



## Solid Waste Generation, Composition and Management in Paro Hotel Industry

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### Article History

Submitted: 16 February 2017/ Accepted: 8 April 2017/ Published online: 30 June 2017

### Abstract

Management of solid waste has become an increasingly important global issue as a result of population growth, as well as increasing individual needs, changes in lifestyle and growth in tourism. This waste management problem has become severe in the Paro region of Bhutan, driven by growth in tourism, changes in consumption patterns and growth in GDP. This research aimed to study the amount of waste sent to landfill, and the current status of solid waste management systems and waste composition in Paro District hotels. The current composition of solid waste from hotels comprises organic waste (53 %), glass (14 %), paper (9 %), metal (7 %), LDPE (7 %), textiles (5 %), HDPE (3 %), rubber (1 %), and others (1 %). To improve solid waste management (SWM) in the hotel industry and to reduce total amount of waste generated, environmentally sound practices in various nations are recommended such as implementation of guidelines, monitoring systems, education and special training programs for hoteliers and customers.

**Keywords:** Paro district; Household waste; Hotel waste; Composting; Solid waste management

### Introduction

Bhutan is a tiny mountainous country with a total area of 38,394 km<sup>2</sup>, sandwiched between China to the north and India to the west. The population of Bhutan is 0.78 million and gross domestic product per capita is US\$ 2,719 in 2015 [1]. With annual rainfall varying from north to south ranging from 500 mm to 5,000

mm, Bhutan has tremendous potential in generating up to 30,000 MW from hydropower [2]. Thus, export of hydropower to India is one of Bhutan's main economic drivers, in addition to tourism and agribusiness. According to a survey conducted by the Tourism Council of Bhutan, tourist growth in 2015 increased to 155,121 from 287 tourists in 1947. In 2015, 63

% of Bhutan's tourists came from the Asian region, while 37 % came from further afield [3]. As a major contributor to local incomes and the national economy, tourism is a resource-intensive sector, that generates a large waste burden. Numerous studies have reported that increases in seasonal population in the tourist zones also results in elevated the municipal solid waste (MSW) [4-6].

Proper management of the hotel industry's waste and resources would lead to direct financial benefits as well as make a major contribution to a sustainable tourism sector [7]. Hence it is very important to study solid waste management in the hotel industry. A range of problems related to municipal solid waste management in Bhutan has emerged due to open dumping, open burning, rural-urban migration, insufficient waste collection services, as compounded by a lack of reliable data and coherent policy framework [8]. Troschinetz and Mihelcic [9] reported that Bhutan lacks a waste composition study, which would provide the fundamental basis for developing and implementing a successful solid waste management strategy. The first ever waste composition data collection in Bhutan was carried out from November 2007 to January 2008 in ten urban

areas in Bhutan [8]; since then, there has been no further study published for almost 10 years.

Most solid waste in Bhutan is disposed of by landfill; waste prevention, minimization and recycling are not widely practiced. A shortage of waste collection vehicles and identifying locations for new landfill sites are the most significant issues faced by municipal authorities and district administrations [10]. In 2014, poor infrastructure and inappropriate location of landfills in gorges and on two hillsides caused an overflow of leachates by rain during the summer season in Thimphu, Bhutan's capital [11]. Landfill leachates contain a vast range of compounds, many of which are toxic and pose health and environmental risks [12-13].

This study aimed to characterize the present solid waste management system, the waste generation and composition in Paro, Bhutan, especially from the tourism sector. Paro (Figure 1) is the second largest of Bhutan's 20 districts, and was selected as a study site for this research work. Paro district has been developing rapidly in recent years, and its population has grown from 39,800 in 2010 to 43,167 in 2015 [14]. It is one of the country's most alluring tourist destinations, and boasts many luxury resorts [15]. The field research for the study was conducted during the tourist season in October 2016.



**Figure 1** Map of Bhutan [17] showing Paro District and its regions [18].

Paro is located at 2,250 m above sea level and is served by Bhutan's only international airport, which is 50 km from the capital, Thimphu. Paro District has some of the most fertile soils in the country, and 65.2 % of land area is covered with forest [15]. The Paro Chhu river flows through the Paro Valley river, providing ample water resources for agriculture and horticulture. Production of vegetables such as cabbage, potato, carrot, and beans is expanding rapidly, and vegetable export to India is one of Paro's key economic activities [16].

