ENHANCING MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM WITH 3R OPTIONS IN THIMPHU, BHUTAN

by

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A thesis submitted in partial fulfillment of the requirements for the
degree of Master of Science in
Environment Engineering and Management

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Regional Office for Asia and the Pacific

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Thailand
December 2007

Acknowledgements

At the outset, my indebted gratitude and enormous thanks goes to Prof C. Visvanathan without whose close attention, benevolence and critical advice, I would have failed to complete this thesis and the Masters degree. My sincere gratitude and thanks also goes to Dr. N. T. Kim Oanh, AIT and Mr. Mylvakanam Iyngararasan from UNEP-ROAP for serving as members of the committee for my thesis and for their constructive comments in the process of my research. Here, I would not like to miss my opportunity to acknowledge Dr. Kim's support and guidance during the period serving as my course advisor. In a wider coverage, I would like to thank the Dean, faculty and the secretaries of the School of Environment, Resources and Development (SERD) for enabling a two years smooth study at the Asian Institute of Technology (AIT).

Very importantly, my sincere gratitude goes to the United Nations Environment Program-Regional Office for Asia and the Pacific (UNEP-ROAP) for supporting with full scholarship to my studies.

Back home, my profound respects to the Royal Government of Bhutan (RGoB) at large and the National Environment Commission Secretariat in particular for giving me the opportunity to pursue the Masters degree. In person, I would like to express my fullest gratitude to His Excellency *Lyonpo* Nado Rinchhen the Hon'ble Deputy Minister of Environment. Without His Excellency's eleemosynary support and encouragement, I would not have visualized the cherished qualifications.

My sincere thanks also go to Khun Prasert Laobusnanant to acknowledge his kind support in many local logistics and specifically for sponsoring and tutoring the SPSS software in my data analysis. Khun Prasert is a Thai PhD student in the field of Environment Engineering at AIT.

Lastly, it gives me a great pleasure to dedicate this study to my late father, my mother, wife and the daughters. The understanding, warmness and love my family bestowed upon me, especially during the period of my stay away from them has been my strength in endeavoring my study and the thesis task.

Abstract

Bhutan, a small Himalayan Kingdom, where "Gross National Happiness (GNH)" philosophy is the guiding spirit for the developmental progress, sustainable wastes management is inevitable, especially the municipal solid wastes (MSW). A nation, highly dependent on import, subsistence farming and tourism needs to be very careful with wastes generation and the management. As of now, the major population remains innocent about the consequences of the unmanaged wastes and waste management techniques. Also, very limited options remain for improvement of the conventional waste management systems. In most urban settlements, formal waste management does not even exist.

In Thimphu, the capital city, the conventional system of collecting, transporting and disposing the MSW initiated in 1993 is ongoing. There has been not much improvement or changes in the system over the years. The collected wastes is transported and dumped at Memelakha, an open site about 10 kilometers away from the downtown. Around 80,000 people live in the 26 square kilometers city area of Thimphu, which stretches from Chantagang in the north to Ngabi Rongchu in the south, fanning on Thimphu River. The Thimphu City Corporation (TCC) is solely responsible for managing the MSW of Thimphu city. It has limited resources, manpower and facilities. Public responsibility sharing and specific waste management institutional tools also are limited.

The weeklong physical survey at the Memelakha disposal site for my thesis study found that around 32 tones of commingled wastes is daily collected and transported to this site. The site is virtually over used and wastes are physically overflowing. The physical survey at the source point conducted for three months, from March to May 2007 found that the per day source point waste generation capacity is around 65 tones. Residential household per capita waste generation is estimated to be 0.56 kg/day. All the uncollected 50% wastes may not be remaining in the environment because certain recyclable waste components are collected by business vendors and informal waste pickers for trading across the border or recycled.

There are cost effective policy options in the 3Rs paradigm to address the MSW management of Thimphu. Few crucial parameters to highlight are; i) introduction of 'polluters pay principle' (municipal taxation and service fees) for financial security and responsibility sharing, ii) formalization of the international/regional waste management cooperation, iii) encouragement of private parties and industries to initiate cooperation in MSW management, iv) enhancing MSW management awareness and education, v) very importantly to apply waste segregation practice at source and establish a transfer station. It is inevitable that the upcoming National Solid Waste Management Act must embrace all these crucial elements.

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List of Abbreviations

3R(s)	Reduce, Reuse, Recycle
AIT	Asian Institute of Technology
ANU	Australian National University
APFED	Asia Pacific Forum for Environment and Development
ASEAN	Association for South East Asia Nations
AWP	Army Welfare Project
BFP	Bhutan Fruit Products
BTN	Bhutanese Ngultrums (currency)
C/N	Carbon/Nitrogen (ratio)
CBS	Centre for Bhutan Studies
CTEM	Clean Technology and Environmental Management
DANIDA	Danish International Development Agency
DNP	Department of National Properties
DRC	Department of Revenue and Customs
DUDES	Department of Urban Development and Engineering Services
EA	Environmental Assessment
ECoP	Environmental Codes of Practices
EPA	Environmental Protection Agency (Ireland)
E-waste	Electronic/electrical waste(s)
EUSPS	Environment and Urban Sectors Programme Support
FDCL	Forestry Development Corporation Limited
GDP	Gross Domestic Product
GHG	Greenhouse Gas(es)
GNH	Gross National Happiness
HCF(s)	Healthcare facilities
HDPE	High Density Polyethylene
HH	Household(s)
IGES	Institute for Global Environmental Strategies
ISO	International Standard Organization
ISWM	Integrated Solid Waste Management
JICA	Japanese International Cooperation Agency
KMT	Karma, Manila and Tenzin
LDC	Least Developed Country
LDPE	Low Density Polyethylene
MEA	Multi Environmental Agreements
M/F	Male/Female
MoE	Ministry of Education
MoH	Ministry of Health
MoWHS	Ministry of Works and Human Settlement
MSW	Municipal Solid Wastes
MTI	Ministry of Trade and Industry
MW	Mega Watts
NEC	National Environment Commission
NIES3	(the republic of Korea, Singapore and Taiwan province of China)
NGO	Non-Governmental Organization
NSB	National Statistical Bureau
NSWM	National Solid Wastes Management
PDR	Peoples Democratic Republic (Laos)

PC	Planning Commission
PET(E)	Polyethylene terephthalate
PHCB	Population and Housing Census of Bhutan
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
RCSC	Royal Civil Service Commission
RDF	Refuse Derived Fuel
RGoB	Royal Government of Bhutan
RSA	Rinchhen and Sons Association
RSPN	Royal Society for Protection of Nature
RSTA	Road Safety and Transport Authority
SERD	School of Environment, Resources and Development
SO	Section Officer/Sub-Overseer
SPSS	Statistical Package for Social Science
SWM	Solid Waste Management
TCC	Thimphu City Corporation
TEI	Thailand Environment Institute
TERI	The Energy Research Institute
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-ROAP	UNEP-Regional Office for Asia Pacific
UNOPS	United Nations Office for Project Services
US$/USD	United States of America Dollar
VCR(s)	Video Cassette Recorder/Replayer
WEEE	Waste Electrical and Electronic Equipment
WSSD	World Summit on Sustainable Development

Chapter 1

Introduction

1.1 Background

Inherent human desire in resources consumption governs the waste generation capacity. The municipal solid wastes (MSW) quantity and composition therefore depend on population density, source diversity and the income of the people in the locality. With increase in population, economic activity and the income, the MSW quantity and composition including the non-biodegradable and hazardous wastes is bound to increase. The evolutionary waste quantity and characteristics accordingly challenge the municipal authorities in management, demanding more and more resources and technological capability. In developing countries where resources and capacity is constrained, the challenges thus become serious.

Bhutan, a small Himalayan Kingdom, winner of the 2004 "Champion of the Earth" (Kuensel, 2005) and the "World Conservation Leadership Award" (Kuensel, 2006) is not spared by the challenge of the urban solid waste management (SWM). Where "Gross National Happiness (GNH)" philosophy is the guiding developmental policy (CBS, 2004), safe and sustainable SWM is inevitable. To maintain good human health and the environment for the GNH spirit, adequate SWM is crucial. Otherwise prioritizing environment conservation in the government policies (PC, 1999; NEC, 1998) as one of the four pillars of the GNH (CBS, 2004) will be undermined. There will be no greater impact on the conservation quality than the contamination of the soil, water and air through unmanaged or under-managed wastes. A nation, highly dependent on subsistence farming for livelihood of the majority population and hydropower and tourism for its external revenue also calls for extra care in wastes management.

As of now, the major population remains innocent about the consequences of the wastes and the "hard to die old habits" continue disposing the wastes irrationally. In Thimphu, the local municipal authority, Thimphu City Corporation (TCC) is solely made responsible of collecting, transporting and disposing the MSW. This mandate is further strengthened by the Bhutan Municipal Act of 1999 (RGoB, 1999) when it communicates that the municipal authorities are responsible for collecting, transporting and disposing the MSW as a public service. The limited authority, fund, manpower and technological options on the other hand have deprived the agency to cater satisfactory services. The solid wastes collection, transportation and disposal at Memelakha for Thimphu was initiated since May 1993 (TCC, 1992). Over the years there has been no improvement or changes in the system. The site at Memelakha is overflowing with wastes. Yet, there is no alternative site or options to stop disposing the wastes at this site. An alternate site identified lacks fund to construct an access road and to develop the site. Reduce and reuse options were never captured in the policies and the recycling option recommended in the 1992 project document (TCC, 1992) has not materialized effectively. The recommendation of recycling of wastes in three phases; 5% in two years time, 10% in three years and 50% in five years to increase the life span of Memelakha site to a maximum of twelve (12) years remained shelved document. The waste disposal at the site is ongoing for the last more than fourteen (14) years without any separation and pretreatment initiatives.

Public responsibility sharing and specific waste management institutional tools also are limited. The rules (RGoB, 1995), and Codes of Practices (NEC, 2000a; NEC, 2000b; NEC, 2002b) developed by various organizations did not have much reference after the publications. Lately, the Royal Society for Protection of Nature (RSPN), the only environmental non-governmental organization (NGO) has published a public-private partnership policy framework for solid waste management (RSPN, 2006). The Ministry of Works and Human Settlement has published a national strategy and action plan for solid waste management (MoWHS, 2007a). Both the documents highlighted requirement of introduction of 3Rs (Reduce, Reuse and Recycle) as effective steps in the Bhutanese solid waste management systems, but did not identify the viable 3R options. The prevailing predominant solid wastes reduction practice is separation of valuable wastes, mostly metals and beer cans and bottles, by the informal waste dealers, scavengers including the municipal waste collection laborers, for sale across the border. This sale across the border remains illegal since no formal agreements for the business exist between the national governments.

If compared with the size of urban areas and the waste quantities in the region, Bhutan's solid wastes is so small that it should be manageable. It should be manageable with appropriate policies and institutional setup in place. Not necessarily requiring sophisticated and expensive technologies. This study therefore aims to analyze management gaps in the present urban solid waste management system of Thimphu and identify 3R options, mainly applicable low cost policy options. Anything that improves the situation in Thimphu should be applicable to other urban settlements in Bhutan as Thimphu is the capital and the biggest urban settlement.

1.2 Objectives

The specific objectives of the study include;

1. To conduct field survey to develop a segregated waste inventory to have an overview of the waste compositions, per capita and total waste generation capacity,
2. To collect secondary data and interview relevant respondents to understand the gaps, mainly the policy gaps in the present waste management system, and
3. To find potential 3Rs options, mainly affordable policy options, for the management of the predominant waste components in Thimphu.

1.3 Scope of the study

1. Collection of primary and secondary data through field survey, observations and questionnaires,
2. Reviewing the data, the existing policies, legal tools and the solid waste management technologies in place,
3. Developing a segregated waste inventory to understand the prevailing waste composition, percapita and total waste generation capacity, and
4. Evaluation and identification of viable 3R options, mainly low cost policy options to enhance urban solid waste management in Thimphu.

Chapter 2

Literature Review

Resources consumption and the waste generation are inbuilt in the living process of a human life. Human activities alter all the wastes composition conditions and pose a challenge in the waste management. The wastes, if unmanaged or inadequately managed pose threats of epidemic diseases, air pollution and groundwater contamination besides space constrain, odor and aesthetic problems. The situation is worse in a municipal waste management where wastes variety ranges from biodegradable organic wastes to toxic, infectious and hazardous wastes generated from various sources (Tchobanoglous *et al*, 1993).

Since late 1990s and especially after the 2002 World Summit on Sustainable Development (WSSD) at the Johannesburg, 3Rs (Reduce, Reuse, Recycle) has become a limelight in solid waste management paradigm (TEI and Sasaki, 2006). The developed countries have adopted the concept with strategic policies and legal instruments. Only in the developing countries, the concept is gaining popularity at a slow pace. In Asia, the developed country, Japan is concerting immense efforts and supporting to elevate the 3Rs concept in the region. The major developing countries like Thailand, Malaysia, China, and India have begun to adapt to the initiative and exercise pilot projects. According to Thailand Environment Institute (TEI) and So Sasaki (2006), Thailand has achieved few exemplary projects of 3Rs initiative for other neighboring countries to follow. It draws therefore the interest to study the feasibility of applying 3Rs options towards enhancing the municipal solid waste management in Bhutan, firstly for Thimphu municipality.

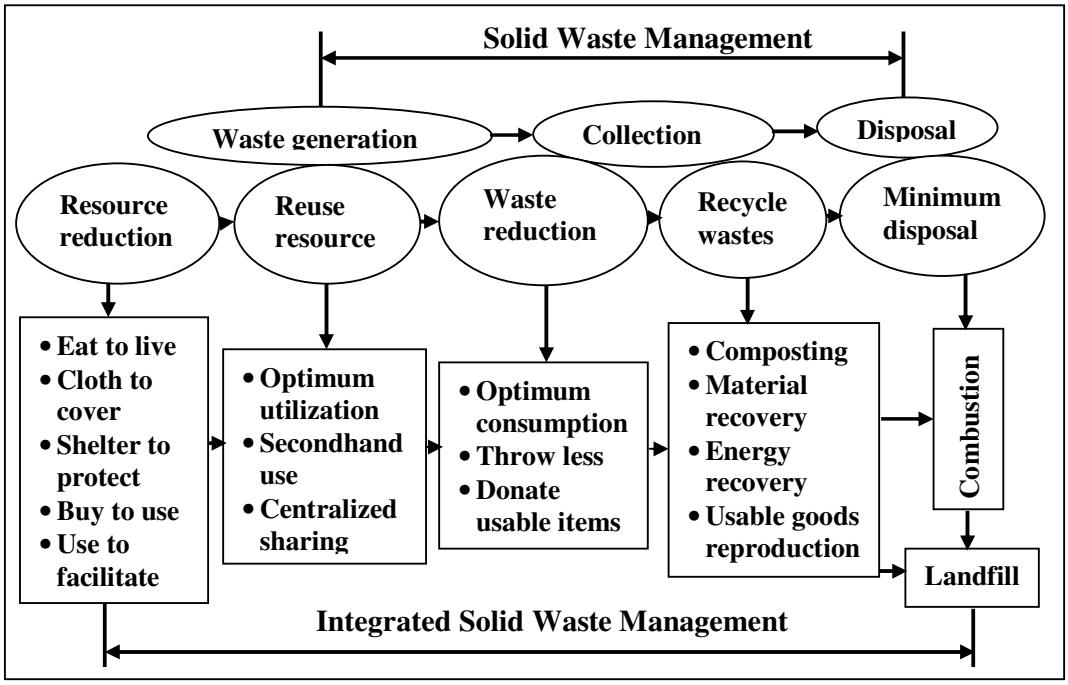
2.1 Municipal solid wastes (MSW) management concept

Public and the local authorities have the responsibility to dispose municipal solid wastes to protect public health and the environment. Managing municipal waste, industrial waste and commercial waste has traditionally consisted of collection, followed by transportation and disposal. The particular concerns of unmanaged wastes arise during rainy seasons, high temperature and when there are settlements in close proximity or the low-lying areas. The run-off and high humid conditions increase the health hazards. The not well maintained landfill sites become prone to soil and groundwater contamination due to leachate percolation. Open dumping of garbage serves as breeding ground for disease vectors like flies, mosquitoes, cockroaches, rats and other pests. High risk of spreading diseases like typhoid, cholera, dysentery, yellow fever, encephalitis, plague and dengue fever also exist in such an environment (TERI, 2006). Other risks of burning of wastes and open dumping are the air pollution to instigate respiratory and skin diseases besides contributing greenhouse gases (GHG) into the atmosphere. Therefore, it becomes a paramount importance for a mountain encased country like Bhutan to have in place a system that addresses safe and sustainable municipal solid wastes management. The MSW management becomes increasingly important as countries expand their economies and urban population keeps increasing (IGES, 2006a; Fernandez, 1997).

2.2 Integrated MSW management

The conventional systems of solid wastes management involving collection, transportation and disposal fails to confront the challenges posed by the modern wastes evolution. It is

therefore important to keep integrating innovative techniques in the prevailing systems to tackle the challenges. The innovative techniques to be integrated must be capable of reducing the quantity of wastes, recovering materials for recycling, producing energy or alternate resources from the wastes, and ultimately reducing hazardous effects for more safe and efficient disposal. A system that integrates various effective techniques towards achieving safe and sustainable wastes management is called the Integrated Solid Waste Management (ISWM). An ISWM process in general may comprise of a system flow as shown below in figure 2.1.

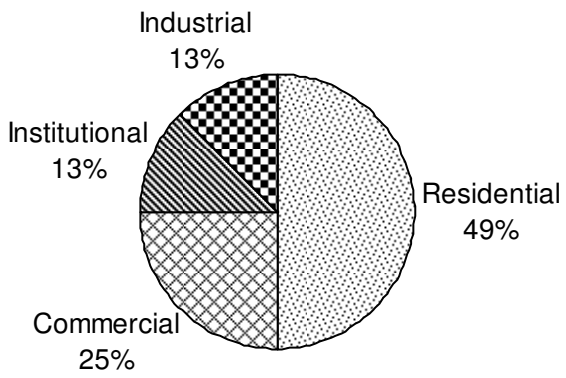


Source: Modified from (Hickman, 1999)

Figure 2.1 Integrated Solid Waste Management paradigms

2.3 MSW sources and composition

The wastes sources can be classified according to resources consumption and the landuse patterns. For MSW, various sources include: residential households; commercial areas; institutions including hospitals, and offices; industries; construction and demolition sites; and street management activities. A typical MSW percentage from various sources in a municipality can be as shown below in figure 2.2.



