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WASTE CONCERN

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WASTE CONCERN

Abstract

This study introduces an innovative and inclusive approach to environmental and social problems. Dhaka, the capital of Bangladesh, suffers from intense solid waste generation, posing a threat to citizens' health and the environment. Waste Concern, a research-based NGO, realized that the solid waste had a 76% organic content and so started to produce and sell organic compost made from the portion of waste formerly perceived to be of no value. Using a house-to-house collection service, Waste Concern collects the organic residuals directly from households and converts them into compost in decentralized composting plants. The compost is then distributed via the network of a local chemical fertilizer producer. As a result, Waste Concern has created jobs for unskilled workers and reduced the total amount of solid waste to be handled by the municipality, while its compost has helped to improve soil quality – a win-win situation for all stakeholders. More recently, Waste Concern has also started a project under the Clean Development Mechanism (CDM) of the Kyoto Protocol and receives further revenue from this source.

WASTE CONCERN

Introduction*

In March 2005, Iftekhar Enayetullah and Maqsood Sinha looked back at their work with pride – their project had been a success. In 1995 they had founded Waste Concern, a research-based NGO, in Dhaka, Bangladesh, with the aim of producing and selling city waste compost. The composting approach seemed appropriate to Bangladesh, as solid waste in residential areas contained a high portion (around 76%) of organic residuals (Enayetullah *et al*., 2005). Despite obstacles put in their way by government bodies, the two entrepreneurs managed to persuade the city corporation to start the project. Their idea turned out to be advantageous for the megacity Dhaka. On the one hand, Bangladesh's capital was having serious problems handling the huge amount of waste generated every day – the waste not only polluted Dhaka's water but also undermined living conditions and was a health hazard for waste pickers (DOE, 2004). At the same time, Bangladesh's soil was suffering from intense chemical fertilizer use, leading to reduced crop yields in the long run (Gani *et al.*, 2001). In this special environment, Waste Concern's decentralized composting approach, taking advantage of the high organic content of Dhaka's solid waste, found a previously neglected niche. As a result, Waste Concern was able to create jobs for unskilled workers, reduce the amount of solid waste to be handled by the city corporation, and enhance soil quality (Enayetullah *et al.*, 2005). The project's financial viability was secured in three ways. First, Waste Concern charged households a fee for the house-to-house waste collection service. Second, it outsourced distribution of the compost to a large chemical fertilizer producer, which agreed to buy Waste Concern's entire output, which it would then enrich to suit special soil needs and sell through its large distribution network. Third, Waste Concern managed to gain acceptance for its composting project under the international Clean Development Mechanism (CDM) of the Kyoto Protocol and so obtain further income from this source.

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Background

Bangladesh is considered one of the poorest countries in the world, with about 50% of its 135 million inhabitants living in poverty[1] (World Bank_a, 2004). Although Bangladesh has managed to improve living conditions and reduce poverty[2] slightly since independence in 1971, the situation remains demanding.

Bangladesh has one of the world's highest population densities (about 800 people per sq km), complicating any attempt to raise the population's overall living standard (World Bank_a, 2004). Historically, until 1951 about 95% of Bangladesh's population lived in rural areas, but continuing migration into urban areas had increased the proportion of city dwellers to 23% by 2001 (DOE, 2004).

Exhibit 1. Urbanization in Bangladesh (DOE, 2004)

Year	Total Urban Population	Percent of Urban Population	Average Annual Growth Rate (%)
1951	1,819,773	4.33	1.69
1961	2,640,726	5.19	3.75
1974	6,273,602	8.78	6.62
1981	13,535,963	15.54	10.63
1991	20,872,204	20.15	5.43
2001	28,808,477	23.39	3.27

The country's already high population density is highest in the cities, with levels of up to 18,000 people per sq km (DOE, 2004), thereby aggravating living conditions.

The Capital of Bangladesh: Dhaka

Dhaka, the capital of Bangladesh, with more than 10 million inhabitants, is one of the fastest growing megacities in the world. In the period 1991 to 2001, it had an average annual growth rate of more than 4% (DOE, 2004).