## Methodology

The research work was carried out in rural and urban areas of Paro. Tools for data collection were as follows:

### 1) Semi-structured questionnaire-based interview

Officials of Paro Municipality and non-government organizations involved in solid waste management of Paro were first identified. Stakeholders were interviewed based on semi-structured schedules to collect information related to current waste management practices, waste collection schedules, numbers of vehicles and key challenges faced in collection and transportation. Information was also collected on any waste management programs, training, and participation by local residents, and on the quality of support provided by government and private organizations in Paro.

Five household areas: Olathang, Gaptey, Ganey, Shaba and Paro town were randomly selected, and interviews conducted with four households from each area. Similarly, hotels from five categories ranging from 1- to 5-star were randomly selected, and representatives interviewed using the questionnaire. The questionnaire covered topics including public opinion on solid waste management practices such as collection schedule, willingness to pay more for waste collection services, adoption of

waste management practices such as segregation of waste at source and any issues relating to the current management framework.

### 2) Waste generation and composition study

A waste composition study was carried out to verify the current situation as compared with the 2007-2008 study. The study of screening area in Paro was determined by the following two criteria for hotel study (star and location). However, household site selection was determined by following only one criteria- distance to the landfill. The scope of the study covered 30 registered hotels and 20 registered households in Paro District. The study on households was conducted to identify any differences in waste composition compared with the hotel industries. Solid waste was collected for 7 consecutive days from each sample household and hotel. The collected wastes were transferred to the assigned landfill destination in order to measure waste generation and composition. The collected waste was sorted into 11 waste components: paper, glass, metal, plastic (hard), plastic (soft), food waste, garden waste, leather, rubber, textiles, and others. The standard method ASTM D5231-92 was used to study the physical waste composition.

### 3) On-site observation

Site observation was carried out to obtain an overview of current solid waste management practices. The sites for the onsite observations included waste disposal sites at some of the hotels, as well as landfill sites. There were no recycling centers or compost plants operating in Paro.

## Result and discussion

### 1) Present situation of municipal solid waste management system in Paro

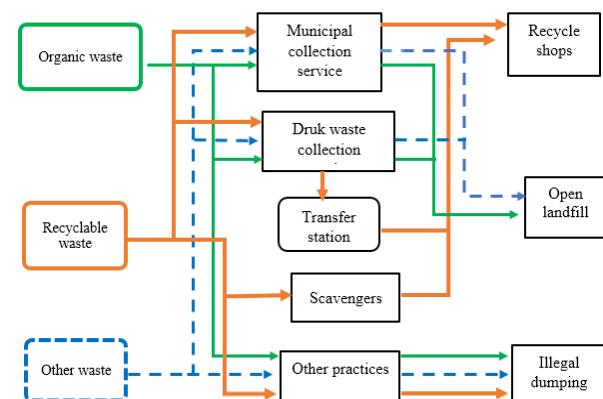
The current municipal solid waste management in Paro is inadequate, with inappropriate disposal activities presenting huge potential dangers to human health and the environment. The present routine of disposing of the waste is neither

environmentally sound nor economically effective. Two specific challenges were evident in the unmanaged waste system, the first being in the process of final waste disposal, where waste is not segregated at source and is not treated before transportation to the landfill. Second, waste disposal sites are not fit for use as a sanitary landfill, and most of the solid waste is dumped in open landfill. The present landfill was constructed in 2010 at a site 11 km from Paro town, with a capacity of 4,200 m<sup>3</sup>.

Two organizations manage collection of waste generated in Paro. The most prominent organization is the Paro Municipal Corporation as it collects waste from all sources. For MSW, different sources include: household units; business ranges; institutions, offices; construction sites; industries; and road management sites; waste from all sources are dumped in open landfill without any separation or treatment. "Druk Waste Collection private limited" is another type of small private organization in Paro, which collect waste only from the hotel industry. Meetings with solid waste management organizations showed that two kinds of existing waste collection practices are door to door and 1 m<sup>3</sup> capacity community steel waste bins situated at strategic junctions.

Paro Municipality has a very limited number of equipment and facilities, with the majority of equipment provided by the donor community. Equipment available in the municipality of Paro include 3 compactor vehicles, 1 tipping truck with tipping mechanism, and 2 open trucks without tipping mechanism, with capacity of 6 m<sup>3</sup>, 4 m<sup>3</sup> and 5 m<sup>3</sup>, respectively. Some of these vehicles are old and worn, and increasingly require more maintenance. Similarly, "Druk Waste Collection" has only one small bolero single cabin with a capacity of 2 m<sup>3</sup>. The waste collection schedule during the low season of tourism is twice a week, or thrice a week during the high tourist season. Household waste was collected only once a week.