Source: (Hickman, 1999)

Figure 2.2 Typical MSW percentages by sources in developed countries

The MSW composition can range from the refuse produced by every family in a household to highly toxic industrial wastes from the production of specialized goods such as electronics, computers, cars, petrochemicals, and plastics (Tchobanoglous *et al*, 1993). This is why the MSW composition is considered complex and it needs considerable care to determine its composition and in defining it. Predominantly the composition of MSW in the developing countries remains biodegradable organic wastes, usually food waste and vegetable wastes. Its decomposition process therefore attracts most of the ill-effects of a MSW. The typical composition of MSW wastes in developing countries is described below in table 2.1 and its characteristics shown in table 2.2.

Table 2.1 Typical MSW categorization and its compositions in India

MSW category	Typical composition
Organic waste	Kitchen waste, vegetables, flowers, leaves, fruits.
Toxic waste	Old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
Recyclable	Paper, glass, metals, plastics.
Soiled	Hospital waste such as cloth soiled with blood and other body fluids.

Source: (TERI, 2006)

Table 2.2 Typical composition of MSW in developing countries

Description	% by weight		
	(a) India (Kolkota)	(b) Thailand (Pathumthani)	(c) In Malaysia (Nibong, Tebal, Penang)
Compostable organic matter	40	49.6	52.0
Paper	10	4.5	16.5
Plastic	8	24	15.0
Glass/ceramics	3	1.7	7.0
Metal	-	2.9	5.0
Yard waste (grass)	-	6.5	2.0
Wood	-	-	1.5
Textile	3	5.5	1.0
Ash and others	35	1.00	-
Leather	1	1.9	-
Miscellaneous	11.73	0.4	-

Source: (a) and (b) Visvanathan *et al*, (2004); (c) Isa *et al*, (2005)

The MSW also is potential to contain hazardous wastes. Usually an approximate component of 1% of the total MSW is hazardous wastes (Tammemagi, 1999). Typical household hazardous waste types are as listed below in table 2.3.

Table 2.3 Household hazardous wastes stream composition in developed countries

Household hazardous waste component	Component percentage (by weight)
Household maintenance products	34
Batteries	19
Cosmetics	12
Household cleaning products	12
Automobile maintenance products	11
Yard maintenance products	4
Miscellaneous	8

Source: (Hickman, 1999)

The municipal solid wastes sometimes is referred to as garbage, refuse, or sludge from waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material including solid, semisolid, liquid or contained gaseous material resulting from industrial, commercial, mining and agricultural operations, and from community activities. The types of solid wastes according to their sources area and composition types also can be classified in three categories; (i) Municipal garbage, (ii) industrial wastes, and (iii) hazardous wastes (Tammemagi, 1999). Whatever, the different categories of waste generated in the municipal garbage takes their own time to degenerate as illustrated below in the table 2.4.

Table 2.4 Types of litters taking respective approximate time to degenerate

Type of litter	Approximate time it takes to degenerate the litter
Organic waste such as vegetable and fruit peels, leftover foodstuff, etc.	A week or two
Paper	10–30 days
Cotton cloth	2–5 months
Wood	10–15 years
Woolen items	1 year
Tin, aluminums, and other metal items such as cans	100–500 years
Plastic bags	One million years?
Glass bottles	Undetermined

Source: (TERI, 2006)

2.4 3Rs for sustainable MSW management

2.4.1 Concepts of 3Rs

The concept of minimizing waste impacts in terms of quantity or ill-effects, by reducing quantity of wastes, reusing the waste products with simple treatments and recycling the wastes by using it as resources to produce same or modified products is usually referred to as "3R" (Shimizu, 2006). Purchasing and using resources with care can reduce the pace of consumption of resources and further connected energy and resources. Ultimately reducing wastes in multifold streams. When long lasting goods are reused time and again, it offsets harvesting of new similar or same products. This saves fresh resources exploitation and waste generation quantity. Some waste products can be consumed as resources for production of different goods or the same product, meaning recycling the same resource. This too saves fresh resources and offsets waste generation. All in all, the 3Rs individually or collectively saves fresh resources exploitation, add value to the already exploited resources and very importantly minimizes the waste quantity and its ill effects. Waste minimization efficiency is stated to be better achieved applying 3Rs in a hierarchical order; Reduce, Reuse and Recycle (Shimizu, 2006).

2.4.2 Initiatives of 3Rs in Asia

The 3Rs was given a high priority at the 2002 World Summit for Sustainable Development (WSSD). Then the 30th G8 Summit in June 2004 held at Sea Island, Georgia adopted the 3R as a new G8 initiative (UNEP, 2005). Under Japan's initiative and support the 3R initiative has reached to the Asian developing countries. Several rounds of expert meetings and Ministerial level conferences had been held to promote 3R initiative in Asia and Pacific. Several expert papers also has been presented, compiled and published (IGES, 2006b). An Asia Pacific Forum for Environment and Development (APFED) on 3Rs has also been launched in 2006 (Shizumi, 2006; IGES, 2006a).

The APFED Policy Dialogue meeting on 3Rs held in March 2006 in Tokyo, Japan made number of recommendations encompassing policy measures, institutional arrangements, market based measures, research and technology development, partnership building and stakeholder involvement, international collaboration, etc. to promote 3Rs initiatives in

Asia. The meeting also identified following wastes in Asia and Pacific region priority to promote 3R initiatives (IGES, 2006a):

(i) Organic waste: Compost and methane fermentation for organic wastes instead of conventional system of incineration and landfill disposal.
(ii) Medical waste: Either incineration or autoclaving to prevent infectious disease outbreak or soil/water contamination from untreated medical waste.
(iii) Waste electrical and electronic equipment (WEEE): Promoting and formalizing regional/international collaboration in trading and recycling recyclable materials between countries to prevent release of hazardous materials from WEEE wastes.
(iv) End-of-life vehicles: Similar to WEEE wastes, end-of-life vehicles also should be recycled through international/regional collaboration and prevent their hazardous materials release to the environment.

2.4.3 Elementary instruments in 3Rs initiative

The United Nations Environment Programme (UNEP) in its contribution paper, "Strategic Elements in Implementing the 3R Platform" to the 3R Ministerial Meeting of April, 2005 in Japan has been explicit in mentioning that a number of prerequisites and barriers are potential to influence the efficiency of 3R initiative (UNEP, 2005). The identified factors were; enabling policy framework, education and awareness of all concerned, capacity building and technology support, including human resources, technology, finance, etc. The document also highlighted that acceptance and implementation of 3R concept by the countries and entities in their policies is of critical importance for the success of the initiative. In order to overcome the barriers and fulfill the prerequisites, it has been felt important to understand few elementary instruments in the implementation of 3Rs.

- **Financial security**

The government funding in full to the wastes management is limited in developing countries (UNOPS, 2007). On the other hand, financial security is the backbone for any innovative and sustainable initiative. Dependence on external (donor) assistance and loan from the financial institutions is risky with extravagance liabilities. Therefore, an internal mechanism to ensure consistent financial resources is crucial to enhance and sustain an appreciable waste management system. The avenues to establish such an inbuilt system are; i) privatization of the activity with adequate guidelines, and enabling instruments provision in the legal framework, or ii) "polluters pay principle", municipal taxation on non-degradable goods import and municipal service fee on the waste generation sources, including the industries (MoWHS, 2007a). This is expected to substantially supplement the financial recovery from the recycling activities to sustain and enhance MSW management.

- **Laws and institutional arrangements**

Governance is one of the main strategic factors that need consideration for the success of 3Rs (UNEP, 2005). Institutional arrangements include framing appropriate policies, laws, regulations, guidelines, standards and enabling instruments that can facilitate implementation of 3Rs initiative. Clear cut responsibilities governed by strategic institutional arrangements can offset misunderstandings, jurisdiction overlap and vested interests, to contribute substantially to the effectiveness and sustainability of a MSW management. Lack of clear roles and responsibilities does constrain solid waste

management (Visvanathan, 2006a). It is therefore of paramount importance that the national governments consider institutional arrangements considering clear cut roles and responsibilities, capacity building through knowledge sharing, enabling policy framework addressing economic and market based instruments, and facilitation of providing accurate and timely information to all stakeholders. An institution addressing all such matters will ensure meeting the national and international commitments including the Multi Environmental Agreements (MEA) obligations (UNEP, 2005).

- **Waste segregation**

Separation of waste at source is of paramount importance in 3Rs initiative. The MSW by virtue of its diverse sources will have mixture of materials. Without waste separation the composition of wastes will not be known and planning, designing and implementation of waste management systems is not possible. Waste separation therefore is a key activity in any successful 3R initiative. In general, the wastes can be separated at three levels; 1) household and community level, 2) in the process of collection and transportation by municipal workers, and 3) at the waste disposal site by the workers and the scavengers (IGES, 2006b). It is also important to note that in absence of recycling industries or buyers for the segregated wastes, the sorted wastes end up discarded and mixed with unsorted wastes in open spaces or at disposal sites.

- **People's participation**

In the 3Rs initiative, people's participation is anticipated to function in an integrated manner. People's participation is the driving engine for success of any mass activity (Tokyo 23 Cities, 2005). Especially in 3Rs initiative, people's participation is crucial and it is necessary to create a "recycling-oriented society" (JICA, 2005). Segregation of wastes can be done best at the source point and it cannot happen without cooperation of the people. People's participation can be accounted in various forms and at various levels. A simple example is that unless people choose to consume recycled products, there will be no buyers for the recycled products. There will be no wider awareness of the benefits of the recycled products. A concerted effort therefore is crucial in the MSW management (RSPN, 2006). It is important to have good relation between people and the government to implement any policies (Kojima, 2005). People's participation worthwhile to note include; wider awareness/education, responsibility and knowledge sharing, creation of innovative market-base instruments, private initiatives to enhance income and employment opportunities, and possibility of leasing MSW management services and cost sharing through service fees. Lack of partnership is an obstacle in any sustainable mission (Shimizu, 2006). People's participation and responsibility sharing can be through; i) payment of municipal tax or fees for financial sustainability of the services, and ii) through encouragement of privatization with incentives like enabling activities, capacity building and legal support.

- **Landfill**

No waste management can go without landfill for the simple reason that waste can never be zero for disposal. With the best policy and technology implementation, waste cannot be made zero. All waste minimization activities; incineration, composting, recycling, etc. produce wastes in their own processes and from the products to cause pollution (Kojima, 2005). Therefore, landfill is the ultimate technology to cease wastes issue. However, waste

disposal cannot sustain with only landfill disposal (Kirkeby *et al*, 2006). It is usual challenge to the local authorities, especially in urban areas, to find new landfill sites due to the scarcity of space and opposition from the public. As a result, solid waste disposal by landfill become more expensive as it needs to be transported far away for disposal.

Also, the characteristics of a modern landfill include methods to contain leachate, such as lining clay or plastic liners. Disposed waste should be compacted and covered to prevent attraction of mice and rats and wind-blow littering. Many landfills also have gas extraction system installed after closure to extract the gas generated by the decomposing wastes. Such gas is often burnt in a gas engine to generate electricity. Flaring the gas off is even a better environmental solution than allowing it to escape to the atmosphere. Main gas from such enclosures is methane, which is a far stronger greenhouse gas than the carbon dioxide. However, inclusion of all such provisions makes the landfill unaffordable (Kirkeby *et al*, 2006) in the developing countries.

- **Composting**

Predominantly the composition of MSW in the developing countries remains biodegradable organic wastes (more than 40%), usually food waste and vegetable wastes (Visvanathan *et al*, 2004; Isa *et al*, 2005). Due to the ubiquitous nature microorganism presence in the biodegradable wastes, it starts to decompose as soon as the waste is discarded at the source point. Therefore, it is this waste component that commonly mess the MSW management with odor and vermin attraction.

Composting is an effective approach to reduce waste pressure on landfill sites and improve hygienic conditions. It needs to be started as soon as the waste is harvested (IGES, 2006b; UNDP, 2000). Composting of organic wastes is a historical concept and a 3Rs initiative. Composting is a controlled aerobic decomposition process of the organic matters considering parameters commonly like; nutrient balance (C/N ratio), particle size, moisture control, aeration requirements, temperature and pH mainly to destroy the pathogens (Polprasert, 1996). A compatible composting system can include waste paper if adequately separated. Composting is managed at various levels; home composting, community composting and central composting (UNDP, 2000; Visvanathan, 2006a).

Adequate segregation of wastes however is a perquisite and the backbone of the compost quality. High cost does incur in qualitative composting and the economic return will solely depend on the quality of the compost and the market. Whatever said and done, considering the landfill space constrains, hygienic and aesthetic values, composting is always a viable option in developing countries for the MSW management. Should the composting work efficiently, it is also a source of revenue generation and employment.

- **Promotion of the 3Rs at the regional and international levels**

The APFED Policy Dialogue on 3Rs in Asia also highlighted that there is already an intensifying trend of trading wastes across the international borders due to the globalization process and interwoven business ventures. Examples are; 1) the ferrous waste import within ASEAN and the NIES3 (the republic of Korea, Singapore and Taiwan Province of China) and 2) the Japanese manufacturer Thai Negoro recycling PET bottles in Thailand (IGES, 2006a; TEI and Sasaki, 2006). The ferrous waste import of ASEAN and NIES3 is that the host country requiring ferrous raw materials for some particular production imports

ferrous waste from neighboring countries in the region. The Thai Negoro PET bottle recycling plant meets its 400 tons raw material demand by collecting 125 tons (about one third) within Thailand and import the remaining two thirds (275 tons) from Japan. 85% of the PET recycled product, a $1m^2$ carpet, producing 1.2 million km^2/month is re-exported to Japan. The APFED Policy Dialogue recommends a similar fashion international/regional movement of all recyclable materials as a 3Rs initiative. A mechanism established to trade waste products from the countries not having their own recycling capacities to the neighboring countries will be a promotion of 3Rs initiative through regional and international cooperation (IGES, 2006a).

- **Informal waste recycling**

Citizens in the developed countries with higher knowledge of environmental consequences practice waste separation at household level and recycling process takes place in a mechanized system (Sinha and Amin, 1995). Such a thing does not happen in the developing countries firstly due to lack of institutional provisions. Secondly, due to low level awareness the sense of environmental responsibility is poor. Also, very prominently in south Asia, the social stigmas, looking down on waste handlers prevent people's interest in the waste management. Therefore, in developing countries, like in the city of Dhaka, Bangladesh, the informal sector waste pickers and waste recycling usually happens at a low profile to improve their economic incentives (Lohani, 1984). It is usually performed at very small scale and in isolated manners. The grim reality in this system is that child and women labor is prominent and security from health hazards and conflicts is negligible. Nevertheless, these informal waste pickers and recyclers perform waste separation more efficiently and contribute significantly to the waste management in developing countries.

A successful example of an informal waste recycling venture is Wongpanit recycling company in Phitsanulok, northern Thailand (TEI and Sasaki, 2006). The company in quest of economic efficiency introduced a Japanese technology to recycle press machines from waste plastics because all the plastic wastes could go into the process of recycling the plastic press machines. The Wongpanit recycled press machines costs only 100,000 Baht against imported machine costing 400,000 Baht. There is no efficiency difference in the machine functions. This attracted the market and the company ultimately helped the city reducing waste quantity from 140-180 tons per day to 70-80 tons in the MSW collection. The municipality is now believed to collect the waste only once or twice a week. The success venture of the Company now is said to be expanding to regional cooperation in Cambodia and Laos PDR with collaboration support from the UNDP.

- **"Junk shop" and "Waste Bank"**

One of the latest innovative ideas on trail that fits into 3Rs concept is the "Junk shop" or "Waste Bank" business (Kojima, 2005; TEI and Sasaki, 2006). It could possibly work better in areas with more institutions, schools and school children. The Junk Shop will accept recyclable wastes to exchange with waste recycled products from the shop. With the Waste Bank, one can deposit the recyclable waste in the Waste Bank and collect the returns as and when required; similar to the functions of the Banks. Such business, both in case of Junk Shop as well as Waste Bank could do with goods some thing like wastes paper exchanged with waste paper product stationeries, packing materials or toys. School children bringing in recyclable waste products like, paper, glasses, metals, plastics, etc. could exchange or withdraw recycled waste paper books, envelopes, packing boxes, toys,

bicycles, football, and T-shirts. An example of Junk Shop technique is referred in Phitsanuk in northern Thailand by TEI and So Sasaki (2006). It is recognized to be quite successful in the city's solid waste management. It is also a recognized system of efficiently educating young children about environmental conservation values and methods.

2.4.4 3R options for predominant waste components in developing countries

- **Municipal organic waste**

While reduction and segregation at source should be a priority, composting is the most effective end-of-pipe treatment considering recycling/recovery benefits for the biodegradable MSW even in the 3Rs concept. With composting, significant quantity of MSW is expected to be prevented from going to the landfill site. Segregation at source for composting also benefits management process of other waste components. Wastes without biodegradable composition will be much cleaner and odor free to handle. Composting of organic wastes kills pathogen to improve hygienic conditions (IGES, 2006b). It creates employment opportunities and alleviates management and budget pressure in the MSW management systems.

Example of a community level composting success is said to have in Pakkret, Thailand (TEI and Sasaki, 2006). The Pakkret city initiated composting of food and organic wastes for fertilizer and methane-energy. The composting plant built with 1.37 million Baht with support from JICA, collects food wastes from about 170 households and process 300 kg/day of wastes to produce fertilizers for the local community.

