

Solid Waste Management in Least Developed Asian Countries – A Comparative Analysis

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Abstract: *Presently, the World Bank has designated 50 countries as the Least Developed Countries (LDCs), out of which 8 countries are from Asia - Afghanistan, Bangladesh, Bhutan, Cambodia, Laos PDR, Maldives, Myanmar and Nepal. This paper highlights the present status of municipal solid waste management in these LDACs including legal, social and financial issues. It is also envisaged to expose on the solid waste generation rate, its composition, collection systems, and areas of responsibilities (public / private sector), transfer and treatment sites and waste disposal systems used. Furthermore, the necessity of the involvement of NGOs, CBOs and private sector for the better understanding and sustainability of the related projects is illustrated. Finally, some successful project stories are discussed which may be good examples for other least developed countries with similar climatic condition and waste composition.*

1. INTRODUCTION

World Bank has categorized some countries as Least Developed Countries (LDCs) in terms of the following criteria: low-income, human resource weakness, and economic vulnerability. At present, 50 countries are designated as LDCs, out of which 8 countries are from Asia - Afghanistan, Bangladesh, Bhutan, Cambodia, Laos PDR, Maldives, Myanmar & Nepal. These countries have a number of priority issues pertaining to the country's development. Among those, management of municipal solid waste is one of the priority urban issues.

Common problems for MSW management in LDACs include institutional deficiencies, inadequate legislation and resource constraints. Long and short term plans are inadequate due to capital and human resource limitations. There is a need for financing equipment for MSW management, training specialists and capacity building. The governments have formulated policies for environmental protection, but they were only implemented in the national capital cities. In rural areas, open dumping is still considered the most popular method of solid waste disposal. Thus, the prevailing issues and conditions in these countries demand extensive studies and researches on solid waste management to improve significantly the local environment for more sustainable living conditions.

In urban solid waste management planning, many of these LDACs adopt a segmental ad hoc approach. However, it is important to practice integrated solid waste management approach such as: Incorporation of more environmental and economic friendly concepts of source separation; recovery of waste; legitimization of the informal systems; partial privatization and public participation.

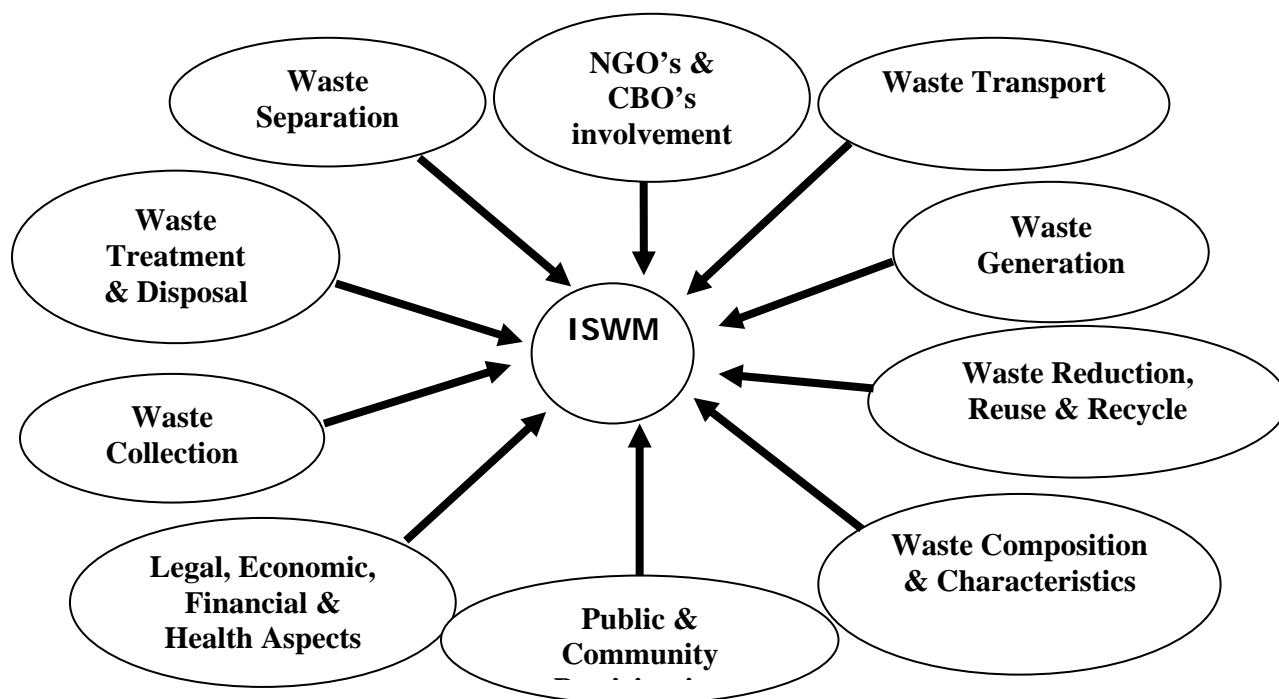


Figure 1: Integrated Solid Waste Management

2. SOLID WASTE CHARACTERIZATION

Although cities of LDACs have a lower rate of waste generation compared to the cities of the developing countries, their quantum of waste is high owing to their higher levels of population density. The tropical climates with a high degree of rainfall and humidity aggravate the problem of solid waste disposal. As cities are becoming more urbanized, their waste composition also changes. The substantial increase in the use of paper and packaging is probably the most obvious change. Other significant changes are due to the higher proportion of plastics and consumer products and their related packaging material in the solid waste. The negative side of greater affluence is that it brings greater volume of wastes, making it more expensive for management.

2.1 Solid waste generation

Accurate information on waste generation is necessary to monitor existing management systems and to make regulatory, financial and institutional decisions. However, reliable data are difficult to obtain in less developed and developing cities. Solid waste generation is based on the economic development, density of population, size of the urban habitation and consumption rate of commercial goods. Figure 2 shows the comparison of solid waste generated per capita (kg/day) in different LDCs and developing countries. It is observed that the generation rate ranges from 0.3 to 1.0 kg/capita/day.

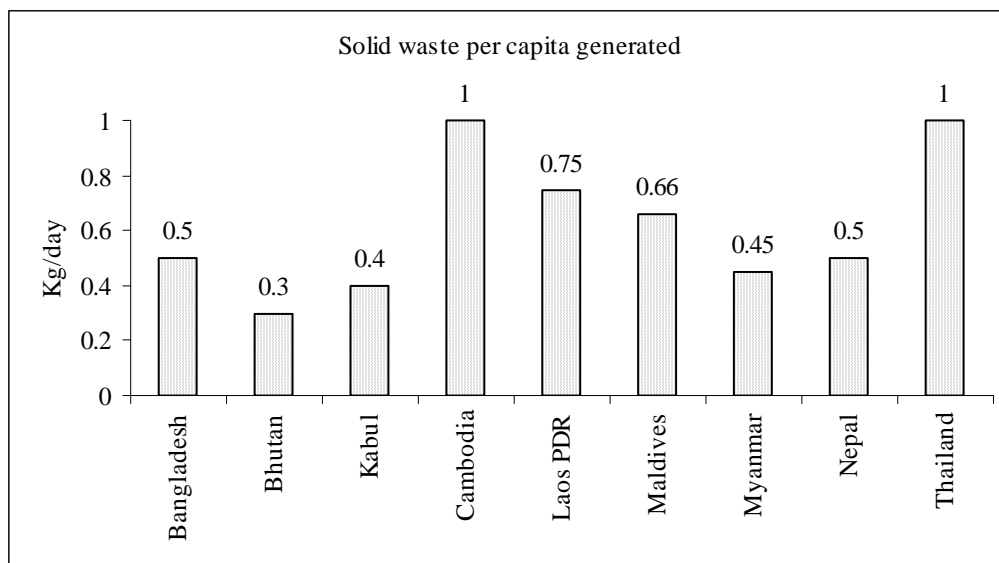


Figure 2: Comparison of Solid Waste Generated per Capita in kg/day

Due to the less industrialized and low income levels, the corresponding figure is less than 1 kg/capita/day. The higher level of waste generation in Maldives is due to rapidly developing construction industry and tourism industry of the country. However, it is interesting to note that the per capita solid waste formation in Cambodia is as high as its industrializing neighbor Thailand.