Exhibit 2. Population Growth of Dhaka City (DOE, 2004)

Year	Population	Average Annual Growth Rate (%)
1951	411,279	1.28
1961	718,766	5.74
1974	2,068,353	8.47
1981	3,440,147	7.53
1991	6,487,459	6.55
2001	9,912,908	4.33

[1] Even compared with other South Asian countries, the poverty rate in Bangladesh is very high. Bangladesh has the highest poverty incidence in Asia and ranks third in number of poor people living in one country, surpassed only by India and China (World Bank_a, 2004).

[2] GNI per capita reached US $ 400 and annual GDP grew at 5.2% in 2003 (World Bank_b, 2004).

The Dhaka metropolitan area, also referred to as the Dhaka megacity, occupies an area of about 1353 sq kms (Enayetullah, 1999). About 6 million residents live under the Dhaka City Corporation (DCC) in an area of 344 sq kms (Enayetullah, 1999). This already very densely populated area is subject to further population densification, as there is only limited flood-free land available.

Waste Generation

These 6 million residents of Dhaka City generate about 4635 tons of solid waste per day (Enayetullah *et al*., 2005), which has to be removed by the city corporation. Of course, population growth means an increasing amount of waste – historically, total urban solid waste generation in Bangladesh has increased in line with urban population growth (DOE, 2004).

Exhibit 3. Total Urban Solid Waste Generation in Bangladesh (DOE, 2004)

Year	Total Urban Population	Urban Population (% Total)	Waste Generation Rate (kg/cap/day)
1991	20,872,204	20.15	0.49
2001	28,808,477	23.39	0.5
2004	32,765,152	25.08	0.5
2025	78,440,000	40.00	0.6

Despite increasing waste generation, the government of Bangladesh does not encourage its citizens to recycle and separate waste at source, as do many developed countries. All types of waste are deposited in the same containers and there are no official recommendations to reduce the amount of waste generated.

Public awareness of the waste problem is relatively low (Enayetullah *et al*., 2004). Irrespective of the municipal authorities' ability to collect it, both collected and uncollected waste creates problems for city residents (World Bank_a, 2004; Enayetullah *et al*., 2004). Apart from health hazards for the local population, concern about the green house gas (GHG) emission potential of urban solid waste was manifested in the Kyoto Protocol of 1997 (Enayetullah *et al*., 2004). With waste generation of 4635 tons/day, Dhaka has a GHG emission potential of 0.76 million tons of CO2 per year (Enayetullah *et al*., 2005), thereby contributing to the overall warming of the earth's atmosphere.

Waste Collection

Although solid waste management is a duty of the municipality, due to capacity constraints the DCC is only able to collect about 37% of total solid waste generated (Enayetullah *et al*., 2005). With the amount of waste steadily increasing due to high population growth, the DCC is unable to cope.[3] Inappropriate technology and institutional weakness further aggravate the waste collection problem, as the DCC mainly uses traditional labour-intensive methods for solid waste removal. The waste is simply collected by trucks or other vehicles and then disposed of in a crude and unsanitary way in low-lying areas outside the city. Procedures are relatively inefficient, as waste is handled four to five times before it is finally disposed of at an open dumping site outside the city. Although the DCC is unable to collect a higher portion of the waste, it spends 50% of its budget on solid

[3] A summary of the DCC's waste management logistics is given in the Appendix.

waste management – about 670 Tk (US $ 11.26) per ton of solid waste, or a total of 419 347 590 Tk (US $ 7 045 039.51) per year. About 50% of this budget comes from city revenues, while the rest comes from central government grants.

DCC's collection system relies on residents' cooperation. In theory, households take their waste to nearby community dustbins or concrete containers, from which it is collected by municipal collection trucks. Unfortunately, however, this rarely happens and people leave the waste right in front of their houses, far from the containers. As the day progresses, the amount of waste at the containers increases and citizens are reluctant to walk across accumulated waste to reach the containers. This complicates the DCC's attempts to achieve a higher percentage of collected waste.

Informal sector labour also intervenes in waste collection. Waste pickers, known in Dhaka as *Tokais*, recover and recycle solid waste. About 87,000 informal workers collect part of the solid waste – mainly recyclable items such as plastic, glass or paper. They then sell what they have collected to intermediaries, who clean and resell it to recycling factories. On the one hand, they are an obstacle to more efficient waste collection because they sift through the accumulated waste looking for recyclables and in the process scatter it even further. On the other, they collect and recycle about 15% of the inorganic portion of solid waste (Enayetullah *et al*., 2005), thus reducing the amount of waste the DCC has to handle. Estimates based on a field survey suggest that the DCC saves about 170 million Tk (US $ 2 856 000) thanks to the informal sector's waste collection activity (Enayetullah *et al*., 2005).