- **Papers and Cardboard**

Paper wastes including corrugated containers and boxboard constitutes usually the largest component (approximately 25-40%) of the MSW in volume (Tchobanoglous *et al*, 1993). Types of paper wastes include newspaper, corrugated cardboard, high-grade paper, and mixed paper. The papers mills receive the paper and cardboard wastes for recycling. The mills accept the waste papers provided they are segregated to meet the raw material quality of the mill. The four usual categories of waste paper are separated into three categories in paper recycling. They are as; pulp substitutes, de-ink grades, and bulk grades. The unprinted papers are favored and accepted to use it directly as substitute pulp. The other waste papers are recycled to reproduce as tissue papers, news papers, stationeries, packing materials, container boxes, etc. The waste papers also can be recycled as building materials by reproducing it into gypsum wallboard and fed as composting raw material. The ultimate disposal option of waste papers will be to use as refuse derived fuel (RDF) due to its high calorific value. In the developing countries, the waste paper usually needs re-segregation and cleaning after receiving at the plant. Therefore, it becomes a source of employment, but a cost burden.

- **Automobile wastes**

Recycling of junk automobiles is highly dependent on the scrap metal market except where recycling is mandated by legislations, usually in the developed countries. Most economists do not account benefits of waste metal recycling to the environment. The cost of extraction of virgin materials is never correlated to recycling. The recycling of metals usually requires

much lesser energy, water and other resources than in producing fresh materials (Butteriss and Sinden, 1994). The examples given are; recycling 1000 kg of aluminum cans saves approximately 5000 kg of bauxite ore being mined and 97% of the energy required to refine it. Recycling of steel saves about 95% of the energy used to refine virgin ore in Australia.

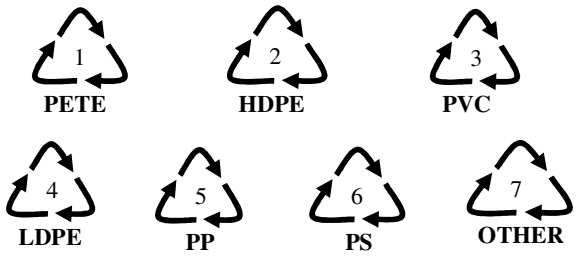
- **Waste glasses**

Typically, glass constitutes around 8% by weight of the total MSW in the developed countries like United States (Tchobanoglous *et al*, 1993). It may be lesser in developing countries. However, it is important to consider waste glasses for recycling. The benefits of glass recycling include reuse of the material, energy saving, reduction in use of landfill sites and in most cases cleaner and safer composting of organic wastes. Glasses can also be used as RDF material. In usual cases, glasses are recycled to reproduce new glasses, glass containers and bottles. Major developing countries are capable and posses glass recycling plants. Therefore, for those countries not having their own recycling capacity, recycling of waste glasses through regional/international cooperation may be an option.

- **Plastics and PET bottles**

Plastic is a convenient commodity to be used in many forms, but mostly used as packing materials, containers and hand-carry bags. Plastics have many advantages: they are light, durable, often provide safer container, good insulators, flexible to be formulated to any shape, etc. Also, due to its advantages in packing wet foods and usage in microwave ovens, plastic goods have largely replaced metals and glass as containers, utensils, plates, cups, etc. It has been in use for many years and the user demand keeps increasing for its conveniences. However, because of its availability in abundance, handy in use, and disposal nature in most packaging, people do not hesitate in disposing the plastic goods. For this reason, plastic wastes over the years have increased drastically to constitute high percentage by volume and by weight in the MSW all over the world. It typically comprises around 7% of the MSW by weight, but much larger in volume (Tchobanoglous *et al*, 1993).

The recycling opportunities for plastics depend on the type of plastic, representing the origin of their resins. Separation of plastic wastes therefore is crucial for recycling opportunities. The categorical classification symbol and codes are as given in figure 2.3 and table 2.5 below, for waste plastics separation. The most commonly recycled plastics are; 1-PETE, 2-HDPE and 3-PVC. Due to its high calorific value, plastic is also highly viable to be used as RDF in the industries. Again, in developing countries, recycling through regional/international cooperation like the Thai Negoro recycling PET bottles in Thailand (TEI and Sasaki, 2006) may be a viable option given the durability and handling convenience advantages in waste plastics.



1. Polyethylene terephthalate (PETE/1)
2. High-density polyethylene (HDPE/2)
3. Polyvinyl chloride (PVC/3)
4. Low-density polyethylene (LDPE/4)
5. Polypropylene (PP/5)
6. Polystyrene (PS/6)
7. Other multilayered plastics (7)

Source: Adapted from (Tammemagi, 1999)

Figure 2.3 Symbols used for identification of plastic

Table 2.5 Classifications, identification codes, and uses for common plastics

Material	SPI Code	Original uses	% use for packaging
Polyethylene terephthalate	1-PETE	Carbonated soft drink bottles, food containers	7
High-density polyethylene	2-HDPE	Milk bottles, detergent bottles, film products such as produce bags, etc.	31
Vinyl/polyvinyl chloride	3-PVC	Household and food product containers; pipe	5
Low-density polyethylene	4-LDPE	Thin-film packaging and wraps; other film materials	33
Polypropylene	5-PP	Crates, cases, closures and labels	10
Polystyrene	6-PS	Foamed cups and plates; injection molded items	10
All other resins and multilayered materials	7-other	Commingled plastics	4

Source: (Tchobanoglous *et al*, 1993)

- **E-wastes**

E-waste is a popular informal name for electronic products nearing the end of their 'useful life' such as computers, televisions, VCRs, stereos, copiers, fax machines, microwaves and washing machines. In the APFED forums, the E-waste is referred to as WEEE (IGES, 2006a). The electronics and electrical goods are imported in bulk and E-waste generation is on the rise in many developing countries. Actually, many of the E-waste materials are reusable or recyclable. However, it has its own obstacles. The recycling of obsolete computers and electronic equipment is costly due to difficulty in separation and extraction of the content materials (UNEP, 2004; Mohamed, 2002). In the discarded computer monitors & televisions there will be large quantities of phosphorous, lead, cadmium, barium and mercury. These heavy metals require adequate skills and technology to be collected and recycled. As a product, these hazardous materials are safely sealed (UNEP, 2004).

In the developing countries, most of the electronic goods are imported. Therefore, the countries lack recycling facilities and capacity for handling such items. The most likely 3R

initiative for such items in developing countries is a policy instrument; check and balance in the import system and recycling of wastes through international/regional cooperation. Projects like "Environmentally Sound Management of E-waste in the Asia-Pacific region" initiated in 2005 under the recommendation of Basel Convention needs to be promoted fast and wider spread for the benefits of the developing countries (IGES, 2006b).

- **Medical waste**

Medical wastes, generally from the hospitals or biomedical wastes from diagnosis, treatment, or immunization of humans and animals or in research activities are usually in the form of syringes, swabs, bandages, body fluids, human excreta, etc., containing infectious properties (Visvanathan, 2006b, TERI, 2006). According to the findings in a research carried out by The Energy Research Institute (TERI) based in New Delhi, 1 kg out of 4 kg hospital wastes could be infected (TERI, 2006). Therefore, it is critical to separate and treat hospital wastes prior to disposal into the environment (IGES, 2006b). Incineration is a common medical waste treatment technology in developed countries, but for the developing countries the cost is high. Autoclaving is an environment friendly technology with moderate cost and easy to operate advantage (Visvanathan, 2006b).

- **Construction and demolition wastes**

Sources of wastes in construction and demolitions can be mainly from three types of activity; earthworks and excavation, demolition and general constructions. The common wastes from construction and demolition are as listed below in table 2.6

Table 2.6 Composition of general construction wastes

Waste type	% of total
Bricks, blocks & mortar	33
Timber	27
Packaging	18
Dry lining	10
Metals	3
Special waste (paint, solvents, etc.)	1
Other waste	10

Source: (Coventry *et al*, 2001)

The overriding factors for construction and demolition wastes minimization are; 1) to save money, and 2) environmental concerns towards sustainable development expressed in Agenda 21 of the WSSD (Coventry *et al*, 2001). Examples of financial benefits in three distinct areas are:

- Reduction in the wastage through material procurement planning and management,
- Reduction in waste quantity through optimization of the material use, and
- Reclaiming materials for reuse.

Finally the conventional manner of disposing construction and demolition wastes are:

- 35% recycling (screening and crushing),
- 13% engineering of landfills,
- 24% landfilling as wastes, and
- 28% mostly soil, spread on sites requiring land reclamation.

Chapter 3

Methodology

3.1 Research overview

The research includes primary and secondary data collection and analysis. In absence of segregated waste information, the composition of the wastes was unknown. The percapita and total waste generation capacity at source point was also not known. With such condition of available information, searching appropriate 3R options was not possible. Therefore, a primary data collection through field survey; physical collection, segregation and wet weight measurement of the wastes and interviewing with set questionnaires was initiated as per the outline of study objective. Side by side, the secondary data in the form of published documents and printed copies were collected from the relevant resource agencies and individuals.

3.2 Research basis

3.2.1 Sampling

Estimation of the sample representative has carried out based on the Environmental Protection Agency, Ireland (EPA, 1996), municipal waste characterization methodology. A sample size of 351 representatives has been selected as detailed below in table 3.1. The 148 residential households sample is from a distribution of 37 representatives from each four main parts of the city; Tashichodzong and above (north), upper area of main town (Motithang, Changangkha, Kawajangsa, Zulikha), lower part of main town (Chubachu, downtown, Changazamtog), and Changjiji and below (south). The level of the living standard based on having more than one car as high-level income, with one car as middle level income and no car as low level income has also been considered in the sampling.

Table 3.1 Respective sample representation

Source description	Source population	Sample population
Residential households	17214	148
Government and Corporate Offices	46	18
Schools	27	10
Retail Shops	393	42
Bar shops	159	16
Hotel & restaurants	112	12
Other shops	335	34
Industry	90	9
Automobile workshops	48	10
Wholesale shops	25	6
Private Offices	460	46
Total	**18909**	**351**

3.2.2 Data format and questionnaire

A modified format from EPA (1996) format has been used for recording the physical wet weight measurement. The format sample is submitted as appendix D. The questionnaire for

interviewing the respondents was modified from the World Bank's questionnaire for solid waste management service survey in Pacific countries (World Bank, 1996). The questionnaire format sample used for this study is enclosed as appendix E.

3.2.3 Data analysis

The analysis of the data is carried out using Microsoft Excel and the Statistical Package for Social Sciences (SPSS) software.

3.3 Data collection steps

The objectives and the scope of study outlined in the study proposal have been stringently referred as guideline for the data collection process. Steps followed in the data collection process are described below in table 3.2.

Table 3.2 Strategic activities to fulfill the objectives of the study

Objective	Activity
To collect secondary data and interview relevant respondents to understand the gaps, mainly the policy gaps in the present waste management system,	• Studying and identification of relevant resource agencies. • Obtaining permission/appointment with relevant stakeholder/personnel. • Developing questionnaires. • Visiting, discussing, collecting available documents and distributing questionnaires. • Collecting duly filled questionnaires at a later date. In cases where the respondents are illiterate or high level personnel, questionnaires needed to be self-filled on the spot according to the information provided. • Analysis of the information.
To conduct field survey to develop a segregated waste inventory to have an overview of the waste compositions, percapita and total waste generation capacity, and	• Obtaining government approval, • Formatting the data forms and developing into multi copies, • Arrangement of labor and transportation, • Obtaining respondents' consent, • Collecting waste sample, segregating and weighing, • Field recording of the data, • Software recording of the data, and • Analysis of the data.
To find potential 3Rs options, mainly low cost policy options, for the management of the predominant waste components in Thimphu.	• Case studies on the prevailing management systems of each predominant waste component, and • Updating viable options from the literatures and other country examples.

3.4 Research process

3.4.1 Framework process

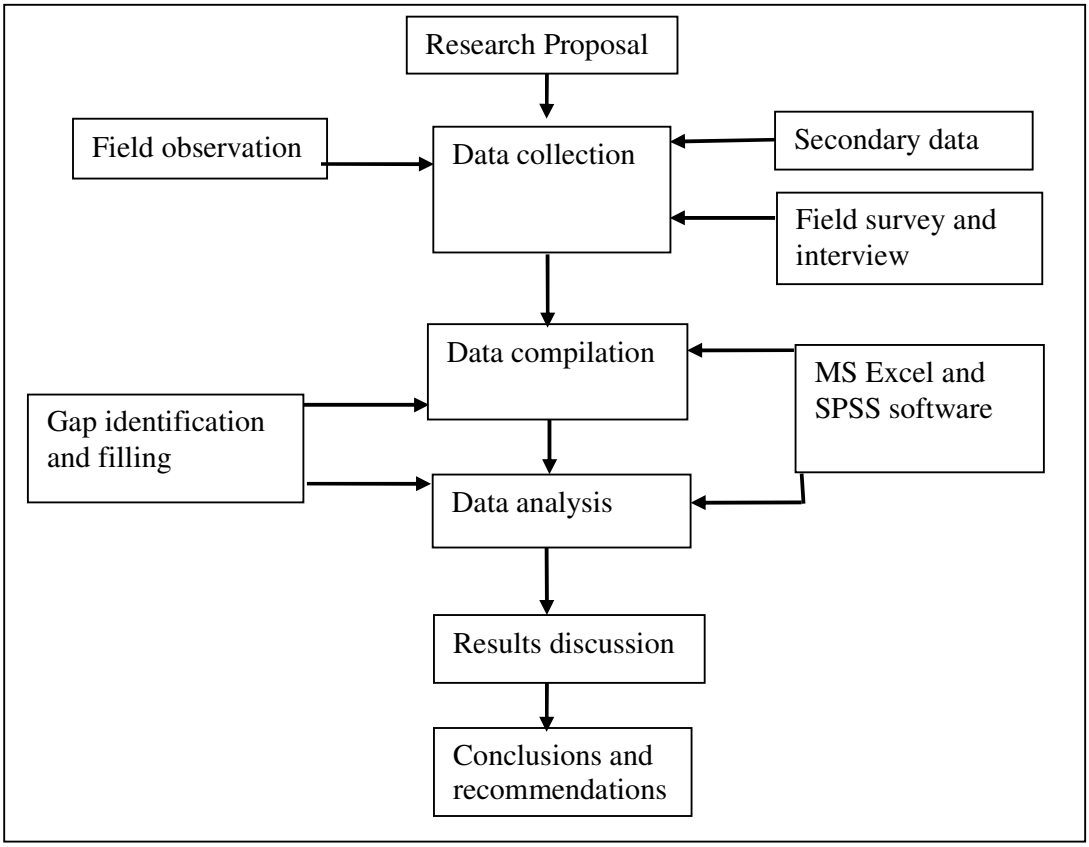


Figure 3.1 Process flowcharts for a strategic research approach

3.4.2 Details of the process

a) Field survey and physical measurement of waste samples

Physical waste data has been initially collected at Memelakha waste disposal site for one week to determine daily waste collection quantity and the composition. Later, for almost three months the source point survey was conducted to determine mainly the percapita waste generation and the total waste generation capacity with specific waste compositions.

i) Field survey at Memelakha

In an average, 16 different containers/trucks per day unload the wastes at the landfill site, collected from various sources. With support from the municipal authorities, randomly selected four to six containers/trucks were made to unload their contents in the designated area. Employing four to six laborers the separable wastes components were segregated and weighed accordingly for one week. The remaining inseparable wastes is weighed and recorded as commingled wastes. The waste measurement was conducted on the wet weight basis.

ii) Data collection at the source points
A 24 hours waste sample collection, separation and measurement of the wet weight was carried out from totally 351 sample representatives of waste generating sources detailed in table 3.1 above.

b) Questionnaire survey and interviews

A 16 points questionnaire has been developed for interviewing the respondents simultaneously. As mentioned above under sub-topic 3.2.2, the questionnaire sample is submitted as appendix E.

c) Visual imaging

Photographs from the study areas and other places have been taken to have visual observations of the sites and activities. Relevant photographs are included in the chapters where appropriate and in the appendices, mainly in appendix C.

3.4.3 Study area

Thimpu municipality area from Changdagang in the north to Ngabi Rongchu in the south is the main study area. The map of Thimphu city's latest demarcated boundary (MoWHS, 2007b) is submitted in appendix B. For the commercial activities and the industries, random sampling selection has been carried out based on the licensing list provided by the Ministry of Trade and Industry. Similarly, for the government and corporate offices sample selection was done according to the list provided by the Royal Civil Service Commission (RCSC). For schools, it was as per the list provided by and the Ministry of Education. The hospitals and construction and demolition waste sources could not be covered in this study.

Industries in the south; Samste, Gomtu, Pasakha and Phuentsholing have been visited to collect supplementary information.

Chapter 4

Results and Discussions

4.1 Thimphu municipality outlook

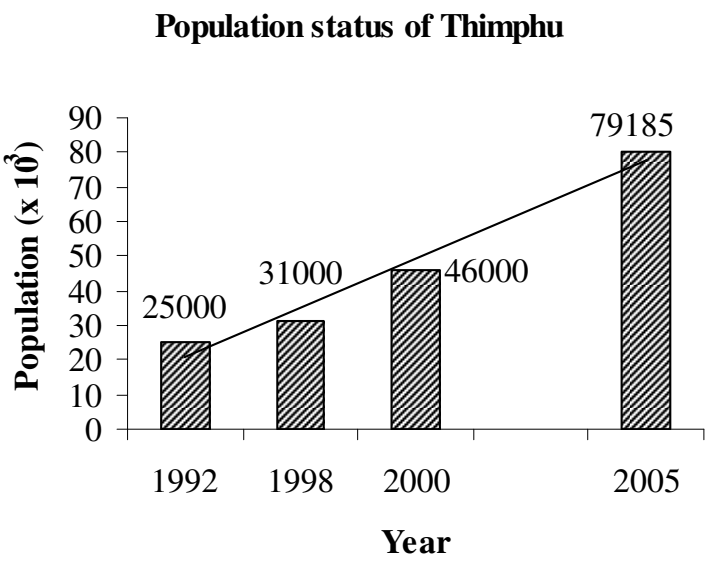
Like any other parts of the kingdom, Thimphu at an elevation of approximately 2400 meters above sea level is located in a mountainous valley in the western region of Bhutan. Approximately 26 square kilometers in area, Thimphu town stretches from Changtagang in the north to Ngabirongchu in the south fanning on Thimphu river (MoWHS, 2007b). With a population of 79,185 (PHCB, 2006), Thimphu is the capital and the biggest urban settlement in Bhutan. The population of Thimphu constitutes 12.5% of the total population of the country, 634,982 persons and 40% of the total urban population, 196,111 persons. Thimphu municipality comprises of various stakeholders as given below in table 4.1. An analysis of the questionnaire interview of 148 residential households representative sample distributing 37 representatives for each four main parts of the city and considering having more than one car, only one car and no car as living standard indicators it was found 4% of Thimphu's population high level income, around 60% middle level income and 36% low level income societies.