2.2 Waste composition

A comparison of the current waste composition in LDACs (Figure 3) shows that about 70% or more (by weight) of the waste is combustible (i.e. organics and paper). However, the composition differs depending on the economic level of countries as well as other factors such as geographical location, energy resources, climate, living standards and cultural habits, and the sources of waste that are considered as MSW.

The ratio of paper and plastics including voluminous materials such as food containers and wrapping materials is higher in some countries where tourism industry is expanding; however organic waste is still the dominating factor in all of the countries being studied. The high content of biodegradable matters results in high waste density (weight to volume ratio) and high moisture content. These physical characteristics indicate the necessity of waste treatment prior to disposal. As waste comprises a high organic content and a low calorific value; biological treatment such as composting and bio-gasification (i.e. anaerobic digestion) are thus more suitable. Incineration would not be a good option due to extreme moisture content and low calorific value. In Bangladesh, the lower percentage of plastic is due to the restrictions of using thin plastics. Cambodia, with its slower urbanization growth, also has the same trend with Bangladesh in terms of paper and plastic wastes. Whereas, the low content of the organic material in Laos PDR is mainly due to the agricultural lifestyle where a large scale of the food waste is used as an animal feed. On the other hand, agricultural countries like Myanmar and Nepal, high percentage of their waste is organic, which is contrary to the waste in Maldives. In Maldives, with its rapidly developing construction industry, which is contributing significantly to the composition of their waste, has also lower organic waste composition. This is similar to the situation in Kabul, Afghanistan where 50-60% of their waste content comes from construction debris or white waste.

Since suitable treatment methods are different for different waste compositions, thus differ among cities with different levels of economic development. However, other factors have to be taken into account while choosing the most appropriate waste treatment method.

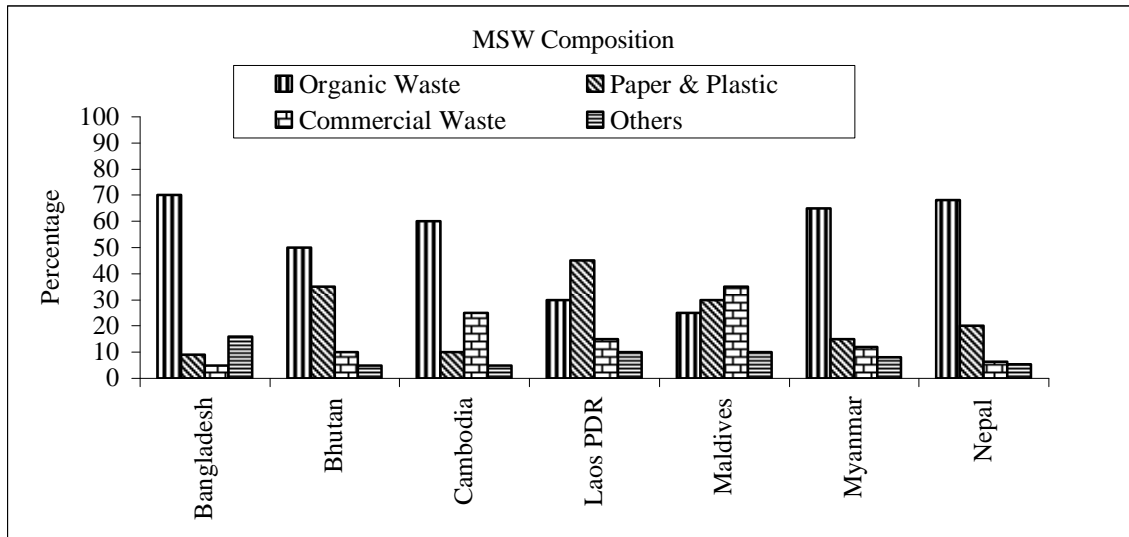


Figure 3: Comparison of organic and inorganic components of MSW

3. SOLID WASTE MANAGEMENT

Nowadays, Capital cities of LDACs are challenged by urbanization and industrialization trends, population increase and consequent rise in waste. Poor government policy and response, lack of political will, lack of appropriate economic and human resources, and weak local institutions result in poor waste management (especially in large cities). These cities therefore face major problems relating to public health and environmental pollution.

3.1 Collection and transport

Generally speaking, significant amount of the solid waste generated in urban centers are uncollected and either burned in the streets or end up in rivers, creeks, marshy areas and empty lots. Waste that is collected is mainly disposed off in open dump-sites, many of which are not properly operated and maintained, thereby posing a serious threat to public health [2]. The collection rate varies from city to city and collection facilities are either inadequate or inefficient in almost all of the cities [3]. Figure 4 describes the collection efficiency of various capital cities in Asia. Bangkok, being one of the fastest developing cities in Asia, exhibited the highest collection efficiency followed by Phnom Penh and Thimphu.

MSW management services account for a high percentage of municipal budgets. Expenditure on MSW management can reach up to 40% of the municipal operating budget and, 70%-90% of this is spent on collection. For instance, Kathmandu spends 38% of the municipal budget on MSW management; 93% of this is spent on sweeping, collection, transfer and transport. In Phnom Penh, part of the collection service is performed by a private company, which demands the waste collection fee from households and directly deducted in their electricity bill.

Since the economic and climatic conditions of LDACs are similar, the system provided for the MSW management is somehow similar in most of the countries. The door to door collection services may not be as efficient as the services in most of the urban areas of the developed countries, but it is also available in LDACs. Others are curbside collection and communal site collection. Mostly the wastes are collected from the curb site. The frequency of collection differs from place to place; at the core areas and commercial areas collection is

done daily while in the low population density areas and residential areas collection is done in every 2 or 3 days interval.