A parallel informal system also operates to collect waste from the community bin, segregating and selling recyclable waste materials across the Indian border, a distance of 129 km from the Paro district. Recyclable materials such as glass bottles, plastic bottles, metals, cardboard and paper dumped in the community trash bin and landfill site are identified as a valuable waste to scavengers and municipal workers at the landfill site. On the other hand, organic waste carries no monetary value for informal waste collectors. The current solid waste management system in the Paro district is shown in Figure 2.



**Figure 2** Current solid waste management system in Paro District.

Some of the gaps identified through several data collection surveys are listed below;

**a. Gaps in hotel waste management systems:**

- No waste separation at source in most hotels, for example, kitchen, restaurant, and bar, housekeeping, clothing and maintenance waste.
- Little use of environment-friendly materials. For example, cloth laundry bags could be used instead of plastic, and shampoo dispensed in reusable ceramic bottles.
- Office stationery and paper are not reused.
- Waste containers shading coded for glass and plastic, paper and cardboard, polythene and

plastic, and wet waste only practiced in 5 stars' hotels.

- Very little recycling of organic waste into organic compost or donation of food waste to pig farms.

**b. Gaps in household waste management systems:**

- No waste separation at source.
- Little interest in participating in waste management programs such as local cleaning campaigns.
- No recycling of organic waste into organic compost.
- Little knowledge of municipal solid waste management.
- Dumping of waste in open spaces, burning waste and disposing waste along roadsides and river banks.

**c. Gaps in responsible agency management:**

- Lack of budget.
- Inadequate cooperation between authorities and the public.

- Lack of research on solid waste management.

**2) Waste generation and composition in hotel industries**

**2.1) Waste generation**

Based on this study, the total amount of 64,061 kg of solid waste collected from all the sources were sent to the landfill every day in Paro District. According to the Tourism Council of Bhutan and the questionnaire survey, a total of 30 hotels with 883 rooms are registered in Paro District. Tourist numbers were estimated from the total number of hotel rooms, as this information was not disclosed by the hotels. Since October is the peak season for tourism, numbers were assessed based on an assumption of 70 % occupancy. Based on this assumption, the estimated 618 tourists occupying the 883 rooms generated 494 kg of solid waste per day, or 0.8 kg per capita per day, as shown in Table 1.

**Table 1** Total waste generated per capita per day

Hotels	Number of room	Occupancy (70%)	Waste generation quantity (kg) Min-Max	Average waste generated per day (kg)	Average waste generated per capita per day (kg)
5 star	104	73	94-235	159	2.2
4 star	117	82	16-60	38	0.5
3 star	77	54	25-42	47	0.9
2 star	200	140	22-36	33	0.2
1 star	147	103	22-36	29	0.3

Daily amounts of waste generated varied significantly as shown in Figure 3, with differences both among different hotel categories and within categories.

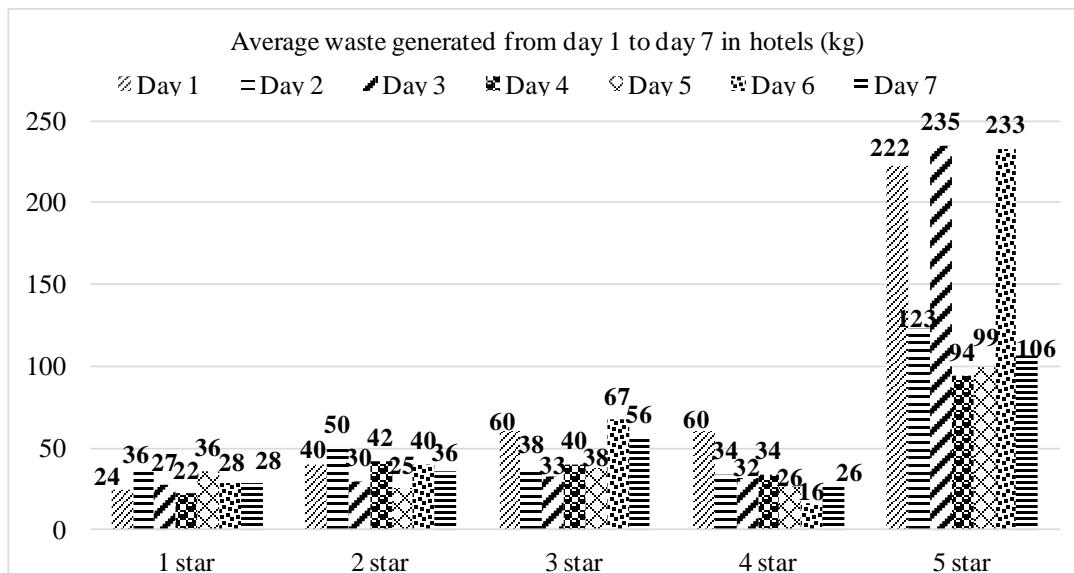
As anticipated, the daily volume of waste generated varied according to the level of luxury. The five 1-star hotels surveyed generated an average 0.2 to 0.3 kg per guest per day, while the six 2-star hotels generated 0.17