Table 4.1 Composition of waste generation sources in Thimphu

Source description	No.	Source of information
Residential households	17214	(PHCB, 2006)
Government and corporate offices	46	Royal Civil Service Commission (RCSC)
Schools and institutions	27	Ministry of Education (MoE)
Retail shops	393	Ministry of Trade & Industry (MTI)
Liquor bar shops	159	MTI
Hotels and restaurants	112	MTI
Miscellaneous service shops	335	MTI
Industries (mostly wood based)	90	MTI
Automobile servicing workshops	48	MTI
Wholesale business ventures	25	MTI
Private offices	460	MTI
Hospitals	5	Ministry of Health (MoH)
Total	**18914**	

4.2 Human demography

According to the report, 'National Assessment of Agenda 21 of Bhutan-The Road from Rio' (NEC, 2002a), the annual urban population growth rate in Bhutan is between 6% to 7%. Thimphu grows at 7% rate. The report estimated around 150,000 inhabitants in Thimphu by 2025. In 1992, the Memelakha waste disposal site development project document (TCC, 1992) considered 25,000 residents with 5% annual increase for estimation of the disposal site carrying capacity. The national Population and Housing Census of Bhutan conducted in 2005 (PHCB, 2006) revealed the resident population figure of Thimphu as around 80,000 persons. If 7% annual increase rate is applied to the 2005 population size, Thimphu could harbor over 200,000 residents by the year 2020.

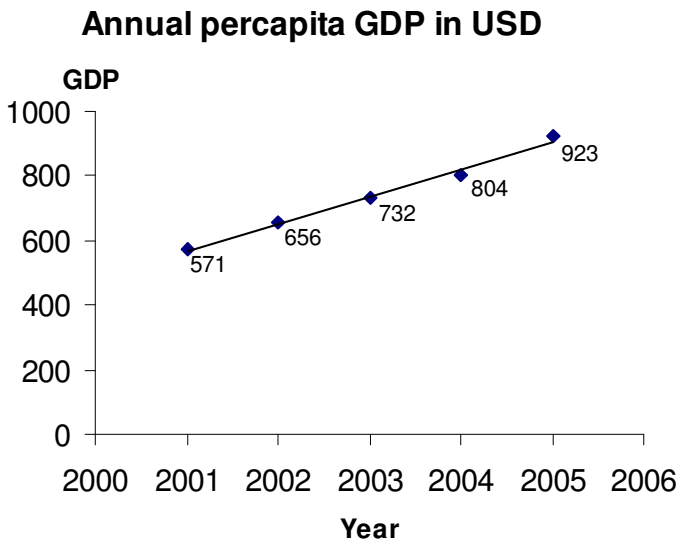


Source: Adapted from (TCC, 1992; NEC, 2002a; PHCB, 2006)

Figure 4.1 Thimphu's population escalation trend over the past few years.

4.3 Economic status

Ever since the initiation of the socio economic developmental activities in 1961, Bhutan has been enjoying progressive percapita income (PC, 1999). Although the import-export balance remained always deficit, the import power of the country grew from approximately United States Dollar (US$) 225 million in 2001 to US$ 425 million in 2005. The corresponding export power also steadily increased from approximately US$ 125 million in 2001 to US$ 285 million in 2005 (DRC, 2006). The percapita Gross Domestic Product (GDP) increased from approximately US$ 570 in 2001 to over US$ 900 in 2005 (NSB, 2006). The exchange rate applied is Bhutanese Ngultrums (BTN) 40.00 equivalent to US$ 1.00. The trend of annual percapita GDP increase between the years 2001 to 2005 is displayed below in figure 4.2.



Source: Adapted from (NSB, 2006)

Figure 4.2 Annual percapita GDP increase in Bhutan from 2001 to 2005

4.4 Institutional arrangements

4.4.1 Reviewing the legal framework and the policies

The legal framework in overall is weak in comprehending effective implementation of the MSW management parameters. The 86th session of the National Assembly held in December 2006 therefore directed the National Environment Commission (NEC) to draft a National Solid Waste Management (NSWM) Act. A drafting Steering Committee for the Act has been recently instituted (June, 2007). Numerous environmental policy documents, guidelines and reports already exist. Of those, the following documents directly or indirectly address solid waste management issues.

1) *National Environment Protection Bill of Bhutan, 2007* (RGoB, 2007);
   The latest adopted National Environment Protection Bill of Bhutan, 2007, does not specify solid waste management, but identified 'principle of 3Rs' and 'the polluters pay principle' amongst the applicable principles towards environmental protection. Solid waste management is a crucial measure in protecting the environment and the human health. The Bill, which is a super environmental legislation, could not narrow down its scope to specify MSW issues.

2) *National Strategy and Action Plan: Integrated Solid Waste Management* (MoWHS, 2007a);
   This strategy and action plan developed with support from the United Nations Environment Programme (UNEP) has explicitly defined the 3Rs and elaborately discussed the present situations of waste management. It has highlighted that no significant waste recycling plants exist in the country. On the financial resources, the document has clearly spelled out that the Thimphu City Corporation had large budget deficits every year. No solid waste management services fee collection

system exist and no concrete action has been taken to secure financial resources for the waste management sector. It has also stressed out that the public-private involvement system prevails only for some ad-hoc public awareness and cleaning campaigns. However, the strategy and action plan did not identify specific 3R options to address the highlighted problems.

3) *Final draft of Thimphu City State of Environment* (MoWHS, 2007b);
This report shows that the Royal government is aware and concerned about the emerging solid waste management problems. The report has noted the overflowing status of the current landfill site and suggested to enhance recycling options to reduce load level on the landfill by at least 50%. Privatization of the MSW management has been identified as a viable option to encourage public-private partnership. The report also incited to explore integrated waste management opportunities for the expected 70 tones or so of the infectious wastes per year and the obsolete pesticides. The report is awaiting finalization and submission to the concerned authorities for approval.

4) *Public-Private Partnership for Urban Environment: Policy Framework for Solid Waste Management* (RSPN, 2006);
This document with a preliminary inventory of the daily waste collection quantity in Thimphu and Phuentsholing mainly focused on policy gap analysis to recommend corrective measures as a non-governmental organizational perspective. The recommendations include; i) a concerted national effort in SWM, ii) development of a national integrated solid waste management policy, iii) reduction of wastes through recycling or waste transformation, iv) enhancing public awareness and education, v) institution of 'polluters pay principle', vi) inter agencies coordination mechanism, viii) autonomy and capacity building of the municipal authorities, and ix) solid waste management strategy development. The last recommendation, solid waste management strategy development was the first achievement. The Ministry of Works and Human Settlement developed the strategy and action plan (MoWHS, 2007b), which is discussed (# 2) above, almost in parallel timing to the recommending document.

5) *Guideline for Infection Control and Healthcare Waste Management in Health Facilities* (*Third Edition*) (MoH, 2006);
This guideline is developed Bhutanizing almost all the aspects. In the sense, the guideline is reviewed and refined occasionally to make it as practical as possible. Safety and precaution measures in handling waste facilities and equipments have been elaborately outlined and practical disinfecting techniques for the biomedical wastes were also discussed at length. In gist, the guideline encourages cautious waste separation between infectious and non-infectious wastes at the source points. For the final disposal, autoclaving and deep burial in dug pits within the health facility premises is recommended.

6) *Environmental Codes of Practice (ECOP) for Hazardous Waste Management* (NEC, 2002b);
Identification of hazardous waste categories and procedural responsibility of hazardous substances are clearly specified in this guideline. Collection, fractioning, storage and transportation steps, occupational health and safety measures, education, training and awareness raising methodology including planning of the

emergency responses are spelled out in the document.

7) *Regulation for the Environmental Clearance of Projects and Regulation on Strategic Environmental Assessment, 2002* (NEC, 2002c);
This regulation authorized under the Environmental Assessment Act, 2000, regulates to assess environmental impacts, issue clearances and monitor any type of projects including the industries and urban development activities. Its definition of 'Clean Technologies' state, 'technological improvements or management practices which will result in improved environmental performances as measured by, for example lower or less toxic discharges'. This indicates that the waste management issue addressable in the environmental assessment and clearance issuance processes.

8) *State of the Environment, Bhutan* (NEC and UNEP, 2001);
This report deliberately provisioned a chapter on the state of solid waste management to draw the attention of the decision makers. The report highlights the state and causes of the problem, with recommendations to adapt scientific techniques to minimize wastes and waste problems. Thimphu and Phuentsholing were specifically identified for prompt action considerations.

9) *ECOP for Solid Waste Management in Urban Areas* (NEC, 2000a);
This guideline encouraging community involvement and responsibility sharing mechanism focused on providing guidelines in training, education and awareness, and waste handling of public, commercial and industrial areas, schools and institutions, automobile workshops and the residential areas. The recycling of wastes with incentives such as tax reduction, waste segregation at source and privatization were discussed in this guideline too. Appropriate techniques to consider selection of the unavoidable landfill site are also discussed.

10) *ECOP for Sewage and Sanitation in Urban Areas* (NEC, 2000b);
This document prepared to supplement the 1995 Water and Sanitation Rules provides guidelines covering research and surveys, and technological options for septic tanks, disposal of effluents, soakpits, dispersion of drainage trenches, disposal of sludge wastes from treatment plants, disposal of sludge from pit latrines, disposal of sludge from septic tanks and the planning and design of the main sewerage systems and public latrines.

11) *Environmental Assessment (EA) Act, 2000* (NEC, 2000c);
This Act under the article number 8 and 9, governs all developmental activities (public and private) requiring to complete environmental assessment and obtain clearance from the NEC or the Competent Authority designated by its regulation (NEC, 2002c), as prerequisite to any developmental consent. Obtaining environment clearance includes infrastructures and industries set up prior to the Act and five years provision was allotted to such activity components to make necessary corrections according to the environmental clearance terms and conditions. By article number 10, the environmental clearance is authorized to set environmental terms and conditions to fulfill in the process of implementation of the activities. Thereby, the EA Act, 2000 and its regulation (NEC, 2002c) indirectly provide authority to address waste management issues. However, lacking knowledge, information and capacity on waste generation processes, its

composition and characteristics, most clearance issuance and monitoring events tend to overlook the waste impacts and its management issues.

12) *The Bhutan Municipal Act of 1999* (RGoB, 1999);
The Bhutan Municipal Act of 1999 has focused mainly on defining the authority and administrative jurisdictions of the Municipal Corporations. Not much has been covered on specific activities of municipal agencies. The only mention of the SWM in the Act is mandating the municipal authorities to collect/dispose wastes and control littering as a functionary obligation under the general public services. Although the Act authorizes the municipal authorities to manage its finances, TCC continues depend on the fund allocation from the government. Implementation of the autonomous status and authority is yet to exercise.

13) *Water and Sanitation Rules, 1995* (RGoB, 1995);
This rule formulated and adopted by the then Public Works Division under the Ministry of Communications continues to be basis of TCC's MSW management procedures. It outlines the requirements in solid waste management with penalty provisions for the offenders. The rule however is limited to management of the existing system. It does not guide research and development opportunities. The rule also fails to address financial security and defend the SWM organizational status.

14) *Final draft of the project document for Solid Waste Management of Thimphu City, Bhutan* (TCC, 1992):
Probably the first document of its kind addressing MSW management in Bhutan was developed to initiate collection and transportation of MSW from Thimphu for disposal at Memelakha. The document evaluating a carrying capacity of 70,000 to 80,000 cubic meters in volume recommend use of the site for maximum 12 years from May 1993 with incremental recycling activities to pick up in the years to come. The recycling activity did not appear significantly and the landfill site has been using for more than 14 years.

On top of the above policy documents, the Royal Government also has exercised initiatives through issuance of government circulars between the years 1998 to 2005, which could significantly benefit solid wastes reduction aspects.

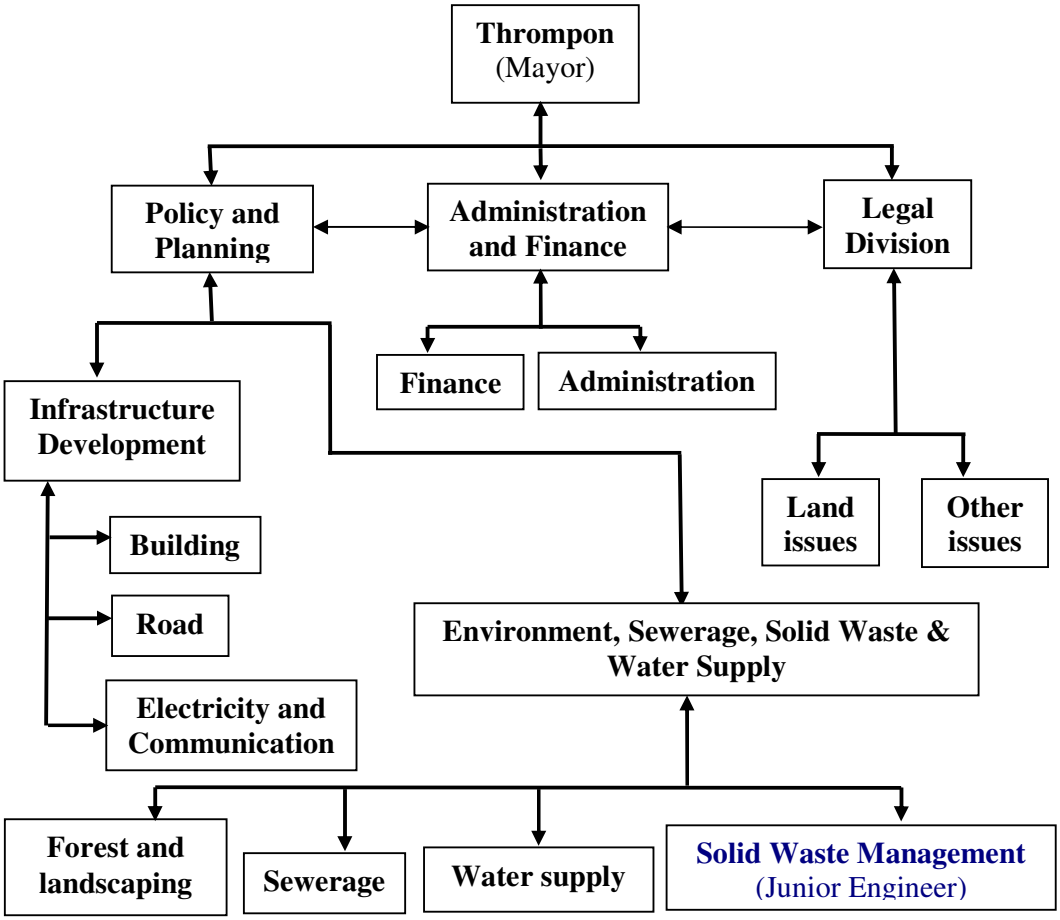
i) Ban of car wash in the streams and rivers exercised by the NEC in 1998,
ii) Ban of import of secondhand cars exercised by the Ministry of Finance in 1998,
iii) Ban of import of scrap materials for reprocessing and reuse in the country exercised by the Ministry of Trade and Industry (MTI) in 1999,
iv) Ban of use and sale of plastic carry bags, package wrappers and pouches exercised by the MTI in 1999, and
v) Ban of import and sale of Tobacco products by the MTI in 2005.

While the ban of secondhand cars and the import of scrap raw materials are effectively implemented other three efforts are facing illegal practices. The effort of ban of use of plastics is mainly impoverished due to deficiency of the alternative biodegradable resources. Identification of specific operational techniques, mainly low cost policy options for respective waste components has been the focus in this study. With enactment of the NSWM Act, incorporating findings from this study and other researches, much of the gaps are expected to be narrowed.

4.4.2 Organizational structures and responsibility

The organizational responsibility allocation is clear in the royal government system to the level of the municipal authority like Thimphu City Corporation (TCC). While the Planning Commission (PC) is mandated to coordinate the national level policies and the overall developmental plans (PC, 1999), the National Environment Commission (NEC)'s responsibility is to formulate the national environmental policies, rules, guidelines and advice the government on the environmental issues (RGoB, 2007). The Department of Urban Development and Engineering Services (DUDES) under the Ministry of Works and Human Settlement is responsible for developing urban development strategies and action plans for emerging urban settlements throughout the kingdom. As mandated under the Bhutan Municipal Act of 1999, the Municipal Corporations are responsible to collect and dispose the wastes from the municipal areas as a public service. Therefore, the TCC is legally mandated to manage the municipal solid wastes of Thimphu.

The main organizational setup crisis of the MSW is when it comes within the TCC. The SWM is organized as a section under the Environment, Wastes, Sewerage and Water Supply Division of TCC. The section has only one Engineer and a Sub-Overseer (SO) to manage the whole fleet of the solid waste management laborers and the trucks. The administrative staffs meant for the waste management section are shared in the centralized administrative office. The technical manpower is also burdened further to undertake dual responsibilities of managing the weekend market and other commercial areas. For financing, no specified budgetary allocations are provided to the waste management section. No strategic work plan is developed to carry out the daily activities of the section. All matters are taken up on adhoc basis seeking approval from the Thrompon (the Mayor). A corrective action in terms of administrative and financial authority is deeming necessary for waste management section to enhance efficiency in the services.