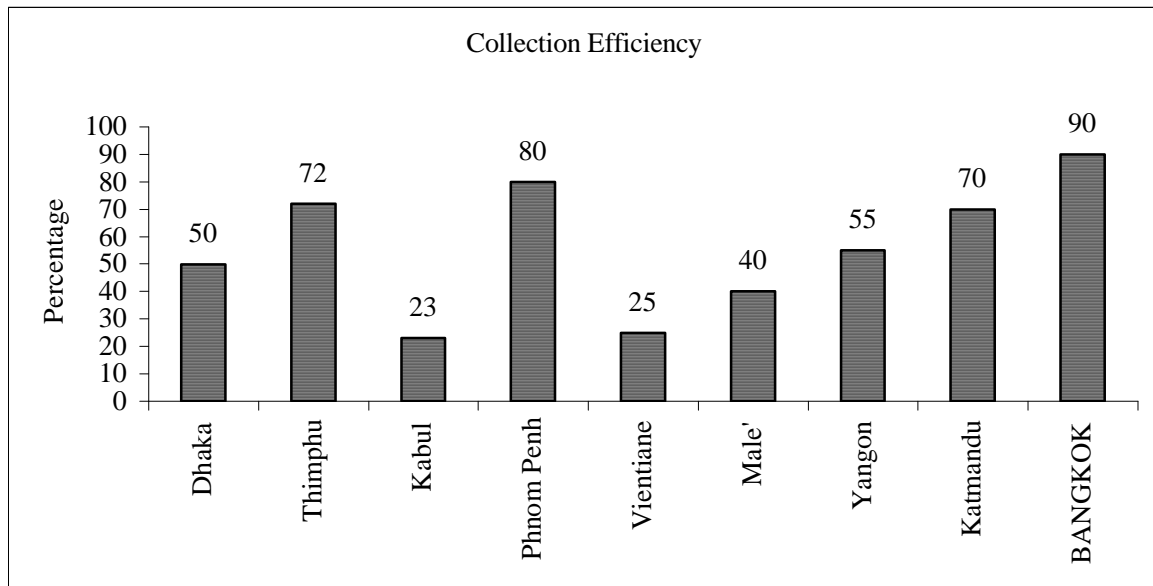


Figure 4: Comparison of Collection Efficiencies

The typical collection fleets used are trucks and pushcarts. Usually in smaller cities pushcarts, rickshaws are most popular for collection, while in larger cities trucks (Fig. 5) with capacity of 7 – 21 m³ are used. There are hardly any transfer stations, which can collect and handle the waste more scientifically. There is a wide practice of using the streets as a secondary transfer station (Fig. 5). In Kathmandu, construction of well equipped transfer station is in progress which may carry on its work after the next few months. Table 1 shows the volume of waste generated and collected in Kabul, Afghanistan. It is evident that only about 25% of the total waste generated in Kabul is being collected while a greater portion of it is not. In addition, Figure 5 also shows that 6-8 persons are assigned for each truck whereas in Bangkok, Thailand only 2 persons are responsible per truck.

Table 1: Volume of Waste Generated and Collected in Kabul, Afghanistan

	Generated	Collected	Uncollected
Volume (m ³)	1540	360	1180
Weight (tons)	1080	250	830



Figure 5: Afghanistan Waste Collection Scenario (Approx 6-8 persons per truck)

3.2 Processing and Disposal of MSW

3.2.1 Landfill

In most of the cities of LDACs, landfill is the most preferred method for the final disposal of solid waste. Most of these sites practice open dumping, with no regards to the requirements for a sanitary landfill. However, government and municipalities are already working to develop the sanitary landfill sites in few urban areas. Since land is fast becoming scarce within city limits, new sanitary landfill are often too distantly located compared to the open dumpsites within municipal limits, thereby making the longer collection and delivery time,, which is ineffectively costly.

In many islands of Maldives organic wastes are composted at home backyards and non-biodegradable waste (such as plastics) is dumped near the beach or buried in a few islands. Burning of combustible waste at designated areas is also widely practice.

In Nepal, after the closing of Gokarna landfill site in 1994, the collected waste is just haphazardly dumped along the Bagmati river banks. In the case of Bangladesh, most of the open dumps are in open land of low lying areas, which usually cause problem during heavy rainfalls and flooding.

Even being the typically used method for final disposal in most LDACs, the overall condition of landfill is still unsatisfactory.

3.2.2 Composting

Composting is the second preferred method of solid waste disposal in LDACs, mainly due to the high percentage of organic material in the waste composition. There are some small-scale composting plants in Dhaka, which has shown more success such as windrow composting, however composting in bigger scale is not that popular in the whole region. The main reason why centralized composting plants are not functioning effectively includes (a) high operating and maintenance costs compared to open landfilling; (b) higher cost of compost than commercial fertilizers; (c) incomplete separation of materials such as plastics and glass, making the compost poor for agricultural application.

3.2.3 Recycling and recovery

Recycling is generally carried out by the informal sector. There are no policies that promote recycling or resource conservation, and the municipalities do not have the expertise to launch the recycling activities. In several places, such as Kathmandu, more of the waste could be recycled if there was better infrastructure for collecting recyclables. However, collection of recyclable waste is done in several steps such as door to door collection, collection at secondary and primary transfer stations and even in the disposal sites. Due to the faulty collection systems and the low quality of scrap, the recycling rate is low despite of high number of waste pickers working.

In Cambodia, even though waste separation at the source is not practice, still some valuable waste is sorted out prior to collection and some done during the transportation. About 12% of the total wastes are collected from the household and from commercial areas by the informal groups for recycling. The main items are soft and hard plastics, glass, steel, paper, cardboard, aluminium and alloys etc. Some items are also exported to Vietnam and Thailand for recycling. In Bhutan, around 20% of the collected wastes are sent for recycling.

Whereas, most of the recyclable wastes collected in Nepal and Bhutan are sent to India, due to insufficient recycling factories in the countries.

3.2.4 Incineration

Due to the high capital, operation and maintenance costs involved for the installation of incineration plants, incineration is not popular as a waste disposal system in the countries being studies. In addition to these, the major portion of the MSW is organic with relatively high moisture content which leads to a low calorific value.

In Afghanistan, due to inadequate incineration facilities at Kabul hospital, medical wastes are improperly disposed off haphazardly along the city streets thereby putting people at risk of exposure to bacteria, viruses, and toxic materials. In Bangladesh, some NGOs are operating incineration plant, especially for handling clinical and hospital wastes, yet still the system is inadequate and inefficient.

4. LEGAL, SOCIAL AND FINANCIAL ISSUES

Due to the similarity in economical and infrastructural development, all the LDACs are facing more or less similar legal, social and financial problems in terms of solid waste management. Considering the necessity of environmental issues in the country's development, government and municipalities are working hard to extend environmental legislation.

Table 2: Responsible Organization & Current situation of MSW in study countries

Country	Responsible Organization	Current situation	Current action
Afghanistan	Ministry of Irrigation, Water resources and Environment and Afghan Assistance Coordination Authority	No environmental legislation	Start to develop legislation since 2001
Bangladesh	Ministry of Environment and Forest	No separate policy or handling rules for solid waste	Preparing a comprehensive solid waste management handling rules
Bhutan	Municipalities	Fails to enforce the law	enforcing the law
Cambodia	Ministry of Environment	n/a	Improving the waste management facilities and educating people
Laos PDR	Ministry of Communications, Transport, Post and Construction	n/a	Establishing a waste management system
Maldives	Ministry of Home Affairs	n/a	n/a
Myanmar	Pollution Control and Cleansing Department	The regulation is outmoded	No action
Nepal	Municipalities	Fails to implement national policy	Improving the waste management facilities and educating people

n/a - not available

Co-operation from the citizens is a vital aspect in managing solid wastes of a city. Habits and attitudes of inhabitants of a city largely affect waste management system. Hence, social aspect can not be separated from the overall waste management system. Public awareness and public participation is a major step in effective implementation of the solid waste management system. Therefore, the government of LDACs are giving importance for environmental education from schools to develop the awareness of the general public.

Financial issues are the main problem for the least developed countries to carry out any kind of development programs. In most of the LDACs donors such as United Nations Development Programme (UNDP), ADB, JICA, German government are helping the local governments for establishing an environmentally sustainable solid waste collection and disposal system.

5. STAKEHOLDERS AND PUBLIC PARTICIPATION

To achieve sustainability in waste management, it is important to look at the roles, interests and power structures prevalent in waste management. Experience in several countries has shown that cooperation and coordination between the different stakeholder groups like city council, provincial government, service users, NGOS, CBOS, the private sector (formal and informal), and donor agencies, will ultimately lead to increase sustainability of the waste management system, such as changes in behavior and sharing of financial responsibilities. On the other hand, ignoring certain activities or groups will result in decreased sustainability of the system, for example in the form of negative public health effects or increased unemployment [4].