to 0.35 kg per guest per day. The two 3-star hotels generated 0.6 to 1.2 kg per guest per day. However, three 4-star hotels generated only 0.2 to 0.7 kg per guest per day as some of these hotels practiced composting of food waste and also donated food waste to pig farms. The two 5-star hotels in the survey generated 1.3 to 3.2 kg per guest per day, mainly because of the diverse activities such as

cultural activities, conferences, weddings, fashion shows, meetings and workshops.

The similar results of weekly waste generation variance are obtained by using ANOVA analysis with significant average differences as shown in Table 2.

There were statistically significant differences in waste generation between hotel categories as well as within the same star category, as determined by ANOVA test ( $F > F_{crit}$ ) at a level of significance of 0.05.



**Figure 3** Average waste generated (kg) from day 1 to day 7 from all the hotel categories.

**Table 2** ANOVA analysis for weekly variation

Groups	Count	Sum	Average	Variance
1 star	7	201	28.71428571	29.57142857
2 star	7	263	37.57142857	67.28571429
3 star	7	332	47.42857143	175.952381
4 star	7	228	32.57142857	186.2857143
5 star	7	1112	158.8571429	4525.142857

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	85117.54286	4	21279.38571	21.34667858	2.02894E-08	2.689627574
Within Groups	29905.42857	30	996.847619			
Total	115022.9714	34				

## 2.2) Waste composition

Generally, waste from the hotel industries comprises wet (natural/biodegradable) and dry waste. Solid waste from Paro hotels comprises food waste, office paper, tissue paper, bottles, plastic, glass, aluminum refreshment compartments and cardboard boxes. During in-depth interview with hotel managers, hotels in all

categories reported little or no waste sorting and no defined system for waste separation. For example, five star hotels have three different containers to collect glass, plastic bottles, and paper, whereas some 1-star and 2-star hotels collect glass and metal for sale to waste dealers. Some 3 and 4-star hotels have only two containers for dry waste and wet waste.

The composition of solid wastes in different types of hotels are shown in Table 3. Organic waste is the highest waste contribution to the waste stream with an average percentage ranging from 42-62 % of the total. The second highest waste contribution in hotel industries is glass, with an average percentage ranging from 12-18 %, followed by other types of waste such

as paper, metal, LDPE, textiles, HDPE, rubber, and others.

The differences in waste volumes and composition may be attributable to a range of factors including hotel rating, location, room number, season and number of days, as shown in Table 4.

**Table 3** Waste composition in different hotel categories

Composition (%)	Hotel star ratings					Average waste composition in hotel (%)
	5	4	3	2	1	
Food waste	60	42	56	44	62	53
Glass	12	17	12	18	14	14
Paper	7	10	8	10	8	9
LDPE	7	9	7	8	6	7
Textiles	3	6	6	5	3	5
Metal	7	8	7	9	3	7
HDPE	1	4	3	3	2	3
Rubber	1	1	1	2	0	1
Others	1	2	1	0	1	1
Garden	1	0	0	0	1	0
Leather	0	1	0	1	0	0