Waste Disposal

The collected waste is disposed of at dumping sites. With the current collection efficiency of 37%, the DCC needs an area of 35 Ha, to a depth of 4m, to dispose of the urban solid waste. If the DCC managed to collect 100% of the solid waste, the landfill volume requirements per year would increase to 95 Ha (Enayetullah *et al*., 2005). Due to the growing population, occupying more and more land, fewer suitable disposal sites are available around Dhaka City, making it difficult to develop new dumping sites in the future. This lack of adequate dumping sites has led communities to dump waste at selected locations that do not conform to the official requirements of controlled landfill sites. Additionally, new suitable dumping sites are more often located outside the megacity, adding to transport time and costs.

Effects of Incomplete Waste Collection

As a result of the incomplete collection of solid waste, half of the waste is left uncollected and is deposited in unsound ways. It stays next to the official collection sites, piles up along roads, lies in low-lying areas or in open drains, spoiling Dhaka's environment (World Bank_a, 2004). Since Bangladesh is heavily affected by flooding and monsoon storms at certain times of year, the negative effects of crude dumping are enormous and the health consequences, devastating. Adding to the contamination of the environment, this crudely dumped waste is a public health hazard, as contaminants enter the ground water. Furthermore, vectors of disease such as rats and cockroaches populate the dumps. Especially during monsoon time, mosquitoes and flies find a perfect breeding ground in clogged drains and uncollected waste (DOE, 2004). Potentially hazardous waste, such as clinical refuse, get deposited in community waste bins, as there is no functioning collection system for it. This is especially dangerous for people working in the informal sector as solid waste recyclers.

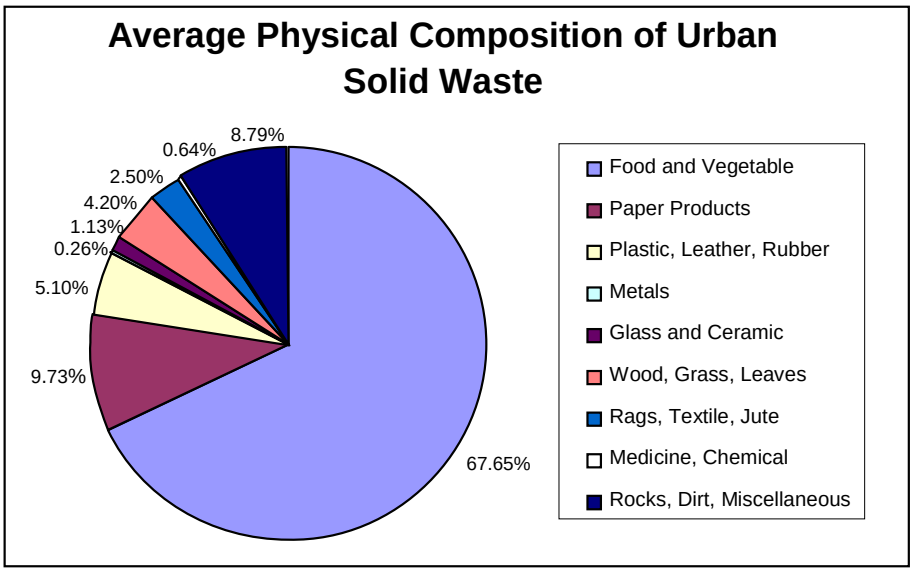
House-to-house Collection Services

Recently, small companies have started house-to-house collection services to relieve DCC's problems and collect a larger proportion of household waste (DOE, 2004). These firms charge households a small amount of money and collect the waste directly at source. The growing popularity of these services has created employment opportunities for low-skilled and poor people. Still, the problem of uncollected waste is most acute in low-income areas. In richer areas residents solve the problem by paying for collection services and so building up their own solid waste management structure.

Composition of Solid Waste

The composition of solid waste in developing countries is strongly dependent on where it comes from. Solid waste generated in residential areas has a different composition from waste generated in commercial or industrial areas (Enayetullah and Sinha, 1999). Remains of vegetables and fruits make up about 70% of solid waste in residential areas.[4] The following figure shows the average physical composition of urban solid waste.