5.1 Community based organizations (CBOs)

Unless and until the whole community do not involve in solid waste management with respect to source segregation, recovery of reusable and recyclable materials and storage of waste prior to collection, the management won't be successful. So, the community based organization is an essential element in ensuring the effectiveness of the solid waste management project in LDACs and increasing the likelihood of its sustainability. One such example of a successful CB scheme is the Community based pilot project in solid waste management in Khulna city in Bangladesh [5].

5.2 Private sector participation

Private sector has played an important role in MSWM in some of the countries mentioned in the paper. Specially, in the capital city of Nepal private sector is participating more in door-to-door collection, street sweeping and waste transfer. Due to the involvement of the private sector, collecting garbage is found to be more efficient and in addition to this burden on Kathmandu Municipal Corporation (KMC) is reduced both in financial and in terms of human resources. Approximately 50% of the people surveyed replied that services provided by the private sector were more effective. Therefore, KMC is gearing towards the involvement of the private sector in all aspects of solid waste management.

5.3 Non-governmental organizations (NGOs)

The NGOs play a vital role in developing awareness on the environmental impacts associated with the management of wastes. One such example of non-governmental organization is "Zero Waste Nepal" in Nepal. Zero Waste Nepal is currently working towards

community based solid waste management through application of Zero Waste Concept comprising of the following principles:

- Don't take home unwanted materials
- Produce clean waste through segregation of waste at source
- Sending back the Waste to its source of generation
- Disposal ban of waste in public place or nature
- Encouraging Community participation through NGO and Private Sector.

Zero Waste Nepal is trying to develop new attitude and behaviour of the people towards handling waste and converting the existing "Throw Away" culture to "Zero Waste" culture. It is taking the initiatives towards Solid Waste Management through development of partnership with local clubs for execution at grass root level through interaction with neighbourhood, ward level, local NGO, international development agencies and Rotary clubs for resource mobilization [6].

In Bangladesh, NGOs like Waste Concern, Prodipan, Environmental and Geographic Information Systems (EGIS) are coming up with strategies to manage the solid waste properly. Prodipan is working from collection of solid waste to composting and runs a small scale incineration plant.

6. SUCCESS STORIES

Even though the overall management of municipal solid waste in the countries being studied is not adequate, there are also some successful projects mainly run by NGOs and CBOs. In Bangladesh, Waste Concern one of the NGO, initiated the first pilot project in 1995 with the help of UNDP and Lions Club. They started the public awareness campaign for the separation of waste at source and minimal payment scheme for door-to-door collection. Due to the high demand of good quality compost, Waste Concern started to collect the domestic organic waste (free from toxic and clinical wastes) from houses for composting. Collection rose to 2 tons of solid waste per day with the help of modified rickshaw vans. The number of household participation also started increasing, which are paying about TK 15 per month.

In Laos PDR, a non-government organization introduced Nongnak village solid waste collection project. The project proposed to collect and dispose of municipal solid waste from the local market and promote hygiene practice. This project covered 11 villages with a population of 12000 people. This project tried to upgrade the urban environment and reduce the environmental health hazards caused by garbage accumulation and lack of proper disposal systems. Implementing this project alleviate in sanitation standards for the urban poor. The project had enabled the collection and transport of a large amount of solid waste to the dumpsite away from the village. After the establishment of the project in March 2003, the urban environmental quality had improved a lot.

The Women's Environment Preservation Committee (WEPCO) in Lalitpur, Nepal started a pilot project supported by DANIDA with waste reduction as its main objective. The group is working for source segregation and composting. It is already servicing 500 households with primary collection. The sweepers sort out the recyclables and sell them to waste traders while the organic waste is composted. The organization sells 1200-1500 kg of compost monthly. This method had picked up extensively in Nepal and had set an example for the other LDACs that produce major fractions of organic waste [7].

7. CONCLUSION

The management of municipal solid wastes in LDACs has still many problems. The current regulation system is not perfect, and the existing management system and the collection facilities do not fit the present requirements at all. Municipal solid wastes are still collected without separation at the source, treatment facilities are limited and mostly the collected wastes are also dumped haphazardly in open areas. Government, NGOs, CBOs and private sectors are working hard in this field but still the action is not enough. The main management strategies to remedy this should include amendment of current laws and regulations, improve current management systems and introduce classified collections. The effective implementation of these strategies will help extensively to solve the environmental pollution problems caused by municipal solid wastes in LDACs. It is also important to observe that there are possibilities for research implementation, collaboration between developing and LDACs (south to south), which have similar climatic and solid waste characteristics.

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SOLID WASTE MANAGEMENT IN LEAST DEVELOPED ASIAN COUNTRIES – A COMPARATIVE ANALYSIS

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SOLID WASTE MANAGEMENT IN LDAC

- ✓ United Nations criteria for a Least Developed Country (LDC)
 - ❖ Low income based on GDP on a average three year scale
 - ❖ Human resources weakness based on nutrition, health, education and adult literacy
 - ❖ Economic vulnerability index based on instability of agricultural production, export of goods and services, GDP, economy of country and population
- ✓ At present (2004) there are 50 LDC in the world – 8 are in Asia

SOLID WASTE MANAGEMENT IN LDAC

✓ Least Developed Asian Countries (LDAC)

- ❖ Afghanistan
- ❖ Bangladesh
- ❖ Bhutan
- ❖ Cambodia
- ❖ Laos PDR
- ❖ Maldives
- ❖ Myanmar
- ❖ Nepal



SOLID WASTE MANAGEMENT IN LDAC

Integrated Solid Waste Management (ISWM) is a combination of



SOLID WASTE MANAGEMENT IN LDAC

- ✓ **Concept** of integrated solid waste management (I SWM) provides a framework of developing a sustainable MSW management system
- ✓ I SWM requires that decisions on waste management should take into account at least the following aspects:
 - ❖ Economic
 - ❖ Environmental
 - ❖ Social and
 - ❖ Institutional