**Table 4** The factors effecting waste composition and generation in hotels

Factors	Factors effecting
Hotel ratings	Status of hotels, the category of tourist, knowledge capacity, budgets and access to training on waste management may influence waste volumes and composition, e.g. composting and donation of food waste are only practiced by some of the 4 and 5-star hotels. Through a survey, some of hoteliers also complained about the lack of budget and expertise to manage waste at budget hotels.
Locations	Environmental awareness at local level, as well as distance from markets may impact on waste generation and composition, e.g. inadequate awareness of waste management in rural areas may lead to gerately increased waste generation.
Number of rooms	Occupancy of hotel rooms affects waste generation and composition, e.g. the higher number of rooms in the hotel will result in more number of occupancy and thereby it will generate more waste.
Number of days	Occupying hotel rooms for a certain number of the day may affect on waste generation and composition. Example: The amount of waste generated from day to day is different due to variation in occupancy and other hotel-based activities such as conferences, meetings, cultural shows, etc.
Seasonal period	The quantity of waste generated, frequency of waste collection and characterization of the waste composition will be affected by tourist season. Example: During peak season in Paro District, waste collection schedule from the hotels is thwice a week due to the higher volumes of waste.

### 3) Comparison of waste composition between household sector and hotels

The main reason for the household study was to identify any differences in composition of solid household waste, as compared with hotels. The findings, shown in Figure 4, indicate relatively similar waste composition. The large volume of organic waste is one of the notable characteristics of waste composition study in both categories. Hotels generated more glass waste (mainly empty bottles) than households. Otherwise, the percentage of other categories of waste was not significantly different between households and hotels.

The paper and cardboard boxes together constitute around 10.5 % by weight for both hotel and household waste. Paper may either be burned or disposed of in the landfill as there is no paper recycling plant. Taken together, plastic bags and PET bottles make up 11.5 % of the total waste generated from both hotels and households. Normally, plastic bags are also dumped in the landfill without any segregation or treatment. However, some waste materials are collected and sold to Indian recycling shops, including cardboard boxes, glass bottles, metals, aluminium cans and PET bottles. The high volume of the cardboard boxes, aluminum jars and PET bottles incur high transport costs due to their low density; there are no waste compressing machines in Paro organizations.

Hotels have a higher potential for reuse as compared with households, for example, with laundry bags, towels, dustbins, bottles for shampoo and toiletries. If all the hotels adopted composting of food waste, a reduction of 50 percentage in food waste could be achieved in the hotel industry.

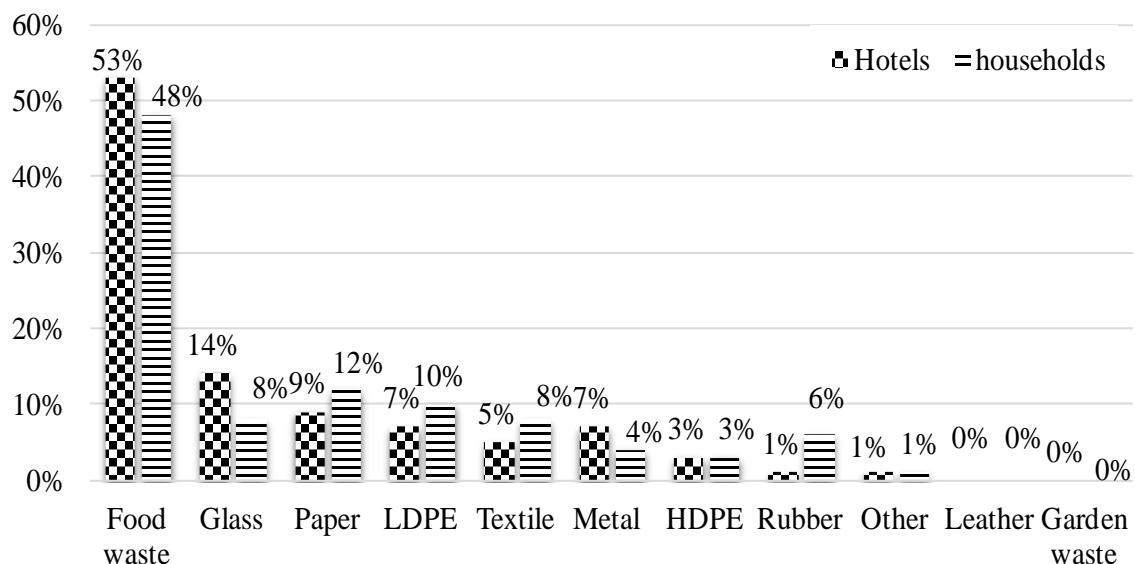
Table 5 compares the composition of solid waste in Paro in 2007 and 2016. The average national waste composition derived from the composition of 10 urban districts of Bhutan. There are no changes in waste composition in the Paro District from 2007 to 2016. However, there is a little difference in the quantity of waste composition between these two years.