Exhibit 4. Average Physical Composition of Urban Solid Waste (Enayetullah *et al*., 2005)



The combination of high moisture content and high temperature facilitates rapid decomposition. But it also requires frequent waste removal due to bad smells. The DCC is already working at full capacity to deal with this additional burden.

Quality of Soil and Use of Chemical Fertilizer

Bangladesh is experiencing a severe deterioration of the quality of its soil (Gani *et al.*, 2001). Only 17% of the country's soil contains sufficient organic matter to be considered good soil (Waste Concern, 2005). Decades of intense chemical fertilizer[5] use have hardened the soil by reducing its water retention capacity and percentage of pore

[4] A detailed table showing the composition of solid waste collected from different locations in Dhaka is shown in the Appendix.

[5] Bangladesh uses about 4 million tons of chemical fertilizer each year (Enayetullah and Sinha, 2005).

space. This vicious circle of ever increasing chemical fertilizer use has led to a decrease in achievable crop output – a decrease running counter to Bangladesh's national policy of increasing agricultural output to feed its millions.

A Possible Solution: Decentralized Composting

Given the high (76%) organic content of waste (Enayetullah *et al.*, 2005), composting can be a viable alternative to present waste handling. Waste Concern's system involves separating organic matter from non-organic waste and treating it separately in small, decentralized, low-mechanized composting plants, so as to make a profit on the organic portion of waste.

Company Founders and History

In view of the waste management problems in Dhaka, engineers Iftekhar Enayetullah and Maqsood Sinha, both holding master's degrees in Urban and Regional Planning, decided to set up a community-based, decentralized composting plant in one of Dhaka's suburbs. The idea was launched and promoted through their non-governmental organization (NGO) Waste Concern, which had to overcome considerable official scepticism regarding the project's feasibility, sustainability and impact on waste reduction (Enayetullah and Sinha, 2003). Although NGOs have a long tradition and a strong position in Bangladesh, being among the most active in the world, and although governments in Bangladesh have always tried to invest in public-private partnerships to increase their ability to handle problems and improve services to citizens (World Bank_a, 2004), Waste Concern's attempts to convince officials were in vain. The first challenge was to persuade the authorities to give them a piece of land on which to set up their pilot composting plant in 1995. Eventually, they managed to convince the Lion's Club Dhaka North to make available a plot of land (1000 sq m) for their project, initially for a limited three-month period. The Lion's Club was very sceptical about giving land to Waste Concern for composting purposes, as it was afraid of odour problems created by the composting activity (Enayetullah and Sinha, 2003). In its first period of activity, Waste Concern proved that there were no odour problems and that composting was a viable option for dealing with the city's waste (Enayetullah and Sinha, 2003).

Operation of the Project – House-to-House Waste Collection, Composting Process and Compost Marketing

Waste Concern aimed to integrate three different levels: house-to-house waste collection, composting, and marketing of the compost.

First, their initiative comprised a house-to-house waste collection service. Households pay a fee of Tk 10 – Tk 20 (US $ 0.168 – US $ 0.336)[6] to have Waste Concern employees collect their waste at source. Waste Concern uses rickshaw vans with a capacity of 1.18 cubic meters, each operated by one driver and one or two waste collectors. One van can serve between 300 and 400 households, and the revenue obtained from collection fees is sufficient to pay the salaries of both the driver and the waste collectors. The house-to-house collection service is thus self-sustaining (Enayetullah and Sinha, 2003).