Funding
SWM



Educating
SWM



Practicing
SWM



Planning
SWM

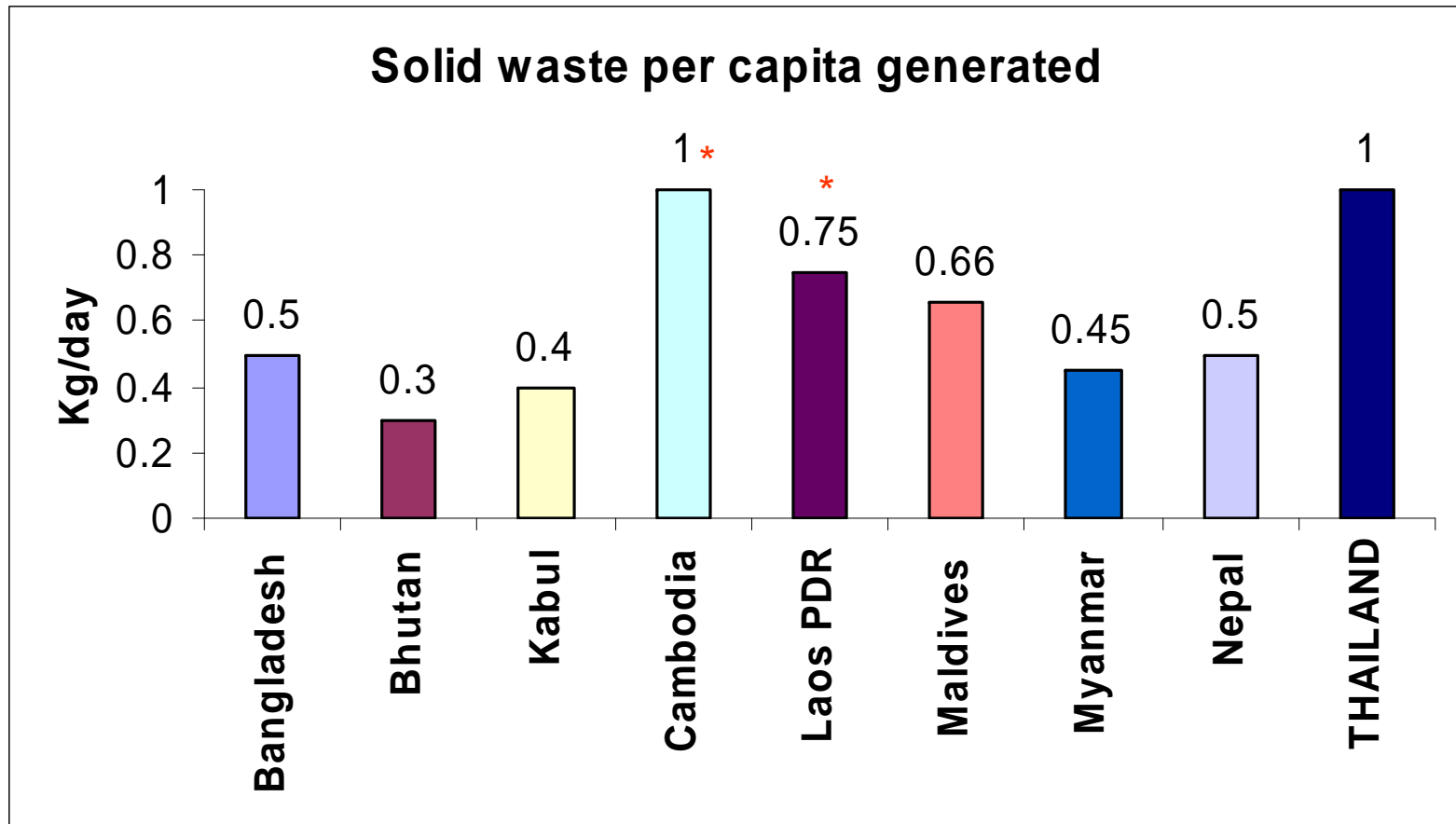
SOLID WASTE MANAGEMENT IN LDAC

- ✓ Integrated approaches to MSW Management
 - ❖ Incorporates More Environment and Economy Friendly Concepts of Source Separation
 - ❖ Recovery of Waste
 - ❖ Legitimization of the Informal Systems
 - ❖ Partial Privatization and
 - ❖ Public Participation



SOLID WASTE MANAGEMENT IN LDAC

Comparison of Solid waste generated per Capita in kg/day

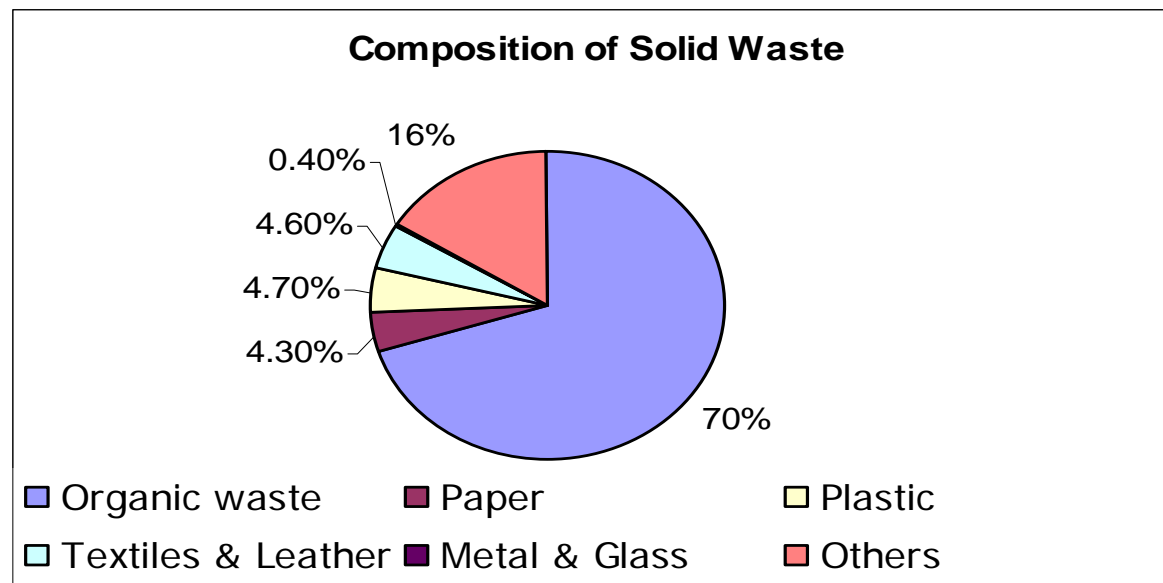


* Approximated Value

SOLID WASTE MANAGEMENT IN LDAC

Bangladesh

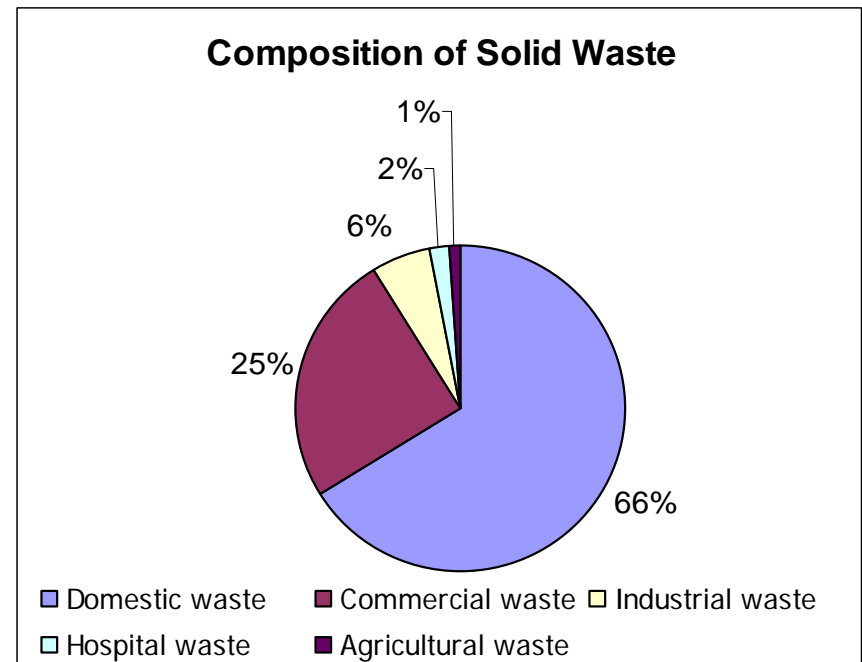
- ❖ Solid waste is finally disposed off at landfill (Dump site) without any treatment and regulations leading to serious environment related problems
- ❖ Composting is practiced with some fraction of organic waste
- ❖ NGO's like Prodiplan have come forward for lending a helping hand for SWM