The data indicate an increase in components such as glass, metal, rubber and textiles over time, pointing to a shift in lifestyle in Paro away from a traditional towards a more modern, consumer-oriented society. On the other hand, the percentage of recyclable waste has reduced from 2007 to 2016, indicating some level of improvement in the overall waste management system.

The findings for hotel waste can be compared with data from other countries. The composition of waste generated in different countries are shown in Table 6 and compared with the data for hotels in Paro district. Since different methodologies are used in reviews, careful judgment is needed while making the comparison. Though Paro District has fewer hotels with fewer tourists, the waste generated is almost same as other countries.

### 4) Global waste reduction practices in hotel industries

The difference in above waste percentage in different countries as well as in the Paro District is due to involvement of waste reduction practices. Some of the waste reduction practices in different countries are shown in the Table 7.



**Figure 4** Comparison of waste composition between households and hotels.

**Table 5** Waste composition in Paro 2007 and 2016

Waste composition	Average (Paro, 2016)	Average (Paro, 2007)	Average (National, 2007)
Food	50%	58%	58%
Glass	11%	5%	4%
Paper	11%	14%	17%
HDPE and LDPE	12%	15%	13%
Metal	5%	1%	1%
Textile	6.5%	3%	2%
Leather	-	3%	2%
Rubber	3.5%	-	-
Other	1%	1%	3%
Garden	0%	-	-

**Table 6** Comparison of waste composition in hotel industries with other countries

Waste composition	UK, 2012 [19]	Los Angeles, 1991-1993 [20]	Kathmandu, Nepal, 2007 [21]	Chicago, 2009 [22]	Paro, Bhutan, 2016 (This study)
Food waste	37%	46%	57.8%	60.3%	53%
Glass	10%	5.6%	8.8%	6.2%	14%
Paper	18%	25.3%	3.3%	19.6%	9%
Cardboard	7%	11.7%	-	-	-
HDPE and LDPE	15%	6.7%	9.6%	6.7%	10%
Textile	-	-	0.4%	0.4%	5%
Metal	-	4.5%	16.9%	0.8%	7%
Rubber	-	-	-	-	1%
Construction waste	-	-	1.6%	4.1%	-
Other	13%	-	1.7%	1.9%	1%
No. of participating hotels	35	25	3	20	30 (outlets)

**Table 7** Waste reduction practices in different countries

Country	Waste reduction practices
Sweden and Poland [23]	In Sweden 80 % of hotels and in Poland 30.6 % of hotels had an active waste sorting and recycling program. Other waste minimization strategies included donation of hotel furniture and equipment (60 % for Sweden, 50.8 % for Poland), reusable food and detergent packaging (61.8 % for Sweden, 50 % for Poland), and donation of leftover, good quality food (17.3 % for Sweden, 32.3 % for Poland).
Canada [24]	Developed composting program to help reduction of organic material in landfill. In order to reduce dependence on petroleum-based plastics, some restaurants have eliminated the use of drinking straws.
Sweden [25]	Developed an environmental training program which incorporates four parts; 1) environmental guide, 2) environmental meetings, 3) environmental program and 4) environmental barometer. These components provide a better understanding to make environmental strategy, representatives' preparation, implementation planning, and productivity reviewing, to hotel suppliers in environmentally appropriate approaches.
Vietnam [26]	Used laser printer cartridges and shampoo bottles are refilled; 10-30 % of waste (paper/cardboard, aluminum cans, plastic, food residuals) are separated and sold to local collectors for reuse or recycling; reuse carton boxes in good condition for storage purposes; reuse of remaining toilet paper rolls and soaps from guestrooms for internal use.
South Africa [27]	Hotels implemented earthworm farms to turn organic food waste into compost, which is used in the hotel gardens.
Ghana [28]	Have an environmental policy, a supervisor in charge of environmental management and submit environmental management practices to the EPA. Reuse material and towels, compost food waste, produce a brochure and recycle paper, utilized eco-accommodating cleaning items, train staff on minimizing waste, request guests to be environmentally conscious, and sponsored research on an environmental issues.

### Recommendations

Drawing on the experience of adoption of best practices in a number of countries, a number of recommendations proposed to address the challenges identified in this study.

1) Tourism operators should have guidelines and motivation to implement environmental practices, such as saving resources, purchasing of green products, and waste minimization activities.