Source: Adapted from (MoWHS, 2007b)

Figure 4.3 Organogram of Thimphu City Corporation

4.5 Present MSW management scenario

Ever since started to implement in May 1993 there was no change in the MSW management system of Thimphu. It is the basic system of collection, transportation and disposal at Memelakha that is ongoing. Informal reuses of the non-biodegradable products prevail, but waste reduction and recycling schemes are very limited. In the Bhutanese context, recycling of wastes has been the practice of collecting and sending recyclable wastes outside the country (MoWHS, 2007a). The informal waste pickers including business ventures, scavengers and municipal waste management laborers collect and separate higher value recyclable materials and sell it to the local scrap dealers or export across the border. From the interview with the local scrap dealers in Thimphu, it is noted that the majority wastes product buyers across the border are Indians from the neighboring town of Jaigaon. Only in some cases, the waste products are sold to the buyers in Bangladesh. These, across border trading waste products are mainly metal items and the Beer bottles. In rare cases, especially the electronic goods like computer, mobile phones, audio/video sets are taken by the privileged travelers for repairing or exchange to Bangkok. Only very lately, the in-country metal processing industries and the beer producers in and around Phuentsholing have started to buy specific metals and beer bottles for recycling and

reuse in their factories. A small scale paper recycling unit has come up in Jemina, Thimphu. The composting plant constructed in 2004/05 at Serbithang to consume organic wastes from Thimphu municipality is gearing up to initiate its operation soon.

4.5.1 MSW inventory

The TCC project document (TCC, 1992) assuming 0.7 percapita waste generations for a population of 25,000 people estimated daily total wastes generation of 17.5 tones in 1992. The Royal Society for Protection of Nature's survey in 2005 (RSPN, 2006) found 36.7 tones daily wastes collection from Thimphu municipality. The 1992 document missed to calculate percentage of waste collection daily and the RSPN survey did not include waste generation capacity at source point. Thereby, no realistic record of the percapita waste generation and total daily waste generations of the city existed. Knowledge about the composition of the MSW remains foreign. Therefore, this study was compelled to include segregated waste inventory in its endeavor to understand the composition of the wastes, variety of sources, percapita waste generation, and correspondingly the total daily waste generation capacity of the city. The abstract of the physical survey data, waste generation in percentage by sources is displayed in figure 4.4 and percentage by composition in figure 4.5 below.

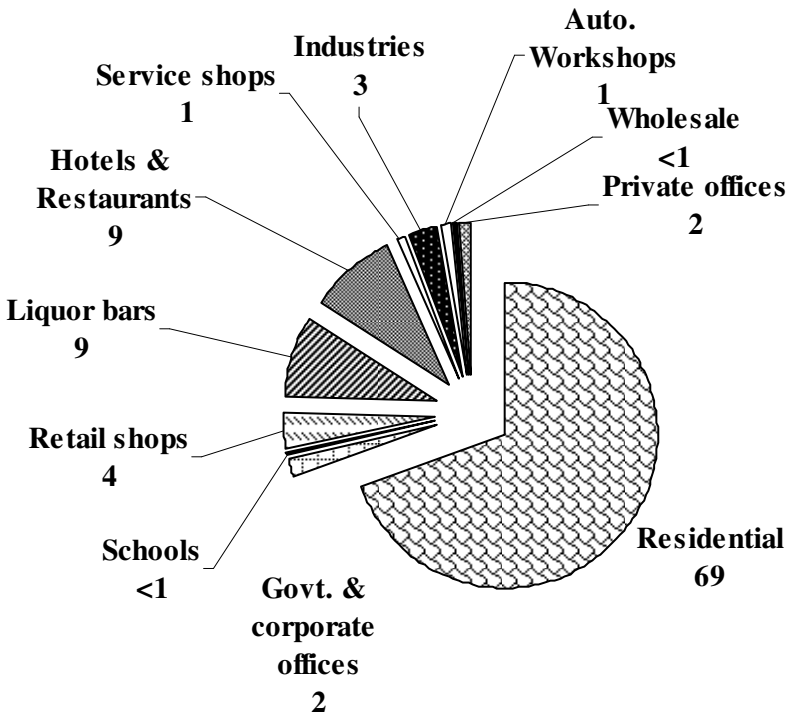


Figure 4.4 Percentage waste generation by sources of the total 65 tones

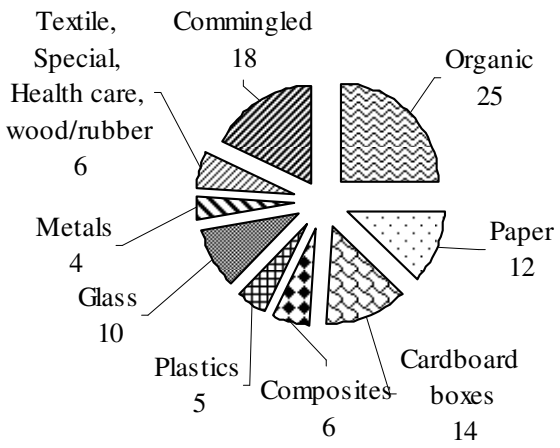
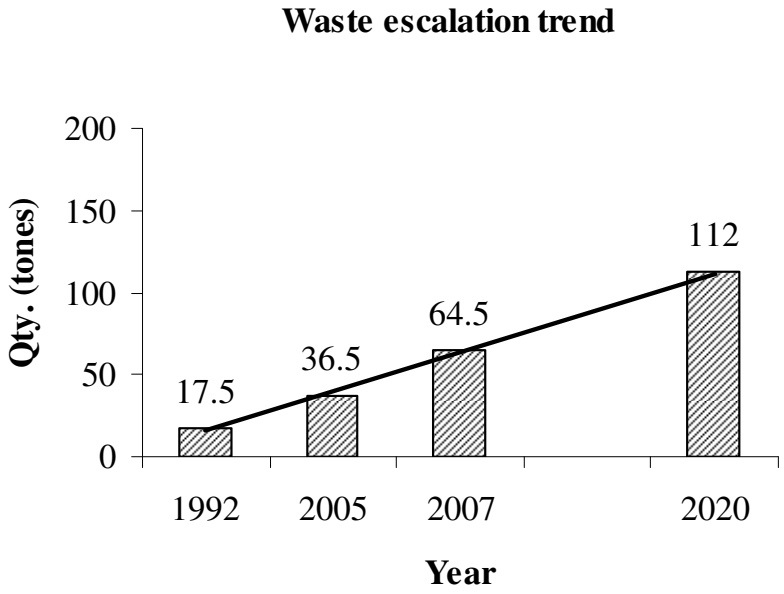


Figure 4.5 Percentage waste generation by compositions of total 65 tones

From the inventory of the wastes at the source point, it was seen that the daily waste generation capacity of the city is around 64.5 tones per day. The residential households constituting around 91% of the source components contribute the highest percentage, around 70% of MSW. The percapita waste generation capacity of the residential households confirms to 0.56 kg/person/day, calculated from its 44,400 kg/day waste generation quantity against the 79,185 population figure of 2005. Segregation and physical weight measurement of the recyclable component was not possible due to time and resources constrains. Through visual observation it was assumed that around 50% in average of the generated wastes is recyclable. It is potential to increase the recyclable waste percentage with stringent waste separation practices.

Surprisingly in Thimphu the segregated waste inventory found organic waste component very low (16 tons = 25% of the total). A unique case for a developing country in Asia. The organic wastes in Thimphu will be mainly vegetables and fruit wastes from the weekend market and the domestic kitchens. The residential households (91%) dominate the waste generation sources. Therefore, the probabilities for this low percentage organic waste component are; i) consumption pattern change with economic gain and lifestyle changes, as an urbanization process, ii) the physical survey months (April and May) being dry or vegetable cultivating season, and iii) the organic wastes are illegally disposed to prevent foul smells in the houses, where daily waste collection services are not available. Thimphu highly depends on imported Indian vegetables and local vegetable from other districts like Paro, Punakha and Wangduephodrang. During the cultivating season, the quantities of imported and local produce reduce drastically in the market and the price escalates. In such situations, culturally, Bhutanese consume preserved vegetables, usually cleaned and dried items. Consumption of such preserved items will have almost nothing to waste. Then, the 18% commingled wastes which could not be separated also will contain substantial organic waste component.

Comparing the estimated waste generation capacity in 1992 with that of 2007, the waste quantity in Thimphu escalates by almost four folds in a span of 15 years. The waste quantity increase is due to population escalation and not due to increase in resources consumption rate. With this trend, should Thimphu harbor more than 200,000 residents by 2020, the daily waste generation quantity will be more than 110 tones as shown below in figure 4.6. The extrapolated result of the questionnaire interview reveals 4% of Thimphu's population in high level income society. Around 60% is middle level income and 36% low level income society. Therefore, closer attention needs to be given to the middle income and low level income population while considering MSW management optional techniques.



Source: For 1992 (TCC, 1992); 2005 (RSPN, 2006)

Figure 4.6 Waste quantity escalation trends in Thimphu

A weeklong physical survey at Memelakha disposal site saw 16 trucks/containers in average coming to the disposal site daily to unload the collected wastes from Thimphu municipality. The trucks/containers carry in average less than 2 tones of commingled wastes. The average sum of the daily waste collection therefore is around 31.5 tones. This is around 49% of the source waste generation capacity. By the time waste reaches at Memelakha, the separable recyclable waste in terms of weight goes below 1%. The commingled nature of the waste offsets the separation opportunity. The waste carrying trucks/containers are deprived to carry more wastes in terms of density because of the high volume content of carton/cardboard boxes from every source point.

All the 51% uncollected waste is not expected to remain in the environment. This study does not cover the percentage of wastes separated/collected by informal waste pickers and respective business ventures for sale and export. Most wastes like metals and beer bottles usually do not reach the disposal site. Accounting the informal waste picking, the waste remaining uncollected in the environment should be lesser than 51%. Metals and beer bottles reaching Memelakha are also immediately collected by the municipal workers and

other human scavengers. Also, most organic wastes (food and vegetables) are consumed by the cattle and the stray dogs scavenging freely at the site.

Figure 4.7 Photos of the scavengers at the Memelakha MSW disposal site

4.5.2 Financial resources

Regarding the financial resources, TCC always faced large budget deficits. The Corporation's financial expenditure records reveal that only Bhutanese Ngultrums 4.84 million (US$ 0.12 million) was spend for operation and maintenance costs of the MSW equipments and the labor payment. Including the monthly salaries of the office staff and the Engineer in-charge, a mere expense of approximately US$ 0.2 million was spent on MSW management in 2006. This fund is fully borne by the government. Solid waste management services fee collection is not provisioned by the existing policy and legal tools (MoWHS, 2007a).

4.5.3 Equipment and facilities

Thimphu City Corporation has limitation in equipments and facilities too. Most of the equipment/facilities are donated in grant by the donor agencies. The equipments are aging and wearing, demanding more and more maintenance costs. There is no financial security to procure/replace or maintain the equipment/facilities.

Table 4.2 List of MSW management equipment/facility with TCC

Equipment/facility	Qty. (No.)	Capacity (volume)
Compactor vehicles	6	6 m^3
Tipping truck with tipping mechanism	2	8 m^3
Tilt-frame or hoist truck handling big receptacle bins	2	
Night soil tanker	2	2000 litres
Tractor	2	1 m^3
Monitoring car (Hilux)	1	
Bull dozer (small)	1	
Backhoe	1	
Receptacle bins	20	3 m^3
Wheel barrows (1 wheel)	10	

(i) 6 m^3 Compacter Truck (ii) Bulldozer/Excavator (iii) Kerbside receptacle bin/carrier

Figure 4.8 Photos of the sample equipment/facilities used by TCC

4.5.4 Human resources

The TCC with limited financial resources can employ only limited numbers of workers. People are reluctant to participate in the wastes management, especially in public areas, except for ad-hoc cleaning campaigns. Limited by the knowledge of benefits from wastes reuse and recycling, not many business ventures showed interest in MSW management. As such, very limited people are involved in the MSW management. Since most of the laborers employed in MSW management are Indians, opportunity to build capacity of the municipal workers is also constrained. The list of manpower directly involved in the MSW management under TCC is as given below in table 4.3.

Table 4.3 List of MSW management manpower

Type of personnel	**No.**
Engineer	1
Sub-Overseer	1
Technical Assistant	2
Technician	2
Supervisor/Monitor	3
Driver	15
Labor	29
Total	**53**

4.5.5 Challenges in the present MSW management system

Firstly, the Memelakha waste disposal site does not qualify to be a sanitary landfill (MoWHS, 2007a). There are no storm water drainage system, lining underneath and covering to control leachate. The landfill also has no gas collection devices and proper fencing to control the scavengers and overflow. With utilization of the site for more than its specified capacity, the waste is physically overflowing. The physical overflow and the leachate are highly potential to flow on to the lateral highway and the water bodies passing below disposal site. The elevated risk is that the stream flowing below the landfill site joins Ola *Rongchu* (stream) used by the local residents of Semtokha and Babesa for irrigation, washing and bathing. There are also apple orchards, residents and institutions not far away in the upstream of the disposal site. The air pollutants from the disposal site could easily reach these areas. Further downstream, Ola Rongchu joins Thimphu river and other major rivers of the western region to form Wangchu, on which the two major hydropower

stations of the Kingdom; the 336 MW Chukha and the 1020 MW Tala are established (NEC, 2002a).

Figure 4.9 Photos of wastes overflowing at the saturated Memelakha

Favored by the mountain terrain and the gravity force, the litter uncollected in the town blown by the wind or washed by the storm water finds its way into the gullies and ultimately into the Thimphu river, especially during the monsoon. With limited accessibility, resources and capacity, the TCC is not able to cover 100% of the municipal area under MSW collection services. The TCC is also handicapped to improve the service techniques. The situation compels to continue with basic collection and transportation of the wastes to Memelakha without any prior segregation and treatment. The scope of researching and development is almost non-existent. Without resources and the capability, the TCC has not been able to develop the new landfill site to relieve the pressure on the present site (MoWHS, 2007a). The new site, 3 kilometers upstream of the present site was identified two years ago.

Figure 4.10 Photo, Thimphu river in close proximity to the city to receive wastes

Combination of the factors like; periodical expansion of the municipal boundary, increasing waste transportation distances, escalating the spare parts and fuel cost, increasing population density, diversification of source types, continuous changing of consumption pattern, non-segregation of wastes at sources, and no intermittent facilities like transfer stations, has become an irresistible force on the ailing old fashion MSW management system. A remedial change in the MSW management of Thimphu has

become an emergency.

4.6 3R gap analysis in MSW management of Thimphu

The concept of 3Rs is not well understood by the decisions makers and the residents alike. Only recycling option was discussed as early as 1992 (TCC, 1992). Only the NEC and the TCC officials heard about 3Rs participating in Asia 3R forums. Few policy documents and guidelines written through donor assisted projects by consultants have cited 3Rs as viable option for MSW management. However, these documents too have not specified options of 3Rs. For this reason, the implementation of 3Rs including the much referred recycling has not materialized in implementation.

The 3R gaps in Bhutan can be visualized from the information given below in table 4.4 and table 4.5.

Table 4.4 Technology status for implementation of 3R in Bhutan

Waste Category	Technology	Status
Urban Municipal Waste	Thermal Recovery	☒
	Fuel Recovery	☒
	Material Recovery	○
	Sorting	○
	Pulverizing	☒
	Composting	☒
	Incineration	☒
E-Waste	Material Recovery	◘
	Sorting	☒
	Pulverizing	☒
Healthcare Waste	Thermal Recovery	☒
	Fuel Recovery	☒
	Material Recovery	☒
	Sorting	◙
	Pulverizing	☒

Note:

● Formal, Strong
○ Informal, Weak
◙ Formal but weak
◘ Informal but Strong
☒ Technology Gap

Table 4.5 Current situation of national policies, legislative measure and initiatives

3R Management Aspects			Status
Systems for Integrating environmental Considerations into Socio-economic Activities	Framework	National Environment Protection Bill National Solid Waste Management Act (draft)	○
	Direct Regulatory	• The Bhutan Municipal Act of 1999 • Environmental Assessment Act, 2000 • Regulation for the Environmental Clearance of Projects and Regulation on Strategic Environmental Assessment, 2002	○
	Economic	• Incentives to facilities and Industry Associations implementing Pollution Prevention programs • Funds from Financial Institutions	☒
	Voluntary	• Eco-labeling • Green Procurement • Industrial Waste Exchange Program • Industrial Environmental Management Project • Promotion of ✓ Industrial Eco Park ✓ Solid waste Reduction master Plan	☒
	Information	• Environmental Code of Practice (ECoP) for Solid Waste Management, 2000 • ECoP for Sewage and Sanitation Management in Urban Areas, 2000 • ECoP for Hazardous Waste Management, 2002 • Public-Private participation in Urban Environment: Policy Framework for Solid Waste Management, 2006 • National Strategy & Action Plan: Integrated Solid Waste Management, 2007	○
	Procedural	Formulation of standards and levels classifying wastes eligible for recycle. Implementation of ISO 14001 - Environmental Management System in government agencies & Business establishment	☒
Support for 3R- Related activities		• Central Government commitment • Local Government-Municipal Authorities • NGO-Royal Society for Protection of Nature	○
Environmental education		Lack of environmental Education (very informal and ad-hoc nature)	○

Science and technology	Lack of science and technological research and initiatives	☒
Reduction of barriers to International Flow	• Response of the Royal Government to Basel convention	○
International Cooperation	• Environmental legislation and policy framing support from DANIDA and UNEP	●
Cooperation of Stakeholders	No systematic cooperation between the government and the stakeholders and amongst various stakeholders in terms of solid waste management	☒
Promotion of Science & Technology for 3R	• Promotion of technology for Waste minimization and recycling and recovery of waste in industries • Hazardous waste generation ,treatment, storage and disposal	☒

□ □ ● Sufficient ○ □Insufficient ☒ Gap

The response from the questionnaire interview asking about the knowledge of 3Rs reveals the ignorance at a uniform platform irrespective of working position, qualification, living standard and gender. The questionnaire interview was responded about 47% saying never heard about 3Rs. 43% says have heard about it and 9% saying they have fair knowledge. Only 1% says they know well about 3R concept. This outcome interprets that the national citizens lack 3R knowledge to digest the concept and transform it into action.