SOLID WASTE MANAGEMENT IN LDAC

Cambodia

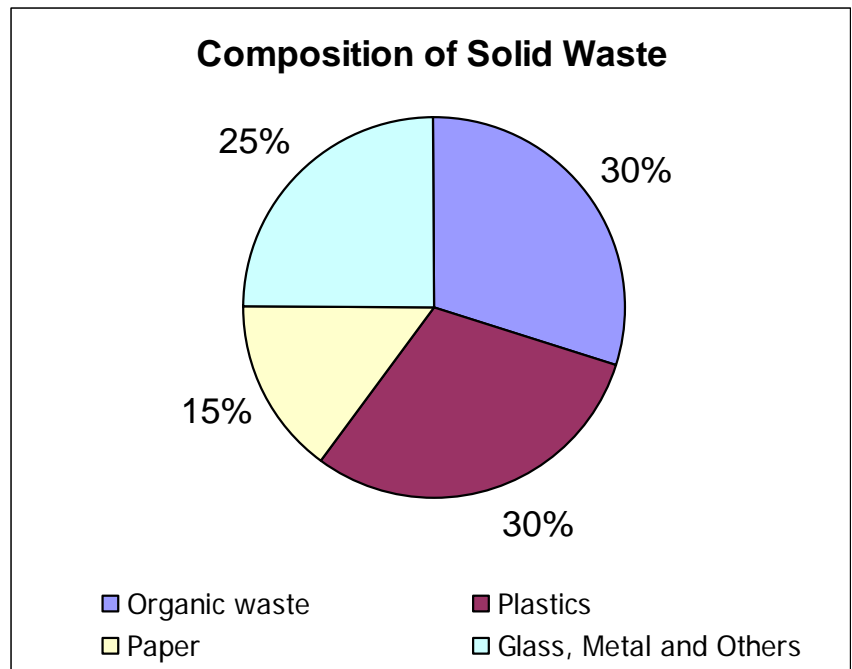
- ❖ Open dumping in a landfill is carried out as the final disposal measure
- ❖ Waste recycling and composting is carried out for suitable wastes
- ❖ Frequent training programs are offered to employees of NGOs like CEPA (Culture and Environment Preservation Association) to cope with SWM issues.



SOLID WASTE MANAGEMENT IN LDAC

Laos PDR

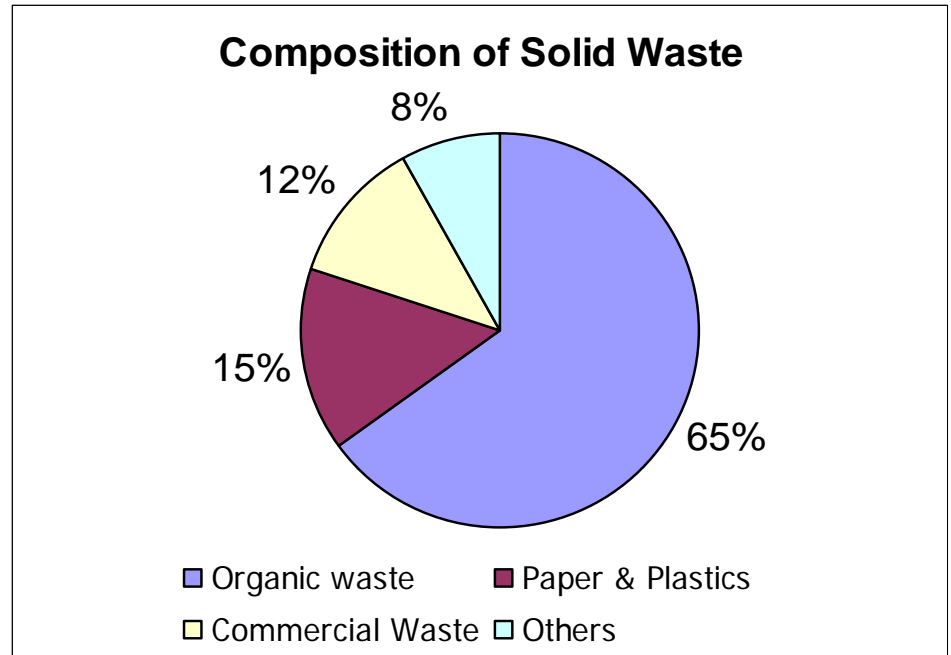
- ❖ Final disposal is a uncontrolled dumpsite outside city limits
- ❖ Occasional burning, scavenging and dumping in water body is also practiced
- ❖ Domestic environmental NGOs do not exist In Laos PDR
- ❖ Foreign NGOs and private companies help the people to overcome the SWM problems



SOLID WASTE MANAGEMENT IN LDAC

Myanmar

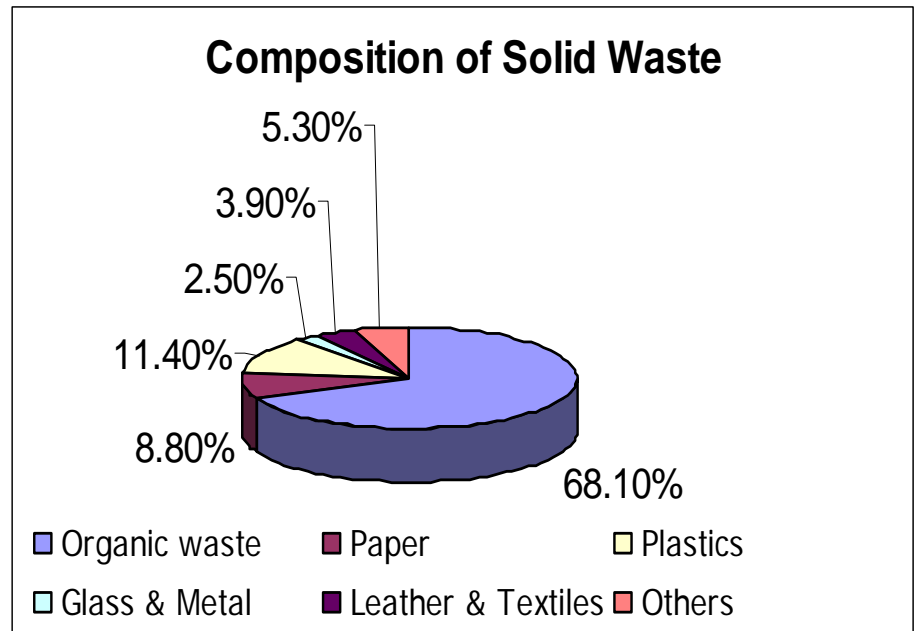
- ❖ Waste is finally disposed of at open dumping site which is uncontrolled
- ❖ Composting and recycling are carried out as alternatives
- ❖ Domestic NGOs take part in SWM activities along with partnership with foreign NGOs like UNEP and UNICEF



SOLID WASTE MANAGEMENT LDAC

Nepal

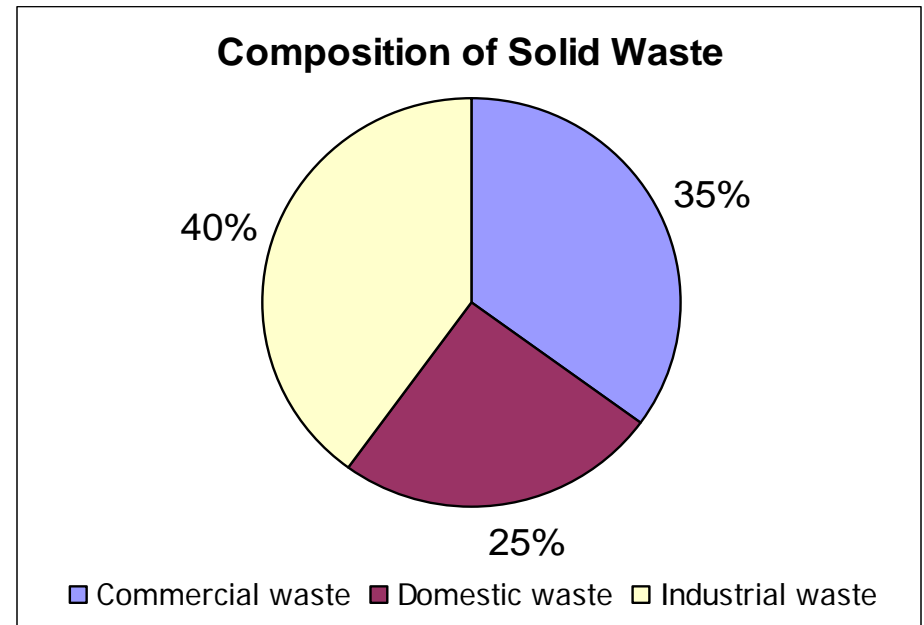
- ❖ Waste is finally disposed off at uncontrolled landfill
- ❖ Disposal on river banks and public places, open burning, scavenging are also followed
- ❖ Only a hand-full of NGOs work for SWM in Nepal who primarily concentrate on earning money from collected waste
- ❖ Foreign NGOs work along with municipalities for SWM activities