2) Involvement of government by providing incentives for the industry is required to adopt environmentally friendly practices. The government needs to acknowledge and institutionalize

the practice by instituting rewards/prizes and offering tax benefits.

3) Local authorities should support hotels in composting and provide them with effective tools and education to implement the practice. Composting practices in hotels are highly recommended to reduce organic waste in the landfill and reduce the environmental impact. The most important factor is the quality of waste segregation at source, to achieve effective composting.

4) Training should be provided for hoteliers to raise awareness and educate staff on the most proficient method to lessen and reuse and

also involve guests in the hotel's waste recycling program. Example, reusing container boxes for storage purposes, reusing remaining tissue rolls and soaps from guest rooms for internal use, refilling used shampoo bottles. Another method of spreading awareness is by advertising hotel's environmental commitment.

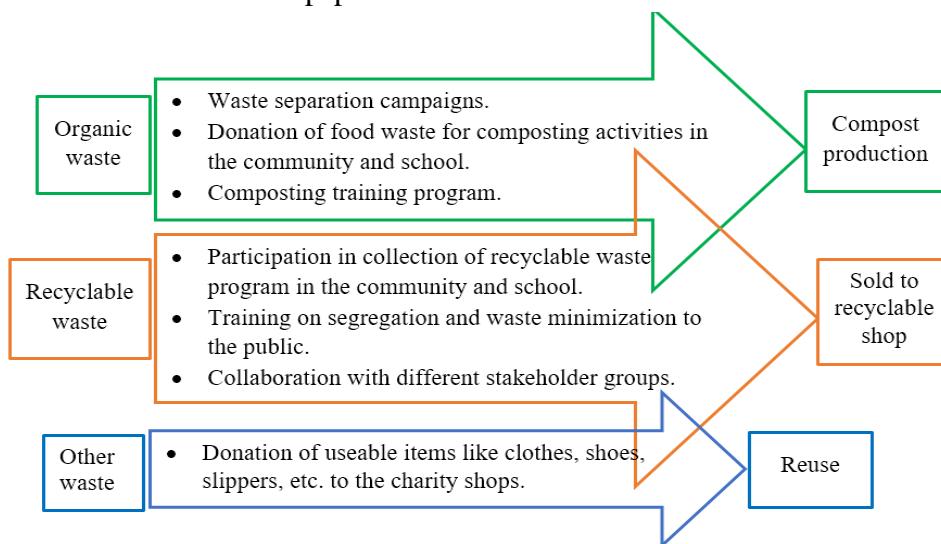
5) Develop monitoring systems and standards for each area of the hotel to set up green hotels. Monitoring of waste segregation at source should be prioritized.

6) A paper shredding machine is also required in Paro District. The "Jemina paper recycling unit" located 22 km distance away from Thimphu District has proven successful, and sorts and shreds all kinds of paper waste

including cardboard paper into different shapes to recycle into various packaging materials and egg trays. Such diversion of recyclables would reduce waste-to-landfill and emissions of greenhouse gases.

7) Focusing on waste reduction in the landfill by developing a transfer station for separation of recyclable wastes is necessary.

8) Build a collaborative relationships among hotels, resorts, and waste collection organizations to conduct good practices of solid waste management. Obtaining different ideas with multi-stakeholders of different districts is necessary to propose a waste utilization strategy as depicted in Figure 5.



**Figure 5** Proposed hotel waste utilization strategy.

## Conclusions

This study has raised our understanding of current solid waste management practices in Paro, Bhutan and led to recommendations for utilizing waste and reducing waste in the landfill, which directly promotes a healthy environment and improves human health. Application of good decision making in waste management programs and training for hoteliers, their staff and the public is important through full support from incentives. Implementing an appropriate solid waste management framework and monitoring system by the waste

management organization will extend the useful life of landfills in Paro District. The most promising and affordable strategies for waste reduction in Paro are composting and recycling. Thus, education on waste separation at source (currently not widely practiced in Paro) is fundamentally important for an effective food waste composting and recycling system.

To raise awareness among the people of Bhutan on solid waste management, environmental impact analysis of the quantified waste generation is essential. There is little infor-

mation or research conducted on environmental impact analysis of solid waste management in Bhutan. Therefore, research on environmental impact analysis is highly recommended for the future work.

### Acknowledgements

Financial support given by the Sirindhorn International Institute of Technology is highly appreciated.

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