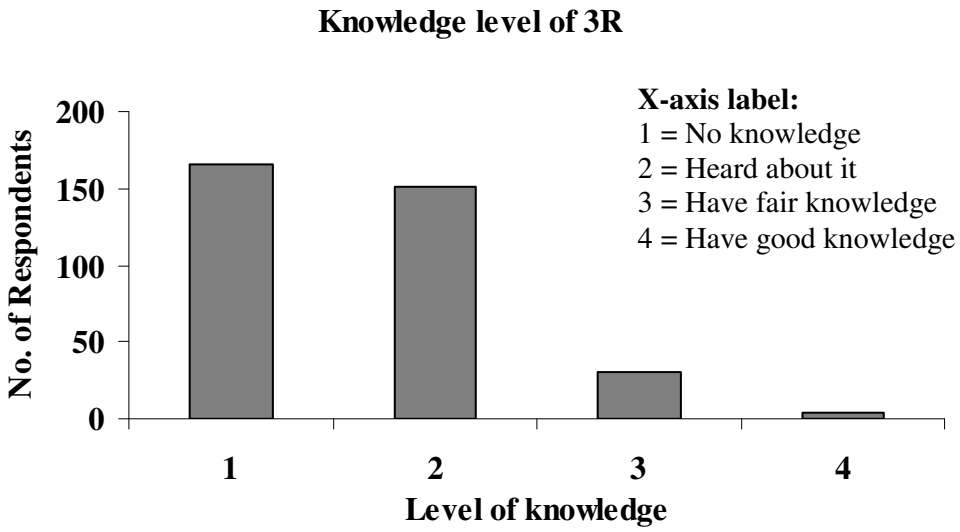


Figure 4.11 Level of 3R knowledge by residents in Thimphu

The waste reduction mechanism did not have a strategic process. Few executive circulars from various government agencies were issued not necessarily to address MSW management but had contribution in it. Like; banning of car wash in the streams and rivers, banning of import of secondhand cars, banning of import of scrap materials for reprocessing and reuse by industries, banning of import and sale of tobacco products, etc.

The ban of use and sale of plastic carry bags is the only initiative taken purposely to tackle waste plastics.

To the fact that Bhutan depends highly on imported goods (DRC, 2006; NSB, 2006) and most items are comparatively expensive, reuse of the goods before disposal is an integral culture. Especially the expensive items like car and its complimentary parts, electronic devices, electrical appliances are not considered a luxury in many societies. Therefore, as much as possible, optimum usage, repairing and reuse of the items are attempted. Once beyond repair, metallic goods are sold to the scrap dealers. The majority questionnaire respondents (85%) as such stated that the E-waste goods are sold to the scrap dealers.

Although recycling of waste products requirement is addressed as early as 1992 in the Solid Waste Management for Thimphu City project document, no significant implementation is seen even today. The Regulation (RGoB, 1995), Environmental Code of Practices (ECoPs), and the strategic policy documents which emphasized recycling of wastes therefore have received very little recognition when it comes to implementation.

4.7 Prerequisites and barriers to enhance 3R options in Thimphu

As stated by the UNEP in its contribution paper (UNEP, 2005) to the 3R ministerial meeting held in Japan in April 2005, prerequisites and barriers are potential to influence the efficiency of the initiatives. It is important to identify and highlight crosscutting and effective parameters. Understanding such parameters will critically fulfill the prerequisites and offset the barriers to enhance implementation of specific techniques for the success of reducing wastes and waste impacts.

4.7.1 Enacting the National Solid Waste Management Act of Bhutan

Accept for the Bhutan Municipal Act of 1999 and the Water and Sanitation Rules, 1995, there are no legal instruments directly addressing municipal entities. The Bhutan Municipal Act of 1999 is more focused on administrative and authority demarcations and therefore SWM did not receive much attention. The provisions under the Water and Sanitation Rules, 1995 focused to guide only the prevailing collection, transportation and disposal systems. It did not address researching and development of new techniques in the system. The latest, National Environment Protection Bill of Bhutan, 2007 went on a visionary level of conserving the environment and it could not narrow down its scope to specific issues like MSW, although it identified 'principle of 3Rs' and 'the polluters pay principle' amongst the applicable principles towards environmental protection. Therefore the NEC needs to expedite enactment of the National Solid Waste Management Act (NSWM Act) which is under drafting process. The NEC also needs to ensure coverage of adequate options towards narrowing the prevailing gaps through wide range consultations and research.

4.7.2 Financial security

In developing countries, a chance of the government funding in full for the wastes management is limited (UNOPS, 2007). Without financial security no innovative technique is safe and sustainable. Dependence on external (donor) assistance and loan from the financial institutions associates high liability risk. Therefore, developing an internal

financing mechanism to ensure consistent financing is crucial in the MSW management system. The avenues to establish such an inbuilt system include; polluter pays principle, and privatization with enabling instruments (MoWHS, 2007a; UNOPS, 2007). Through the questionnaire interviews it was found that the citizens of Thimphu are willing to cooperate in anything to get rid of the waste problem. When asked for the willingness to pay, 46.7% said happy to pay, 42.5% agree to pay if asked for and only around 11% responded not willing to pay. Whatever, it is important that the collected money should be directly plowed back to the SWM activity instead of following the usual financial norms. Otherwise, the willingness to pay will not persist if poor services are provided after fees/tax collection.

i) Polluters pay principle:
   - Provisioned within the NSWM Act, municipal service tax/fee can be imposed on non-degradable goods on import or the industries production.
   - Collection of SWM service fees from the residents, shops and the industries according to their waste generation capacity for the municipal authorities or the private party to provide paid services.

ii) Privatization with incentives: Nurturing/encouraging private parties to undertake MSW management on the whole or in parts through capacity building support, subsidies and/or soft loans, and competition for economically viable recycling activities.

iii) Privatization through enabling instruments: Relieving/reducing income/sales tax on their waste recycled products and/or controlling the markets to let waste recycled products survive. The market control mechanism can be through either imposing heavy import tax on fresh resource goods to balance the market price or by controlling the imports applying legal instruments. Making mandatory for the residents to buy recycled products and streamlining the business licenses are also some viable enabling instrument in private party initiative.

4.7.3 Capacity building

Developing policy framework, guidelines and in many cases legal instruments is possible through hiring of experts or well qualified professionals. However, splendid policies, strategy and action plans usually do not fulfill the expected outputs in absence of the required capacity with the relevant organizations. Institutional capacity is usually weak in developing countries (UNOPS, 2007). Lacking capacity and resources, especially skilled manpower and finance undermines the determined objectives. The questionnaire interview information interprets that people having fair knowledge of unmanaged waste implications dominate the population. However, the knowledge about 3R concepts is poor. As such, it has become very important for Bhutan to prioritize institutional and human resources capacity building in the MSW management policies. The capacity development can be through;

- Involvement of the national counterparts throughout the exercise with the international experts in developing the policies, guidelines and regulation documents,
- Infusing basic environmental education regarding waste management, safe drinking water, proper sanitation, etc. into the school curriculum,

- Providing periodical short-term intensive training for the officials and the staff working in the field,
- Providing continual long term scholarship for higher studies in the field of Environment Engineering and Management,
- Regular media advertisement of environment protection through MSW management,
- Conducting periodical public campaigning on clean and healthy city themes,
- Regular reminder of waste reduction, reuse and recycling focus in waste management.

4.7.4 Enabling policy instruments

Governance is one of the main strategic factors that need consideration for the success of 3Rs (UNEP, 2005). Institutional arrangements include framing appropriate enabling instruments that can facilitate implementation of 3Rs initiatives. Governments considering enabling policy framework addressing economic and market based instruments facilitate public participation especially through private initiative. Bhutan is yet to initiate 3R principles and enabling instruments should go hand in hand with the initiation of the concept. Enabling instrument include;

- Relaxation of rules and liabilities as deem necessary,
- Relaxation of taxes/fees/fines on activities benefiting the general public,
- Levying of taxes/fees/fines on activities affecting adversely on the general public,
- Nurturing/encouraging public to participate in MSW management on the whole or in parts,
- Providing capacity building opportunities to the parties coming forward to participate,
- Providing subsidies and/or soft loans to establish recycling plants,
- Maintaining transparency and equity in opportunities, information dissemination,
- Controlling the market forces to give more opportunities for recycled products,
- Making mandatory for the in-country agencies and residents to buy recycled products, and
- Streamlining the business licenses to facilitate separation of such ventures from other commercial activities and provide them support, wherever necessary.

4.7.5 Public awareness and education

Public awareness is a mass capacity building instrument. With adequate information dissemination more and more people will understand the benefits of the MSW management. Increase in number of people understanding the problems of wastes and knowing how to manage it adequately will benefit the MSW management implementers and the public at large. Other than the ad-hoc cleaning campaigning conducted by various government and private agencies and the educational institutions, no regular public awareness program exist in Bhutan. The media actually can play a crucial role in disseminating public information. However, financial resources limit both the media agencies and the environmental agencies to advocate regular public awareness programs.

Also, very little environmental education is imparted in the schooling curriculum. For long term benefit to the society, Education Ministry and NEC should explore possibilities of introducing waste management education in the regular school curricula. From the lessons learned as of now, school authorities and the students have been very instrumental in influencing general public on the solid waste management. The schools in Thimphu practice pilot waste segregation to demonstrate the benefits of waste segregation. The schools also adopted one stream each, flowing next to the school premises, posting sign boards to refrain from littering wastes into the streams. Therefore, infusing environmental themes in education curricula is envisaged to be a crucial parameter for the success of 3R initiative.

Figure 4.12 Photos of the pilot MSW management system by schools in Thimphu

One cost effective and immediately applicable public awareness option is to introduce waste collection bins and announcement system in the public transportation modes (buses and taxis).

4.7.6 Waste segregation at source and transfer station

Separation of waste at source is of paramount importance in 3Rs initiative. The MSW by virtue of its diverse sources will have mixture of materials. Without waste separation the composition of wastes will not be known and planning, designing and implementation of waste management systems will be undermined. Waste separation therefore is a key activity in any successful 3R initiative. In general, the wastes can be separated at three levels; 1) household and community level, 2) in the process of collection and transportation by municipal workers, and 3) at the waste disposal site by the workers and the scavengers (IGES, 2006b). In Thimphu, except for the school demonstrations, waste segregation is not practiced. This is confirmed from the questionnaire interview. 95% of the interviewees said they do not segregate waste. People are however willing to cooperate in practice of waste segregation. Around 195 respondents (55.6%) said they are 100%willing to segregate wastes, 21% said >50% willingness. Only 15% said willingness to segregate <50% and 8% said not willing to segregate wastes. The upcoming NSWM Act must make it mandatory for all residents to segregate wastes and a stringent monitoring mechanism must be instituted.

The quality and efficiency of the recycling plants highly depend on the quality of the segregated wastes. Especially the composting of organic wastes purely depends on quality of waste separation. To confirm segregation quality and elevate the efficiency of the recycling plants, and also to reduce the transportation costs of the waste materials, a transfer station is deeming necessary. Thimphu as of now does not have a transfer station.

4.7.7 Regional/International cooperation

The prevailing most prominent waste recycling activity in Bhutan is collecting, separating and selling of the higher value waste materials across the border to India and Bangladesh. Waste management through regional/international cooperation is encouraged in the Asia 3R paradigm (IGES, 2006a). Like the Thai Negoro PET bottle recycling, Bhutan can also export waste materials abroad and purchase recycled products. Bhutan anyway is highly dependent on import of most non-biodegradable products. Bhutan needs to formalize the trading system with the neighboring countries to enable waste dealers carry out the activity legally and fairly.

4.7.8 Public-private participation and industries undertaking

Due to the fact that there is motivated thrust in private initiative, privatization is a recognized mechanism to boost economic development and social services in any country. Solid waste management (SWM) is a crucial social service and possibly could be potential economic activity where private initiative can make a difference in the services efficiency and minimization of waste problems. The Policy framework for solid waste management developed by RSPN and the National Strategy and Action Plan developed by MoWHS in Bhutan also have recommended concerted effort in the MSW management domain. The policy document developed by RSPN (RSPN, 2006) highlights that the coordination amongst the government agencies and between the government and the private needs to be enhanced to address MSW problems. Lack of partnership is an obstacle in any sustainable mission (Shimizu, 2006). Therefore, encouragement of public-private partnership is reiterated to implement in Thimphu's MSW management effort.

The prominent waste reduction and recycling activity is the informal system of collecting, separating and selling of the higher value waste materials across the border to India and Bangladesh. For this, the Royal Government needs to streamline the business licenses and support the waste dealing business as an incentive to reduce waste related problems. According to M/s Karma, a local scrap dealer based in Semtokha, there is no restriction under the umbrella of the retail business licenses to venture any business including waste materials. The statement was later confirmed by the Director of the Department of Trade. This free horizon retail business provides opportunity for anyone to collect and export the higher value, less risk waste products like metals and beer bottles. But, the low value, high risk and special care requiring waste products like plastics, papers and cardboard boxes remain discarded. Further, the waste storage yards were never permitted in the commercially viable areas by the City Corporation. This increases the collection and transportation costs, making the waste dealership an unattractive venture.

With proper research, there is a potentiality to reuse, recycle, and dispose various components of wastes in a meaningful manner by the industries within the country. But, this has never happened in absence of a legal instrument to enforce the industrialists. The industries could consume some waste materials as supplementary raw materials or as RDF in heat energy furnaces. Like; Army Welfare Project (AWP), Samtse Unit could consume cardboard/carton boxes and the liquor glass bottles for reusing and recycling to same products. The RSA Poly Products Pvt. Ltd. in Phuentsholing and Bhutan Polymers in Gomtu could possibly consume some PVC and LDPE origin waste plastics for its production of the Poly film and Texturised Yarns. The Bhutan Polythene industry in Phuentsholing could consume some HDPE and LDPE product wastes for its production of

polythene pipes and fittings. Industries like Penden Cement and Lhaki Cement factories in Gomtu, Bhutan Ferro Alloys, Bhutan Chemical Carbide, Bhutan Steel industries and Druk Iron & Steel Factory in and around Phuentsholing could use waste plastics, paper and cardboard, glass and commingled components as RDF in their furnaces after segregating the hazardous compositions. The NSWM Act is required to enforce industries to research and develop techniques to consume MSW besides managing their on wastes.

Otherwise too, during my study research, there were many private individuals expressing interests in venturing MSW management in parts or in a package. The obstacles for them have been long procedural formalities, very little flexibility and none concrete decisions from the authorities. Probably, this is due to the absence of a legal framework addressing solvable avenues on both sides; the government and the interested parties. As such, adoption of the NSWM Act with adequate provisions to address all the prevailing loopholes has been very crucial and urgent.

4.8 Correlating viable 3R options for prominent waste components in Thimphu

The prominent waste components from the inventory of the study are; paper and cardboard boxes, 17 tones, organic wastes 16 tones, glass-mainly glass bottles 7 tones, composites 4 tones, plastics 4 tones and the commingled wastes 11.5 tones. At this juncture, it is noted that only paper/cardboard and the organic wastes are feasible for recycling within the country. The rest may need to be continued with the management through regional/international cooperation. It has therefore become very crucial for the Royal Government of Bhutan to formalize the export system of recyclable wastes. Here below, the 3R options for relevant waste components will be discussed.

4.8.1 Paper and cardboards

Most imported and in-country produced goods come packed in carton/cardboard boxes. Therefore cardboard usually constitutes a large component in the collected wastes coming to Memelakha disposal site. High content of the cardboard boxes deprives the waste transportation carriers to carry high density waste. Making more rounds of transportation and increasing the transportation cost. The paper and cardboard/carton boxes together constitute around 26% of the total waste in terms of weight. Few small scale paper recycling units in a decentralized system should address the paper and cardboard component of the wastes in Thimphu. Like in any other developing country (Tchobanoglous *et al*, 1993), the waste paper in Thimphu needs re-segregation and cleaning after receiving at the plant. It is an alternative employment opportunity, but a cost burden.

Figure 4.13 Photos of the high volume cardboard boxes in the MSW of Thimphu

Currently, a private entrepreneur, Jungshi Paper Industry has initiated a paper recycling plant in Jemina, about 20 kilometers from Thimphu town, but it needs to enhance its logistics efficiency. Mechanized system is limited in the plant and there is only one private press agency (KMT Press) which consumes the plant's products constantly. The plant consumes all types of waste papers including the cardboard boxes and reproduces wrapping papers, packing boxes, envelopes, incense and pencil containers, arrow containers, dolls and mask. In the present working capacity the plant can consume only 400 to 500 kilograms of waste paper. With fully mechanized system, it is envisaged to consume 5 to 6 tones of waste paper daily. The promoter however needs policy and financial support from the government to enhance the capacity of the plant. The proprietor seems to have approached the relevant government agencies like NEC, MTI and TCC, but to no avail as of date.

Figure 4.14 Photos from the paper recycling plant in Jemina, Thimphu

4.8.2 Organic wastes

A fairly small unit composting plant should effectively consume the organic waste quantity generated in the urban areas like Thimphu. If the composting plant at Serbithang which is suffering a teething problem becomes operational, the organic waste problem of Thimphu municipality should be resolved. However, composting efficiency will highly depend on quality of waste separation. Just within the organic wastes only, there will be easily decomposing and non-decomposing compositions. In the organic MSW of Thimphu, special care needs to be taken separating Bettle-nut cover from compostable organics. Due to the fact that Bhutanese culturally consume high amount of bettle-nut, significant quantities of bettle-nut cover was observed in the commingled wastes. Food wastes having high salt content also may hamper composting systems and quality. The distance of transportation of raw material wastes to the composting plant and compost products back to the market will significantly influence the price of the compost product. Alas the composting plant in Serbithang is set up too far away from the waste source and the compost market.

Figure 4.15 Photos of the Bettle-nut in the market and the cover in the wastes

4.8.3 Glass

In usual cases, glasses are recycled to reproduce new glasses, glass containers and bottles. Glasses can also be used as RDF material (Tchobanoglous *et al*, 1993). Glass, with 6.65 tones (10.3%) constitutes the third highest component of wastes in terms of weight in the MSW of Thimphu. Majority component of the waste glass is reusable/recyclable (around 90%) bottles those contained liquor and fruit squash juice. The Army Welfare Project (AWP) in Gelephug and Samtse produces 750 milliliters (ml) bottled distillery liquor and the Bhutan Fruit Products (BFP) in Samtse produces mainly 600 ml Orange squash bottled juice for commercial business. Bottles other than beer bottles were less collected by the waste pickers for its low price. The AWP and the BFP instead of collecting their bottles continue importing fresh bottles from India. Only the rural communities reuse the 750 ml liquor bottles for containing and distribution of their local brewery.