SOLID WASTE MANAGEMENT IN LDAC

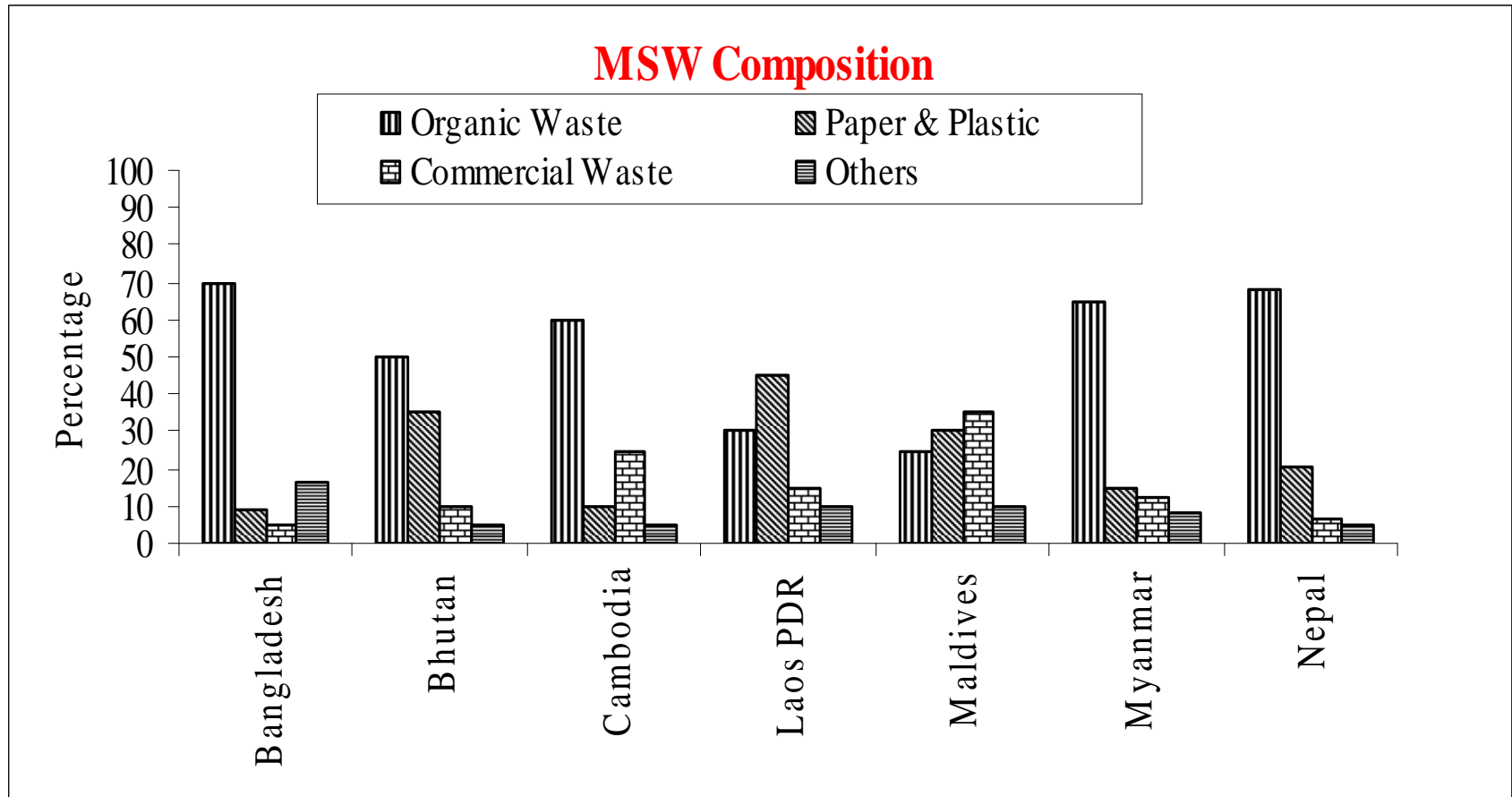
Maldives

- ❖ Waste is finally disposed in a landfill through an intermediate transfer station in Male
- ❖ Open dumping, composting and burning are also practiced widely
- ❖ NGOs like Blue Peace and VESHI work on environment related problems in Maldives