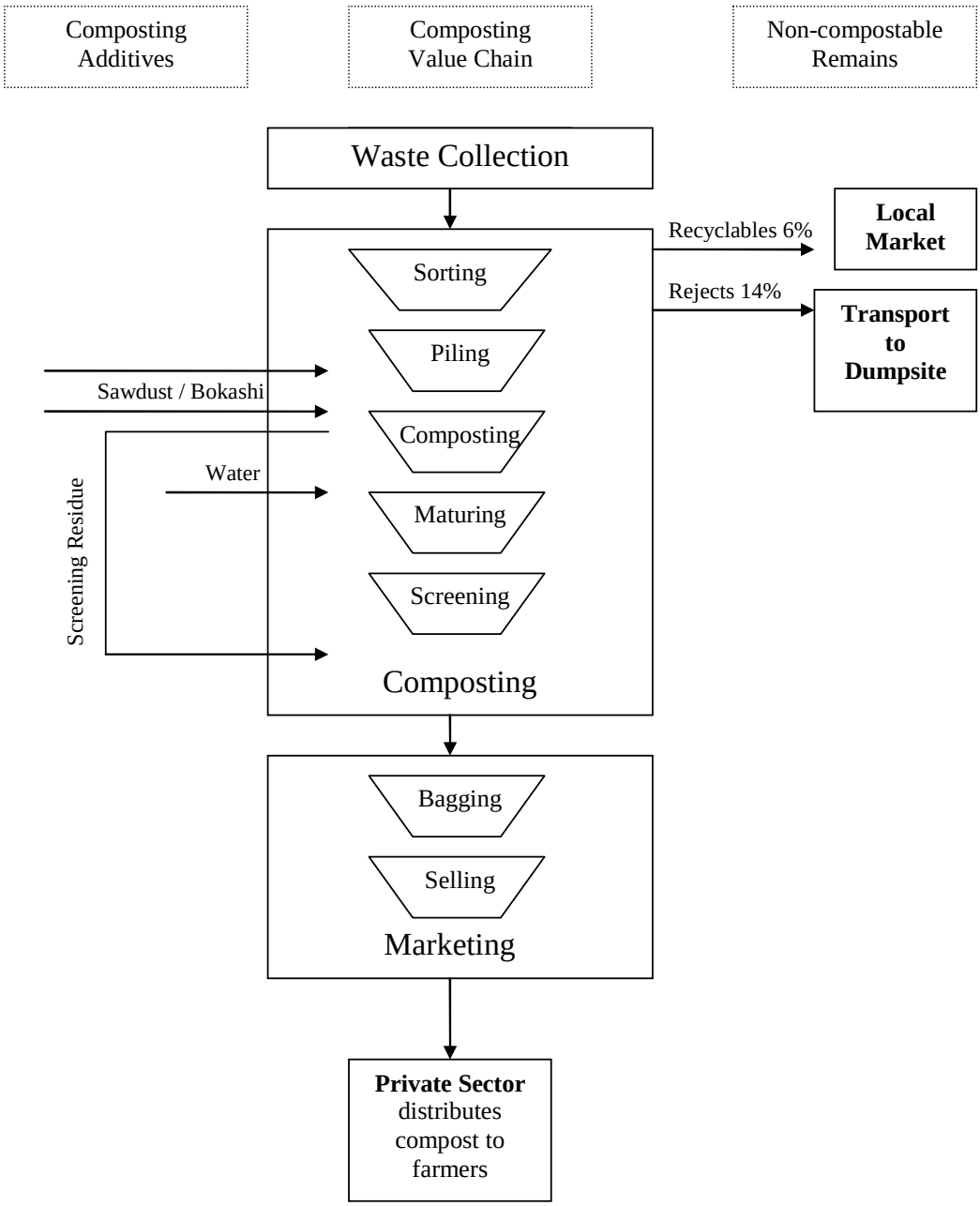
Second, composting takes place in small, decentralized composting plants located near urban residential areas, thereby reducing transport costs. Waste Concern deliberately

[6] Throughout the case, we use a constant exchange rate of Tk 1 = US $ 0.0168.

opted for small-scale plants, as they are better suited to Dhaka's waste stream, climate and socio-economic conditions, relying on low-cost technologies using manual labour[7] (Enayetullah and Sinha, 1999; Enayetullah and Sinha, 2003). Composting as such is not new to Bangladesh; but previously it was used only in rural areas, never in cities with a high population density. Therefore, concerns about odour nuisance were important to the authorities. However, smells were proven to be minimal.

The following exhibit delineates the composting process and the marketing of compost:

Exhibit 5. Composting Process (Waste Concern, 2005)



[7] Experience has shown that large, centralized composting plants are not suitable to the environment of developing countries and have had to be closed down after a short period of activity (Enayetullah and Sinha, 2003) due to high maintenance, transport and operational costs.