Even the broken bottles and the waste glass from the commercial hardware shops if separated and collected are recyclable. The hardware shops habituated used to disposing waste glass into the MSW bin, which after commingling with other wastes becomes difficult to separate and risky to handle for the MSW workers. All glass products are imported and not produced in Bhutan. Therefore, to optimize utilization of the resources and reduce risk to the MSW workers, it is pertinent to consider segregation of waste glasses for recycling. The benefits of glass recycling include reuse of the material, energy saving, reduction in use of landfill sites and in most cases cleaner and safer handling of the wastes. In absence of glass recycling plants within the country, waste glasses needs to be resolved through regional/international cooperation.

Figure 4.16 Photos of waste bottle dealers preparing to transport the collected bottles

4.8.4 Composites, plastics and PET bottles

Composite constitute around 3.6 tones (5.62%) and plastics including the PET bottles constitute 3.7 tones (5.23%) of the daily MSW in Thimphu. Steady substitution of organic wastes by composites is a sign of consumption pattern transformation from local organic products to imported package food. Plastic is a convenient commodity to be used in many forms, but mostly used as packing materials, containers and hand-carry bags. Also, it is difficult to find alternative biodegradable sources to offset use of plastics. Therefore, the ban of purchase and use of plastics products exercised by the government in 1999 did not show effective outcome. Separation at source is again very important for recycling waste plastics too. Otherwise, due to its high calorific value, plastic is highly viable to be used as RDF in the industries (Tchobanoglous *et al*, 1993).

The PET bottles can be shredded to pellets to increase density and reduce volume for transportation convenience while increasing the value of the material. The price is fetched better since it saves space, time and energy of the recycling units when exported in pellets. The machines under use with the TCC and the Bhutan Agro Industries in Thimphu are capable of shredding 32 kilograms of PET bottle pellets a day. 40 PET bottles make one kilogram of pellets. The Thai Negoro recycling of PET bottles to 1 m^2 plastic boards and the Wongpanit recycling waste plastics to press machine (TEI and Sasaki, 2006) are very good examples, but the quantity and capacity within Bhutan is not viable to initiate such a venture. It therefore has to be managed through regional/international cooperation.

Figure 4.17 Photos of PET bottles, shredding machine and the pellets

4.8.5 Commingled waste

By the time the wastes reach at the disposal site the waste is fully mixed. The commingled nature of the wastes makes it almost impossible to separate recyclable wastes. A week long physical survey at Memelakha found that a separable waste in terms of wet weight is less than 1% in average. Despite prior information and explanation on how to separate the wastes, the source point survey also experienced significant quantity of commingled wastes. In total, 11.45 tones (17.75%) of the collected wastes at source point for physical measurement was commingled. If adequate separation effort is applied, the recyclable waste component could significantly increase and the corresponding commingled quantity will decrease. Therefore, a stringent provision for waste separation at source and monitoring authority is necessary in the upcoming NSWM Act.

The commingled wastes after optimum separation of the hazardous and recyclable wastes can be either consumed as RDF in industries or managed through disposal at the landfill site. Landfill is the ultimate option for disposal of the non-separable commingled wastes.

Since no waste management technique is capable of making zero waste, landfill has to be in place to complete the waste management system. All waste minimization activities; incineration, composting, and recycling are to reduce quantity of wastes going to landfill to increase the lifespan of the landfills (Kojima, 2005; Kirkeby *et al*, 2006). With removal of the hazardous waste composition, the characteristics requirement of the landfill will be much simpler and cheaper.

4.8.6 Junk shop and waste bank technique of waste management

Other 3R optional opportunity to explore is the "Junk shop" or "Waste Bank" business as initiated in Phitsanuk in northern Thailand (TEI and Sasaki, 2006). It is doubtful to operate such options in Bhutan due to small population and small amount of appropriate waste products. However, there is no harm in studying the feasibility, especially where there are schools nearby.

4.9 Other wastes

Other than the inventoried waste components, there are also few pertinent wastes which are worthwhile to discuss. They are;

4.9.1 Medical wastes

Autoclaving is an environment friendly technology with moderate cost and easy to operate advantage (Visvanathan, 2006b). For the medical wastes in Bhutan, the Ministry of Health (MoH) has developed a 'guideline for infection control and health care waste management in health facilities' which recommends deep pit burial within the health facility premises after disinfecting the wastes through wet thermal disinfection/autoclaving. The third edition of the guideline was published in 2006. According to the Department of Medical Services officials, the guideline is Bhutanised in the sense that it is made as practical as possible and stringently monitored in its implementation. The initial incineration plant at the Jigme Dorji Wangchuck National Referral Hospital in Thimphu used for incinerating medical wastes is out of order and the Health Ministry is not encouraging to restore the plant. The guideline emphasizes segregation of waste at source. The types of waste categorized by the guideline are; Yellow/White waste-infectious waste in the form of sharps, Red waste-other types of infectious waste, Green waste-Non-infectious waste/general waste, and Blue waste-food waste. The green and blue wastes are directly disposable in the MSW waste bins. Practical treatment/disposal methods for each type of the yellow/white and the red wastes are outlined in the guideline. The MoH is also in the process of developing a guideline for the pharmaceutical wastes management.

4.9.2 E-waste

The Department of National Properties (DNP) collects all the government agencies old/obsolete furniture, car, electrical and electronic devices for public auction time to time. The items that could not be disposed in running condition are auctioned as scrap. From March 2006 to February 2007 the department has auctioned goods worth of approx. USD 1.65 million including trucks, cars, car batteries, worn-out tyres, computers, fax machines, photocopier, TV/Video sets, telephone sets, etc. The international offices usually auction the old items to secondhand buyers before it gets obsolete. The private offices, commercial business and residential household users try to optimize the utilization of E-goods.

Repairing within or outside the country is attempted at first instance for reuse. Ultimately, when it is beyond repair, the goods are sold as scraps to the scrap dealers to recover at least the minimal cost of the item. The most likely 3R initiative that is feasible for E-waste in Bhutan is to substantiate the prevailing system of public auctioning and recycling of wastes through international/regional cooperation.

4.9.3 Construction and demolition waste

Construction and demolition wastes according to the TCC officials are mainly excavated materials from foundation digging and landscaping of the building constructions. The stone boulders are reused into the construction and excavated earth is usually managed for landscaping along the Thimphu river. The demolition waste from the traditional houses constituting mainly wood, stone blocks and rammed earth blocks are also reused. The wood waste, whatever is not reusable is burned by the construction and municipal workers for cooking and heating.

Chapter 5

Conclusions and Recommendations

5.1 Conclusion

The municipal solid waste although comparatively smaller in quantity and less complexity in composition is an emerging challenge in Bhutan particularly in Thimphu. The Thimphu City Corporation lacking authority, resources, knowledge and public support is facing daunting challenges to tackle the MSW appropriately. Memelakha landfill disposal site is overflowing. Implementations of recycling options are constrained by financial resources, human resources and the technological capacity. There are effective but affordable policy options in the 3Rs concept, potential to address the MSW challenges in Thimphu. The study has come forth with various crosscutting and specific options to apply for predominant waste components. For a country like Bhutan, which cannot afford to establish many technocratic and expensive waste recycling plants within the country, the regional/international cooperation for MSW management considered in the APFED on 3Rs (IGES, 2006a; TEI and Sasaki, 2006) is one suitable 3Rs option. The other 3R options requiring immediate application in Thimphu are; institution of waste separation system, polluters pay concept adoption and promotion of private party initiative in the MSW management.

In an overriding manner, a large gap exists between documented policies and the implementation. The reasons for the failure are; i) lacking of a legal instrument that explicitly addresses municipal solid waste management, ii) lack of financial resources, iii) lack of capacity and organizational liberation/upgradation of the waste management sector under TCC, and iv) absence of specified technological options for management of the predominant waste components. Adoption of the NSWM Act encompassing solutions for all the identified gaps and implementation of the specific waste component management options is expected to significantly narrow the gaps and enhance the MSW management situation in Thimphu. A transfer station is deeming necessary to ensure quality of waste separation and reduce waste transportation cost and hassles.

5.2 Recommendations

5.2.1 Crosscutting options

The prevalent 3R options forth coming from the study worthwhile to recommend is enactment of the draft national SWM Act, at the earliest, embracing;

i) Enhancement of international/regional waste management cooperation,
ii) Waste separation mandate to all citizens/residents/ stakeholders,
iii) 'Polluter pays principle' (taxation on non-degradable goods and containers and MSW management fee on residents based on volumetric waste discharge) to ensure financial security,
iv) Nurturing/promotion of private (including industries) initiatives in the MSW management,
v) Institutional and manpower capacity building, and
vi) Enhancing public awareness and education (infusing curricula on waste management in schools, various media programmes and announcements in public mode of transports).

5.2.2 Waste component specific options

Specific options for predominant waste components are:

i) Composting for managing organic wastes. Otherwise, separation of food waste and vegetable wastes for donation to animal caring centers and livestock rearing residents is a food waste quantity reduction option.

ii) Imposing municipal tax on the packing materials for all imported goods at the entry points and on in-country producer agents and charging municipal service fees on the local business vendors and the residents according to their waste generation capacity is expected to reduce significantly waste components like plastics, paper and cardboard boxes. Encouraging/nurturing private parties to participate in recycling of waste paper and cardboard boxes like that of Jungshi Paper Recycling Plant in Jemina are in-country recycling options for waste paper.

iii) Industries requiring heat energy could collect and consume wastes products other than hazardous and recyclable components as refuse derived fuel (RDF) in their furnaces.

iv) Streamlining business licenses and making mandatory for the waste dealers to deal with all sorts of recyclable waste products is an option to manage low value, high liability waste products. The policing duty of the waste product business also can be entrusted to the specific waste dealers in such a system.

v) Controlling the market for survival of the in-country recycled products is an enabling instrument option to encourage more waste recycling ventures.

vi) Making mandatory for the in-country manufacturers to accept back their product wastes (worn-out/obsolete and containers) will be another option to encourage industries participation in MSW management,

vii) Very importantly, institutional capacity building.

5.3 Potential scope for future studies

5.3.1 Study scope in Thimphu

The MSW management concept is still at an initial stage in Bhutan. This study is limited to analysis of policy gaps and appropriate options from 3R paradigm to improve MSW management in Thimphu. It did not cover physical, chemical, biological waste treatment options and cost benefit analysis. Also, the study physical survey conducted was for three dry months season (March-May) only. Therefore, future studies are recommended covering whole year waste generation scenario, cost benefit analysis and various technological options.

5.3.2 National level study scope

Urbanization is an emerging issue in Bhutan. Around 50% of the Bhutanese population is expected to live in urban settlements by 2020 (MoWHS, 2007a). The MSW management system is poor in the capital city and non-existent in most of the district level urban settlements. While the scope of study for MSW management at the national level remains open and wide, one important observation in this study is lack of institutional and human resources capacity to cope with the MSW management challenges. This study however could not encompass an in-depth analysis on the aspects. Therefore, an immediate institutional capacity building analysis study at the national level is recommended.

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Appendices

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Appendix H	Contact and information sources

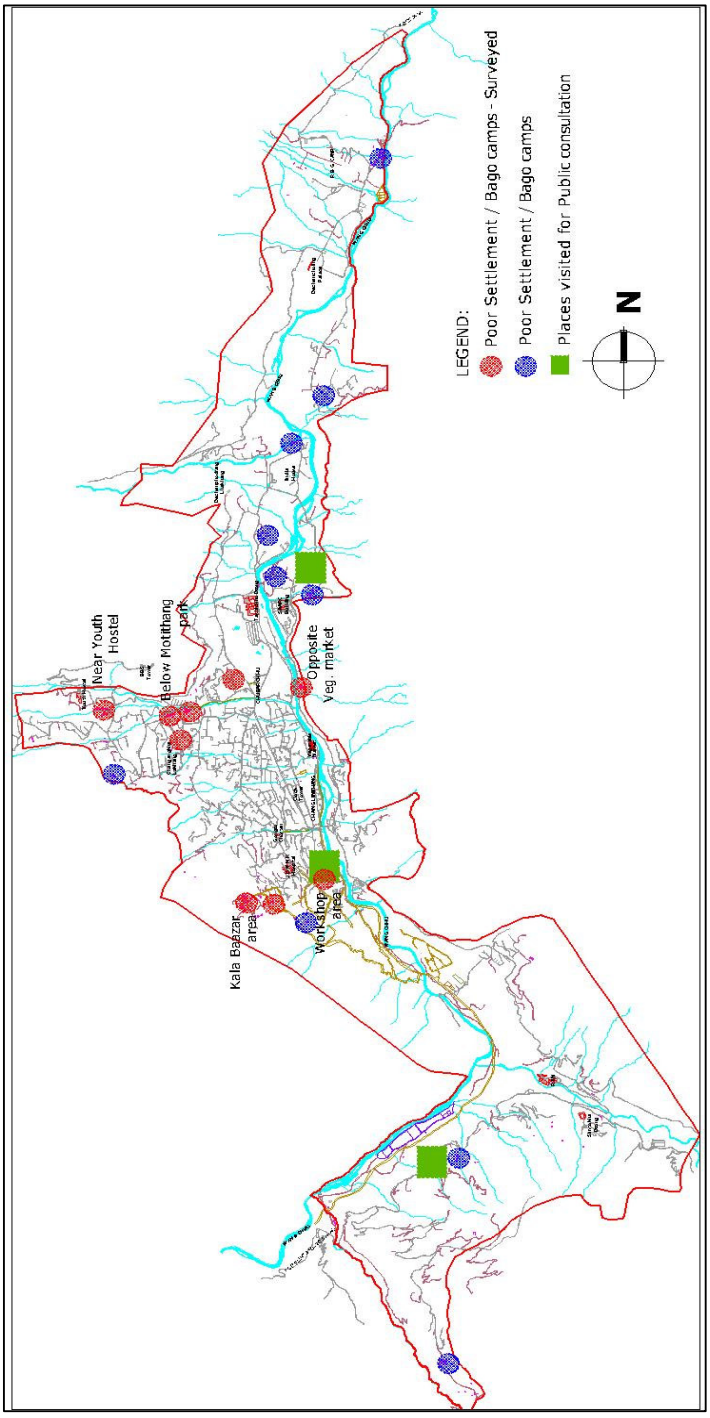
Appendix A

Map of Bhutan

Source: (Drukair, 2007)

Appendix B

Map of Thimphu city



Source: (MoWHS, 2007b)

Appendix C

Photos of MSW in Thimphu and during data collection

Main part of Thimphu city

Overflowing kerbside receptacle bin

Waste collection service by TCC

Wastes collected by informal waste pickers

Mismanagement of wastes by residents

Post weekend vegetable market scenario

Risks of unmanaged wastes

Disposal at Memelakha

Scenario at Memelakha

Physical waste segregation and weight measurement survey for this thesis study

Appendix D

Sample of the field data collection format

Data collection date:
Location:
Source category: Residential HH,
Office/Institution/Commercial shop/Veg. market/
Hospital/Auto. Workshop/Construction & demolition

Waste Category	**Weight (kg)**	**% of Total**	**% Recyclable**
ORGANIC WASTES			
PAPER WASTES			
CARDBOARDS			
COMPOSITES			
PLASTICS			
GLASS			
METALS			
TEXTILES			
HEALTH CARE TEXTILES			
SPECIAL MUNIICPAL WASTE			
UNCLASSIFIED COMBUSTIBLES			
Wood packaging (*Crates, cartons, fruit trays/boxes*)			
Other unclassified combustibles (*wood-boards, leather, rubber, bones*)			
UNCLASSIFIED INCOMBUSTIBLES			
COMMINGLED WASTES			
GRAND TOTAL			

Source: Modified from (EPA, 1996)

Appendix E

Questionnaire sample
(Modified from World Bank, 1996)

General Information:
Date of interview:
Name of the Respondent:
Gender: (M/F)
Qualification (University/High School/None):
Address/Location:
Family/Staff size:
Occupation:
(Residential, Retail shop, Schools, Govt. & Corporate offices, Private Offices, Wholesale business, Hotels & Restaurant, Bar shops, other service shops, Industry, Automobile workshop)

1. Do you have municipal solid waste service accessibility?

   Yes **No**

2. What is the service frequency?

   Daily **Weekly** **3 days a week** **Never**

3. What type of waste collection service do you receive?

   Door-to-door **Kerbside bin** **Collection trucks** **Others** **NO**

4. Do you segregate wastes?

   Yes **No**

5. How much do you know about implications of the unmanaged wastes?

   Well **Fair** **Little** **No**

6. Where do you dispose electrical/electronic devices when it is damaged and it gets obsolete?

   Municipal bins **Sale for scrap** **Recycling abroad**

7. Where do you dispose your cosmetics containers?

   Municipal bins **Open space** **Safe disposal**

8. Where do you dispose shoe polish containers and batteries (pencil and torch battery)?

   Municipal bins **Open space** **Safe disposal**

9. Where do you dispose obsolete fluorescence bulbs and tubes?

Municipal bins	Open space	Safe disposal

10. Where do you dispose your battery and other wastes fluid and polish conatiners?

Workshop/export	Open space	MSW Collector	No car

11. What type of waste containers do you maintain at home?

Plastic bins	Metal bins	Plastic bags	Others (boxes)