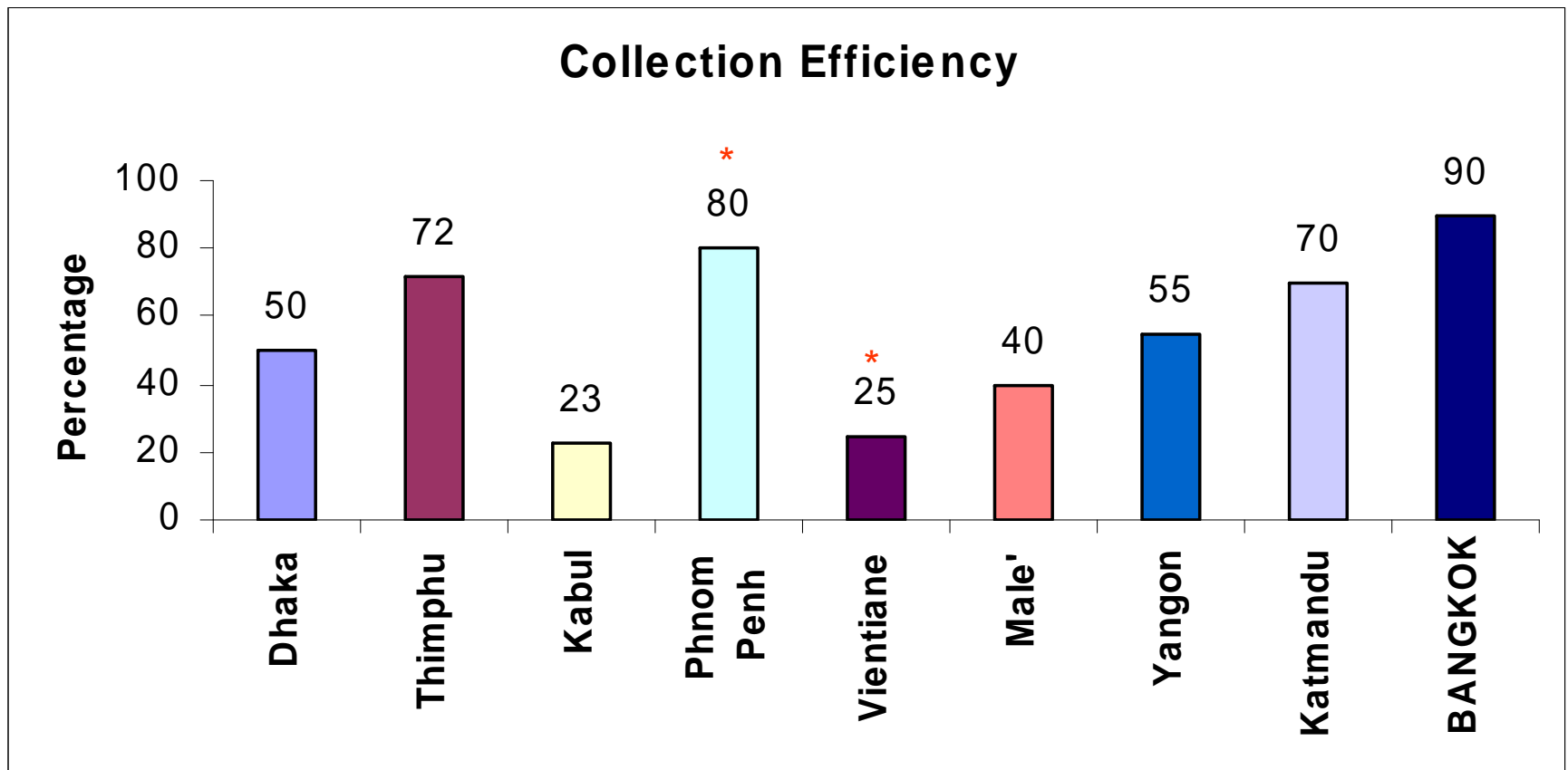
SOLID WASTE MANAGEMENT IN LDAC

Comparison of Organic and Inorganic Components of MSW



SOLID WASTE MANAGEMENT IN LDAC

Comparison of Collection Efficiencies



* Approximated Value

SOLID WASTE MANAGEMENT IN LDAC

Afghanistan (Kabul)

Waste composition

Waste contains 50%-60% of construction debris: **White Waste**



SOLID WASTE MANAGEMENT IN LDAC

Afghanistan (Kabul)

Waste scenario

	Generated	Collected	Un-collected
Volume (m ³):	1540	360	1180
Weight (tons):	1080	250	830



Approx. 6-8 people for each truck)

SOLID WASTE MANAGEMENT IN LDAC

Afghanistan (Kabul)

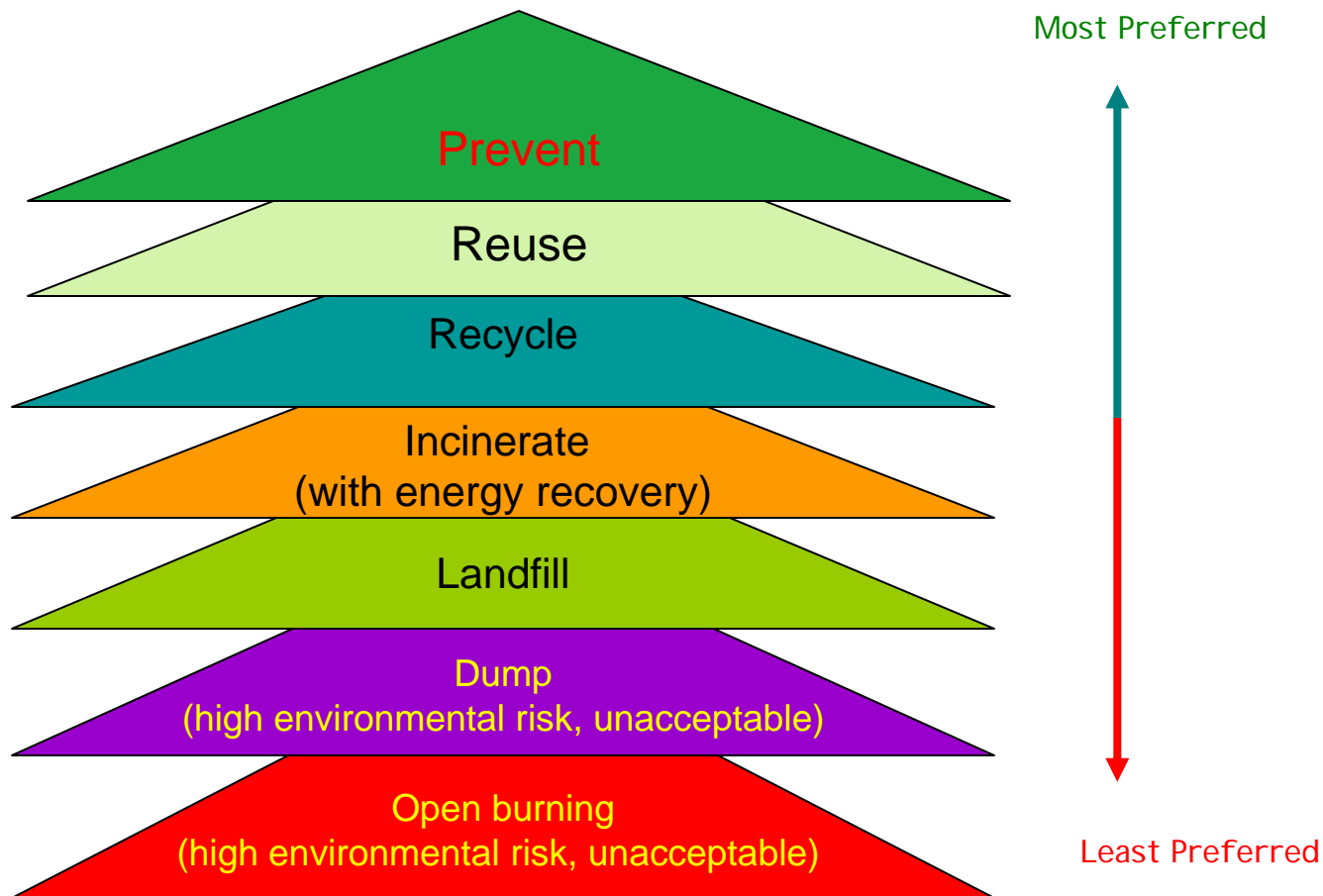
Collection vehicle

- Total Trucks in Working Condition : 51
- No. of trucks collecting/transporting waste : 35 /day



SOLID WASTE MANAGEMENT IN LDAC

Reduction of quantity (Waste Management Hierarchy)



PREVENTION OF BIODEGRADATION BY SEALING

SOLID WASTE MANAGEMENT IN LDAC

Cambodia

Scavengers in Cambodia



Final disposal point in Cambodia

SOLID WASTE MANAGEMENT IN LDAC

Laos PDR

Scavengers at the landfill in Laos PDR



Final disposal point in Laos PDR

SOLID WASTE MANAGEMENT IN LDAC

Maldives

Waste disposal along sea coast
in Maldives



Open burning in Maldives

SOLID WASTE MANAGEMENT IN LDAC

Nepal

Disposal at landfill in Nepal



Scavengers in Nepal

SOLID WASTE MANAGEMENT IN LDAC

Bangladesh



Rag pickers



Dhaka Street

SOLID WASTE MANAGEMENT IN LDAC

Afghanistan (Kabul)

Snap shots



SOLID WASTE MANAGEMENT IN LDAC

Myanmar

Composting in Myanmar



Odor control
at final
disposal
point in
Myanmar



Roadside view

SOLID WASTE MANAGEMENT IN LDAC

Afghanistan (Kabul)

Reused, recycled material represents approx. 30-40% of the **uncollected waste**

Uncollected waste in Kabul per day : 77% of total generated;
(aprox. 830 tons or 1180 cum)



SOLID WASTE MANAGEMENT IN LDAC

Bhutan



Collection bins in Bhutan



Children with solid waste in Bhutan



SOLID WASTE MANAGEMENT IN LDAC

Recommendations

- ❖ An integrated approach for dumpsite management can be followed leading to improvements in the way to reach the goal of sustainable waste management.
- ❖ Steps that are to be used depend on the circumstances needed for improving open dumping and to change open dumping system to a sustainable landfill system as shown in the figure.

