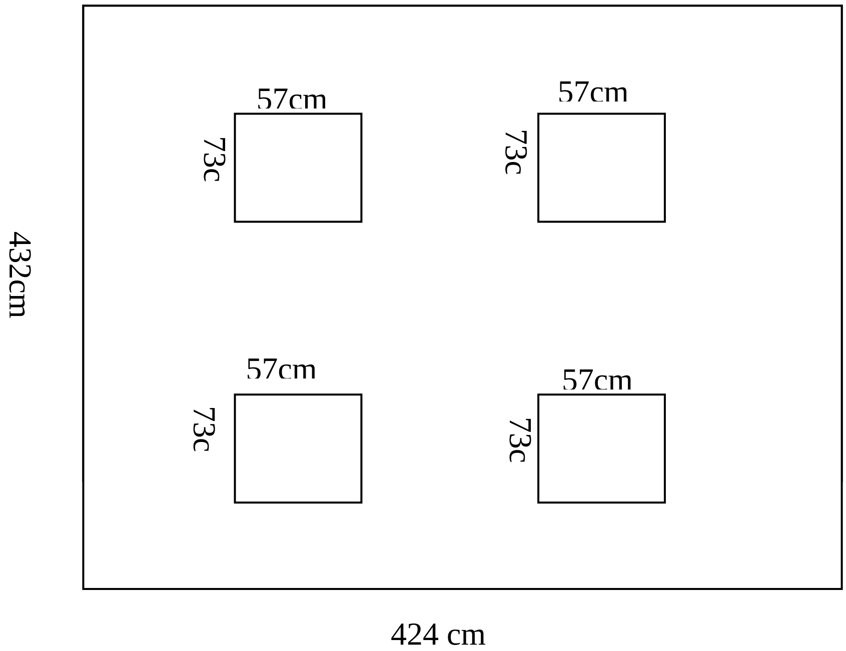

Figure 3.42 Upper view of the chamber

The chamber composting process takes place in a two storey box type infrastructure (Figure 3.42). The upper and lower portion of the chamber is separated by metallic net. The metallic line is also lined with straw. For the process of composting, collected biodegradable and non-biodegradable wastes are segregated before feeding to the chamber (Refer Annex 11, photo 11-13). The segregated biodegradable wastes are then kept in the composting chamber from the top. The chamber receives about 100 kg of waste per day. The decomposition of organic waste occurs under aerobic condition and is carried out by microbial activity. Periodic turning of waste is done in order to increase aerobic process that boosts microbial activity for the compost preparation. Effective micro-organisms are also added during winter season since decomposition process is comparatively slow in this season. The well degraded waste material drops down in the form of compost fertilizer.

Table 3.14 Composting from solid waste at WEPCO

Year	Solid waste (Tons/ Year)	Annual Baseline Emission (tCO2 eq)	Annual Project Emission (tCO2)	Annual Emission Reduction (tCO2eq)	Annual $ Received ($6/ton CO2 eq)
First year	438	386.32	38.63	347.68	2086.11
Every Year	438	386.32	38.63	347.68	2086.11

Table 3.15 Chamber Composting from solid waste at Madhyapur-Thimi Municipality

Year	Solid waste (Tons/ Year)	Annual Baseline Emission (tCO_2 eq)	Annual Project Emission (tCO_2eq)	Annual Emission Reduction (tCO_2eq)	Annual $ Received ($6/ton CO_2eq)
First Year	36.5	42.49	4.25	38.25	229.47
Every Year	36.5	42.49	4.25	38.25	229.47

The baseline emission for composting at WEPCO and Madhyapur-Thimi was calculated from the annual mass of organic components in ton. This value was multiplied with the IPCC default values of 0.6 Methane Correction Factor (MCF), 0.18 Degradable Organic Carbon (DOC), 0.77 Degradable Organic Carbon Fraction (DOCF) and 0.5 Fraction of Methane in Landfill Gas (F) and 21 Global Warming Potential (GWP) of methane. This gave the baseline emission (BE) of the project in ton of CO_2 equivalent. From this BE certain amount of methane is lost to the atmosphere known as project emission (PE) and was considered to be 10%. PE was then subtracted from the BE to get the annual methane recovered which was then multiplied with the expected \$6/tonCO_2 to derive the total money to be received under the CDM (Table 3.14 & 3.15).

3.3.8 Composting in Bharatpur Municipality

A 3 day visit (September 7-9, 2008) was made to the Bharatpur municiaplity for the assessment of the ongoing municipal composting and biogas production activities. With a very high rural to urban migration especially in the Central Development Region the municipality is making plans and taking initiatives to efficiently manage and reduce municipal solid waste generation. Being located closer to the Chitwan National Park the number of tourists visiting the city is high, therefore the necessity of keeping the city clean has become an important task for the municipality.

Bharatpur municipality under the Urban and Environmental Improvement Project, has distributed 620 compost bins. With the funding from Action Aid Nepal, one bin for each household was distributed. Each bin is of 100 liter capacity and made out of plastic material. The objective was to segregate the organic portion of municipal waste and make compost. The bins have been distributed after providing training and collecting some amount of money from each home. A sum of NRS 80 to 150 per household from Shyauli Bazar Tole Sudhar Samiti, Ward 10 (250 household), Chautari Namuna Tole, Ward Number 4 (90 households), Ananda Nagar Ward Number 4 (100 households), Bhagwati Tole Ward Number 4 (100 households) and Mills Area Ward Number 2 (80 households) has been collected. A metal hook for plastic collection is provided by organization named *Suiro* Program and collects every 2 to 3 times a month for recycling (Refer Annex 11, photo 14). In addition to this the municipality has assured those homes of collecting bottles in near future.