12. How much do you know about 3Rs (Reduce, Reuse, Recycle) concept of the MSW management?

Well	Fair	Heard	No

13. With what system do you think a MSW management will better sustain?

Municipal fee	Awareness	Privatization	Legal tools

14. How much is your willingness to separate wastes at the household level if such a system introduced?

100%	>50%	<50%	Not willing

15. How would be your willingness pay, if "polluter pays principle" is intorduced?

Happy	Agree	Not happy

16. What is your suggestion for improvement of the urban solid waste management in Bhutan?

Awareness	Penalty	Service fee	Privatization	No comment

Appendix F

Raw data

1. Collected MSW composition and wet weight measured at Memelakha

Waste Composition	Daily collected wastes (kg)	% to total waste	% Recyclable
Organic	432	1.5	1
Paper	913	3	3
Cardboard	770	2.5	2
Composites	367	1	1
Plastics	929	3	3
Glass	224	0.7	1
Metals	15	<1	<1
Textiles	464	2	NA
Healthcare waste	4814	15	NA
Sepcial waste	8	<1	NA
Unclassified (combust)	432	1.5	NA
Commingled	22140	70	NA
Total	**31,508**	**100**	**Approx. 1%**

2. Sample representative size for source point physical survey and interview

Source description	Population (No.)	Sample representative (No.)
Residential household	17214	148
Govt. & Corporate Office	46	18
Schools	27	10
Retail Shops	393	42
Bar shops	159	16
Hotel & restaurants	112	12
Other shops	335	34
Industry	90	9
Auotmobile workshops	48	10
Wholesale shops	25	6
Private Offices	460	46
Total	**18909**	**351**

3. Wastes measurement by sources

Waste generation sources	Total (kg/day)	Observed recyclable (%)
Residential households	44,400	70
Govt. & Corporate Offices	1310	70
Schools	190	70
Retail shops	2620	70
Liquor bars	5520	80
Hotels and restaurants	6070	60
Other services shop	600	30
Industries	1880	30
Automobile workshop	850	20
Wholesale Business stores	130	50
Private Offices	960	60
Grand total	**64,530**	**49.7 %**
Recyclable (%)		**Say 50%**

4. Wastes measurement by compositions at source point

Waste compositions	Quantity (kg/day)	% to Total	Observed recyclable (%)
Organic	15900	25	60
Paper and cardboard boxes	17000	26	80
Composite	3640	6	30
Plastics	3380	5	60
Glass	6650	10	90
Metals	2850	4	90
Textile	1600	2.5	NA
Healthcare	95	<1	NA
Special (Cosmetic, polish, paint etc. containers)	585	1	10
Wood/rubber	1380	2	20
Commingled	11450	18	NA
Total	**64,530**	**100%**	**Av. 50%**

Appendix G

Case studies

1. Memelakha disposal case study

Details for Process/Operation and Management

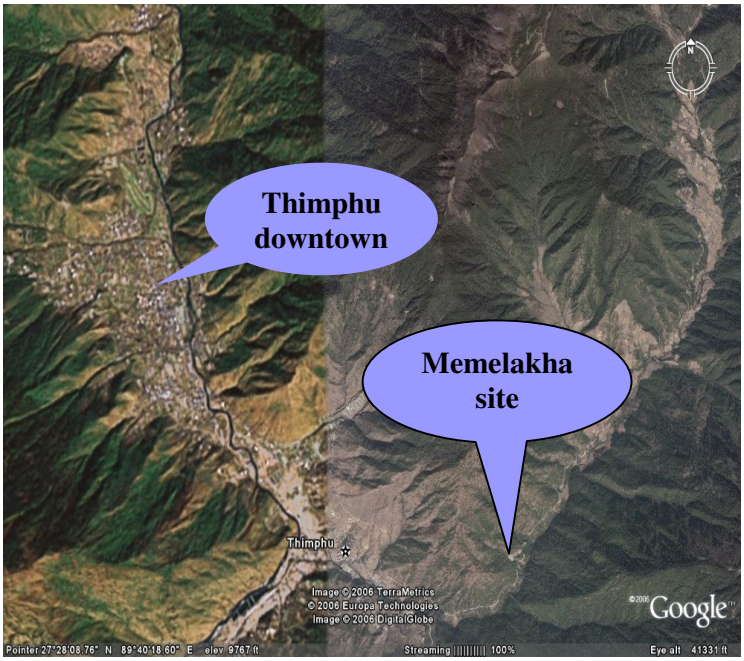
Thimphu City Corporation (TCC) is the sole agency responsible for management of the waste within Thimphu municipality. With assistance from the Danish government (DANIDA) the Memelakha waste disposal site project document was formulated in 1992. The site was made operational since May 1993. Memelakha is on the outskirts of Thimphu city about 10 kilometers from the downtown. When the project was formulated, a population of 25,000 persons with an annual increase of 5% was considered. The volumetric capacity of the site was evaluated between 70,000-80,000 cubic meters. Considering a per capita waste generation of 0.7 kg per day equivalent to a maximum volumetric waste collection of 415 m^3/week (90% collection), the Memelakha disposal site was evaluated to sustain 5 years without any waste recycling scenario. With 5%, 10% and 50% incremental waste recycling attempt (including composting), the lifespan of the disposal site was expected to increase to 6.5 years, 8 years and 12 years respectively.

The waste management remained collection and disposal system. No waste segregation at source was initiated. The commingled collection is simply transported and disposed at Memelakha. Other than informal waste pickers/scavengers and minor scrap dealers, no significant waste recycling plans were initiated. Whatever wastes that could be collected and transported by the waste pickers/dealers were traded across the border to India and Bangladesh. The population of 2005 for Thimphu according to the population and housing census of Bhutan (PHCB, 2006) was around 80,000 people. The daily waste collection according to the primary data collection at Memelakha in April 2007 was around 32 tones. Daily an average of 16 trucks and various capacity containers transport this commingled wastes to Memelakha. Under this condition, the disposal site after more than 14 years of operation is overflowing. A new landfill site has been identified 3 kilometers upstream of present site, but TCC lacked resources to construct the access road and develop the landfill site for operation. No other suitable options are in hand to offset the wastes going to Memelakha.

Future Opportunity/Concluding Remarks/Recommendations

Sustainable waste management in Bhutan is possible through;

- ✓ Urgent enactment of the upcoming national SWM Act,
- ✓ Securing financial resources by introducing 'polluters pay principle'; impose municipal tax on imported goods and charge MSW service fee to the residents,
- ✓ Initiation of waste separation to enhance opportunities for recycling of wastes,
- ✓ Privatization of waste management systems for greater job concentration,
- ✓ Formalization of bilateral arrangements for waste exports,
- ✓ Streamlining of trade licenses and specifying business responsibilities,
- ✓ Promptly making the composting plant at Serbithang functional.



Source: (Europa Technologies, 2006)

Memelakha is about 10 kilometers from the downtown, on the outskirts of the city. About 65 tones of wastes is generated daily in the city

Around 32 tones of commingled wastes is collected and dumped at Memelakha daily

2. Composting plant at Serbithang

Details for Process/Operation and Management

Danish government assistance through Danish International Development Agency (DANIDA) is the second highest donor, next to government of India in the Bhutanese socio-economic development. In the environment sector DANIDA stands the highest donor agency. The Environment and Urban Sector Programme Support (EUSPS) coordinates various components across the line ministries and agencies in the government systems. Clean Technology and Environmental Management (CTEM) is one component implemented under the Ministry of Trade and Industry (MTI). Through the scope of this component, management of wastes from the automobile workshops and the composting of the organic wastes from Bhutan Agro Industry in Serbithang were highlighted. In parallel, under the same donor support component to the Thimphu City Corporation (TCC), composting of the organic MSW became a priority activity. As such, the two composting visions were merged and a site was identified in upper Serbithang, about 2 kilometers upstream of the Bhutan Agro Industry to establish joint composting plant.

Three organizations; the National Environment Commission (NEC) as the national coordinator for the EUSPS assistance, the MTI and the TCC as the host and beneficiary components were involved in the mission. The TCC undertook the responsibility of constructing the composting plant at site. Around US$ 47,000 was invested from the CTEM component. On completion of the shed construction and installation of the required machineries, it was realized that electricity supply to the plant, access road improvement and fencing of the plant were missing in the plan and the budget estimation. The DANIDA support lapsed by then and no other funding sources existed. Therefore, the operation of the plant remained suspended till now. Lately, the government is reconsidering the issue after many controversial media coverage and discussions at the 87th national assembly in June-July 2007.

Composting plant sheds constructed at Serbithang expecting to be operational soon

3. Jungshi paper recycling plant at Jemina, Thimphu

Details for Process/Operation and Management

Jungshi Paper Factory, a private endeavor in the paper production venture is having two units of its enterprise. The one in Thimphu produces traditional handmade paper from natural plants mainly two species of Daphne plant collected from outside Thimphu. The traditional handmade papers are widely used for writing religious scripts, packing materials and hand-carry bags. The unit in Jimina, about 22 kilometers from the center Thimphu town recycles waste papers. The waste paper recycling unit was privately initiated in the late 1990s availing a loan from financial institutions. Due to limited market for its production, the unit had to be closed for few years in between. It was reopened in 2005 on receiving demand for its products as packing materials from another private party, KMT press.

Although the raw material (waste paper) is abundantly available from various offices, institutions and the commercial markets, the manual operation of the plant limits the consumption capacity to 400 to 500 kilograms daily. The plant could consume all sorts of waste papers including the cardboard boxes. The commingled waste paper is sorted manually for metal pins and other defective ingredients prior to feeding into shredding and mashing processes for pulp. The recycled product of the waste paper sheets are produced into desired thicknesses and dried in open space manually. Packing materials like; paper sheets of various sizes and shapes, envelopes of various sizes and shapes, paper boxes, arrow and incense container tubes, and pen/pencil containers are produced as end product. Toys and masks of various kinds also could be molded from the recycled paper pulp. If the recycling could be fully mechanized, it is envisaged that 5 to 6 tons of waste papers could be recycled daily. The packing material production of the recycled waste papers is also expected to substitute plastic containers, thereby, reducing waste plastics. Currently, five persons, most of them family members of the proprietor are employed in the recycling unit. Upgradation of the plant could enhance employment opportunities besides addressing the municipal waste papers problem. The proprietor approached various relevant government agencies (NEC, MTI, TCC) for support in upgrading and fully mechanizing the plant, but to no avail as of date.

Future Opportunity/Concluding Remarks/Recommendations

Promotion of few such private paper recycling plants in a decentralized system would address the waste paper problem locally. Enabling instruments provision in the policy and the upcoming NSWM Act would be appropriate to address the issues. Practice of waste separation at source is must to benefit and sustain the quality of recycling. Government institutions, private and all citizens must share the responsibility of providing segregated waste papers in such a venture.

Manual segregation of waste papers for recycling

Manual drying and stacking of the recycled paper sheets

4. Medical wastes case study

Details for Process/Operation and Management

The handling of wastes at Healthcare facilities (HCFs) chapter in the guideline (3rd ed.) for Infection Control and Health Care Waste Management in health facilities, 2006 considers four types of wastes potential for generation from HCFs;

1. Infectious waste in the form of sharps-Yellow/White
2. Other types of infectious waste-Red
3. Non-infectious waste/general waste-Green
4. Food waste-Blue

Examples of wastes in each category are identified and management guidelines specified. The guideline also specifies transportation, waste treatment and disposal at the establishment techniques for the health care wastes. The techniques are very much Bhutanized for implementation convenience even at the remotest HCFs with limited capacity and resources.

Infectious waste in the form of sharps-Yellow/White: items that include those that can cause cuts or puncture wounds whether infected or not are considered hazardous and potentially infectious. In the management, it is made mandatory to segregate, pack and in safety boxes like previously containing drugs or pharmaceuticals and autoclave wherever possible prior to deep burial pits disposal. Handling with care mechanisms are emphasized to ensure safety of the medical and the ancillary staff and the general public. Low voltage (1600-1700 ^{0}C) electrical needle destroyer is supplied wherever electricity supplies exist. Mechanical needle destroying system is encouraged in absence of the electricity supply.

Other types of infectious waste-Red: that are susceptible to contain pathogens in sufficient concentration to cause diseases to a potential hosts such as discarded materials or equipments from diagnosis, treatment and prevention including dressing, swabs, sanitary towels, blood bags, feces, urine, body fluids, sputum or lung secretions are to be collected in red-colored dustbins or plastic bags of thickness: 0.1mm. When the dustbin is 3/4th full, it should be autoclaved prior to disposal into the municipal waste bins.

The non-infectious wastes including office waste, cloth, paper, plastics, glass and bottles, decontaminated media and lab ware, styrofoam, cans which cannot be recycled and uncontaminated bedding is directly disposed into municipal waste bins and encouraged to recycle them.

Food waste to be collected in blue bins is encouraged to be collected by end-users for cattle and other domestic animal feeds.

Future Opportunity/Concluding Remarks/Recommendations

According to the officials with the Department of Medical Services, health care waste is a serious concern and all the HCFs throughout the country are made mandatory to manage the health care wastes with safety. The HFC officials were trained alternatively or in batches as training of trainers to outreach the waste management knowledge/techniques to the HCF support staff. While techniques designed in the guideline is in accordance to the

grassroots resources and the capacity for realistic implementation, monitoring of the sharps destroyer and autoclaving of the infectious wastes needs close monitoring scheme.

Close-lid waste bins for general wastes collection in the hospital corridors

Collected glucose container, PVC bottles

5. Automobile workshop relocation

Details for Process/Operation and Management

Ever since the five-year developmental plan began in Bhutan in 1961, road construction received major thrust to ease transportation and elevate economic activities in the country. Over the years, the road expanded and number of cars increased in multifold. By the end of the year 2006, the Road Safety and Transport Authority (RSTA) registered 33,241 various types of vehicles. Thimphu alone registered 18,967 (57%) vehicles. Although major repair works of vehicles are usually carried out across the border in India, the multifold increase in number of vehicles demanded regular and minor service workshops in various locations within the country. In Thimphu, the automobile service workshops sprang up in Changzamtog area, in an open space nature on right hand side of the Thimphu river. Due to the fact that most of the owners of the automobile service workshops are not the landlord, investment in infrastructure improvement did not advance from temporary shelters. Substantial spillage of used oil directly on the ground or in the drain continued polluting the land and the river water. This aggravated concern of the Royal Government over the years.

In 1997, the NEC encouraged a private entrepreneur to collect and transport waste oils from the automobile workshops for sale across the border. The private party was provided a Tractor, drums and storage shed at Memelakha to facilitate the business. The initiative, however, did not last long. Although the informal waste oil collection and sale across the border revived in 2006 with increasing demand from the bordering Indian town of Jaigaon, the government has already considered relocating the workshops with an improved infrastructure to address environmental concerns. Initially the Ministry of Trade and Industry (MTI) was designated to implement the relocation of the automobile workshops. The Ministry in consultation with the Thimphu City Corporation (TCC) identified the new site at lower Changzamtog. A project proposal was submitted to the Cleaner Technology and Environmental Management component within MTI. The plan, however, deterred when the Thimphu-Babesa express highway alignment came across the identified automobile workshop site. The TCC after that ran short of space to identify as substitute site. In the meantime, the DANIDA assistance term expired.

By 2006, the government decides allow private landowners in Ola Rongchu, below Semtokha to develop infrastructures for automobile services and rent it out to the automobile workshop owners in Thimphu. This decision too is opposed by the automobile workshop owners. The argument is that the automobile workshop owners will be at the mercy of the landlords on rental charges. However, the infrastructure construction in Ola Rongchu is making rapid progress.

Future Opportunity/Concluding Remarks/Recommendations

With appropriate infrastructural design to prevent environmental degradation from automobile services wastes, and government mediation to negotiate the rental charges, the new location and infrastructure is expected to improve the quality of the services.

Present open space automobile servicing workshops in Changzamtog

Metal drums used for collection of waste oils in present system

A private initiative, inbuilt automobile servicing system at Ngabi Rongchu

Upcoming automobile service workshops infrastructure at Ola Rongchu

6. Other wastes recycling

Details for Process/Operation and Management

6.1 Sawdust briquetting

Sawdust briquetting venture at Ramtokto, Thimphu to address sawdust problem from the sawmills is a success story in the event of solid waste management. Until early 2005, sawdust generated from the sawmills has been a concern across the country and especially in Thimphu. Controversial water pollution and sawdust hindrance to the surrounding inhabitants during the windy season has pressured the government to search for alternative solutions. On the other hand, the high rate firewood consumption has depleted forest resources in and around Thimphu. Traditionally Bhutanese solely depended on firewood burning for domestic cooking and all purposes of heat energy. Even today, especially in winter, Bhutanese consume significant quantities of firewood for heat energy. Ultimately, through repeated research and trial, the Forestry Development Corporation Limited (FDCL) has managed to establish a sawdust briquetting plant at Ramtokto in lower Thimphu valley. This plant substantially consumed sawdust generated in Thimphu and Paro and substituted the firewood supply, reducing pressure on the local forest resources.

Sawdust to briquette for reuse as firewood

6.2 Metal scrap

The metal scrap actually did not persist to be a waste management challenge. In fact, cases of loosing useful metal items to the informal waste pickers often arise leading to legal cases. The two new Iron and Steel industries; Druk Iron and Steel at Raptengang (Kamji) and Bhutan Steel Industry at Pasakha have further eased the metal scrap business by consuming locally the metal scraps as raw materials. Otherwise, the tin scrap and e-waste hardware are exported in bulk to India by the scrap dealers and the informal waste pickers. Aluminum and copper waste items are consumed locally by the traditional metal fabricating units within the country and across the border. The Karma scrap dealer in Thimphu alone exports annually an average of 5 tons metal scrap to India and Bangladesh.

Beer cans and other metal containers collected for export

6.3 Shredding of PET bottles

No plastic and PET bottle recycling plants exist in the kingdom. However, lately the NEC and TCC have initiated to shred PET bottles to pellets in order to purchase better prices in export while reducing the bulk and the transportation cost. With support from the TCC, the Bhutan Beverages Limited (PEPSI) has established a PET bottle shredding unit in the heart of Thimphu city, capable of shredding 32 kilograms of PET bottle pellets a day. 40 PET bottles make one kilogram of pellets. The Bhutan Agro Industry in Serbithang, Thimphu, which bottles spring water has also procured PET bottle shredding machine to contribute to the PET bottle waste management. The Industry has plans to purchase more machines and distribute to the distributing agents across the country.

PET bottles to pellets for reducing bulk in transportation, storage and higher price

Appendix H

Contact and information sources

i. Policy makers / Government agencies

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