Waste Concern uses an aerobic composting technique known as the Indonesian Windrow Technique, which turned out to produce better results than others. One of its benefits is that it produces almost no odour.[8] Waste Concern currently uses composting plants with capacity to process three tons of organic waste per day, delivering compost output of 750 kg per day. The composting process requires 40 days, with an additional 15 days for the compost to mature. Waste Concern assures the quality of compost by constant monitoring and testing in the laboratories of the Soil Resources Development Institute of the Government of Bangladesh (Enayetullah and Sinha, 2003). In each composting plant, Waste Concern employs four[9] (female) workers, mainly from the informal sector (Enayetullah and Sinha, 1999; Waste Concern, 2005).

Third, Waste Concern developed a partnership with local chemical fertilizer producer MAP Agro to ensure distribution of compost. MAP Agro acts on behalf of its parent group, ALPHA Agro. Waste Concern currently sells the raw compost to MAP Agro for Tk 2.5 (US $ 0.042). MAP Agro has invested US $ 50 000 to build a compost nutrient enrichment plant and uses that to enrich part of the acquired compost. Both types of compost are sold via ALPHA Agro's vast distribution networks at prices ranging from Tk 6 (US $ 0.1008) for raw compost to Tk 12 (US $ 0.2016) for enriched compost (Enayetullah and Sinha, 1999; Waste Concern, 2005).

Benefits of Decentralized Composting

In general, decentralized composting is very well suited to the economic and environmental conditions of Bangladesh. Until Waste Concern's project started, however, it was an unexplored sector. Raising public awareness was difficult for Waste Concern at the beginning of the project, but now they are actively educating people about this way of treating urban solid waste and are building awareness among the general public that increased waste generation is linked to increased environmental problems. There are special benefits associated with decentralized composting. Decentralized composting can reduce the negative effects associated with crude dumping, reduce landfill volume requirements for waste disposal, reduce Green House Gas (GHG) emission rates, create employment for the unskilled workforce, and improve soil quality.

First, increased composting can actively reduce the negative environmental effects associated with excessive dumping of solid waste (Enayetullah and Sinha, 2003), because less solid waste arrives at dumping sites and so there is less pollution.

Second, by setting up composting plants, the city of Dhaka can reduce the number and size of landfill sites required for solid waste disposal and extend the life span of existing sites (Enayetullah and Sinha, 2003). Assuming a collection efficiency of 100% –all solid waste collected by the DCC– the land required for the disposal of solid waste would diminish from 94.97 acres to 34.43 acres (38.43 Ha to 13.93 Ha[10]), as shown in the following exhibit.

[8] Some odour production is found when the piles are turned for further decomposition, but levels are reported to be tolerable (Enayetullah and Sinha, 1999).

[9] These four female workers represent the labour required for composting purposes only.

[10] 1 acre is equivalent to 0.4046837 hectares (Ha)

Exhibit 6. Area Required for Landfill and Composting Plant[11] (Enayetullah *et al*., 2005)

City/Town	Landfill Area Required with 4m depth (acres per year)			Area Required for Composting Plant (acres)	
	Without Composting	50% Composting	74% Composting	50% Composting	74% Composting
Dhaka	94.97	54.61	34.43	55.15	81.62

Exact estimates of land use associated with the composting activity are hard to obtain, since areas required for landfill sites are normally outside the cities, whereas plots for decentralized composting activities are located in residential areas.[12]

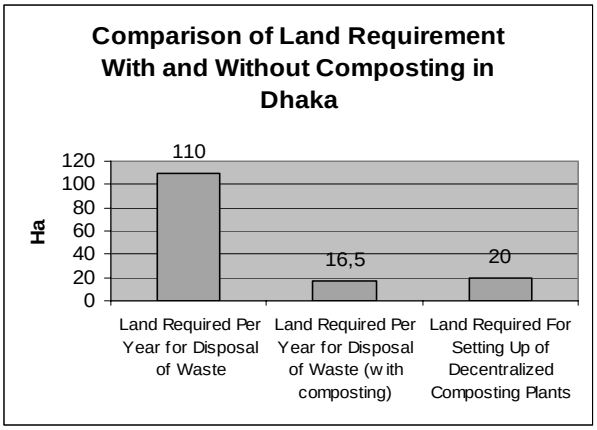
Third, composting can reduce emissions of methane gas, which is mainly associated with uncontrolled decomposition of organic waste (Enayetullah and Sinha, 2003). Composting one ton of organic residuals saves half a ton of methane gas (Waste Concern, 2005).