To get the view about composting from public, randomly 11 households were sampled from all the project locations. The opinions and problems about household composting varied according to locality and weakness of everybody was against bin composting. The problem about the material of the bin being weak was observed in all the places. The major problem was of the weak material provided by the municipality which collapsed on by its own weight (Refer Annex 11, photo 15). In addition to this, infestation by insects and rodents was causing a nuisance. A major setback about ineffectiveness of the training program was observed. Some houses were unaware of preparing bed in the composting bin. While some house owners reported to have dumped the bins because of it requiring timely monitoring and management. Another problem observed with household bin composting was of the excessive moisture in the compost during the monsoon resulting in the formation of sewer like material which discouraged its further use. The public opinion towards household composting has;70% preferred recycling and other waste management options (Kharel B., Undated).

Reduction of plastic wate in streets was the positive aspect of this initiative in the municipality. The respondents interviewed acknowledged the *Suiro* Program to have made their locality a pleasant place. There was one particular house in Shyauli Bazar Tole Sudhar Samiti of Mrs Tulasa Gyawali who had practiced the process of bin and vermi-composting on own initiative for 8 years and was successfully using the manure in the garden. Organization as JICA too had approached the owner and made appreciation for setting such an example. Even the plastic wastes in her house were observed to be used as a flowerpot. She had been encouraged by her educated husband and well trained by JICA. This example indicates that such programs cannot be effectively executed without good training, women participation and support from family members.

If managed effectively at household level the municipality will be able to avoid 677.8 m^3 of waste collection per year. This is calculated with the waste density of 0.25kg/liter and average family size of 5.2 for Bharatpur municipality.

CHAPTER IV

CONCLUSIONS

The urban areas of Nepal comprise nearly 15% of total population and municipal solid waste management is prominent issues in these areas. This study was focused on the objective of carrying out feasibility study in assessing greenhouse gas (GHG) emission municipal solid waste disposal and clean development mechanism (CDM) opportunities to mitigate the release of GHGs by improving waste management in 15 municipalities of Nepal.

The information was collected by applying different research instruments. Literature were reviewed in order to gather relevant information on municipal solid waste management and CDM opportunities in waste sector from national and international context. Further, household survey and questionnaire survey were conducted to observe and to analyze the current situation of waste management in 15 municipalities of Nepal.

From the study it was found that municipal per capita solid waste generation ranged from the highest 0.325 kg in Biratnagar to lowest 0.12 kg in Bidur and rest of other municipalities lies within this range. Similarly, MSW generation ranged from 65 ton /day generation in Biratnagar to 2.2 ton/day in Ilam. The municipal solid waste shows that it is organic in nature in study area as it consist of 72% kitchen waste followed by 16% and 13% of recyclable and inert waste (including other materials) respectively (Refer Annex 12).

From the survey it was found that majority of study areas were disposing their waste either in open places or at a poorly engineered landfill site in municipality level. In household level the plastic containers were found as commonly used dustbin in all municipalities. It was also observed that 90 % of Baglung community were using plastic bin to collect household waste. Waste separation practice was poorly developed in all municipalities of study area. 90 % of people in Baglung and followed by 60%, 65% and 65% people in Biratnagar, Bharatpur and Ilam municipalities mentioned mixing of all types waste in same container. Similarly, disposal of waste batteries along with other waste was found in all municipalities.

Also, it was found from the survey that people were willing to pay more than Rs. 100 per month (100% respondents in Bidur to 20% in Putalibazar) for efficient solid waste management. Further, the respondents mentioned that it would be better if the city container was located at a 5 minutes walking distance. They also added that the waste should be collected at least once a day.

Awareness regarding compost preparation from organic waste was prevailing in all municipalities of study area and households were ready to make compost from the waste if there would be any kind promotional activities on it .Moreover, almost all respondents in all municipalities would be happy to implement such facility which makes their areas clean and waste free.

Eight areas of Indonesia were also covered in study and found that it had the highest waste generation of 9000 m^3 per day in the area covered under Agency of Cleanliness-2 to the lowest of 1342 m^3 per day in the areas covered under UPTD Kebersihan. The organic fraction was found to be 68% of the total share in Indonesia which was similar to the findings in Nepal.

Anaerobic decomposition of municipal solid waste through open dumping and inefficient landfill site and emission of potential GHG into the atmospheres are responsible to increase adverse environmental impact which is known as global warming. Baseline CO_{2e} emission for solid waste disposal ranged from the highest in 20,925 ton in Biratnagar to the lowest of 708 ton in Ilam and an average emission of 3495 ton from 15 municipalities of Nepal for the base year 2007.Based on these estimation PIN for various disposal options were prepared during the workshop. In addition, some examples of small scale projects in MSW management were studied which included biogas plants and composting facilities, and vermi composting.

A typical small scale biogas plant would reduce an annual GHG emission of 4.16 ton for the first year and 1.63 tons every year. Similarly, from a typical biogas plant utilizing both solid waste and black water would reduce 56.39 tCO_{2e} for the first year and 31.25 tCO_{2e} for every year. Moreover, small scale composting chamber in Madhyapur Thimi could reduce approximately 38.25 ton and 347.68 ton of CO_{2e} emission.

Although, composting was found a feasible option for solid waste disposal, the emission estimation indicated that there could be a barrier of scale economy for putting the projects under CDM framework. Similarly, the institutional capability and political willingness were additional issues identified as major bottleneck. Bundling of the composting projects of two or more municipalities could still be considered for CDM funding.

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