Fourth, Waste Concern is able to create employment for urban poor and unskilled workers (Enayetullah and Sinha, 2003), mainly from the informal sector. In the composting plants, Waste Concern employs mostly women, whereas men are employed for waste collection. Currently, Waste Concern employs 20 workers for every three-ton composting plant – nine workers in house-to-house waste collection and eleven in the plant at the different steps of the composting process, including the plant manager (Enayetullah and Sinha, 2003).

[11] Enayetullah *et al.* (2005) assume a 100% waste collection rate. Therefore, figures for landfill volumes may be higher than under actual circumstances considering a 37% collection rate.

[12] Indeed, there is conflicting evidence about the effect of composting on land requirements. In another table distributed by Waste Concern (2005), total land requirements for both the composting activity and the landfill site is reduced after the introduction of composting as an alternative for solid waste handling.

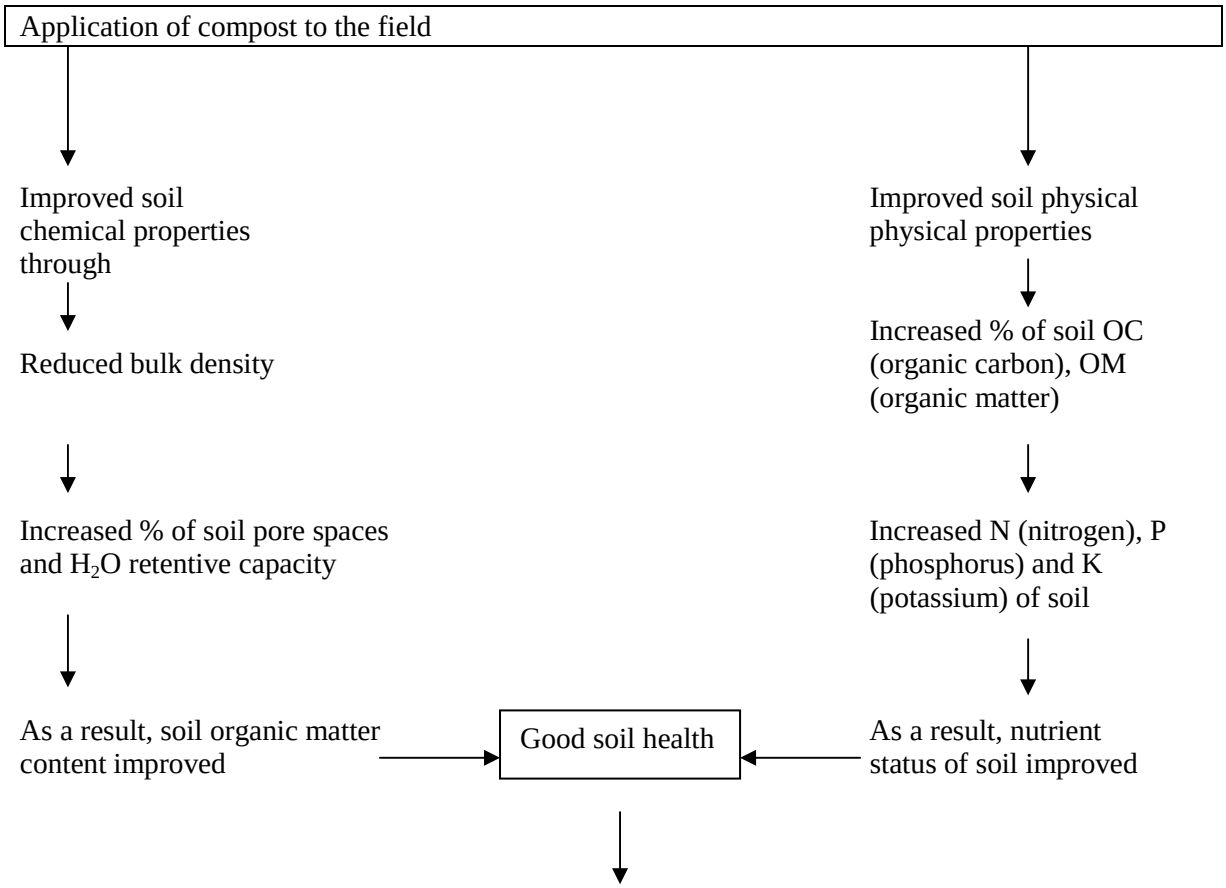
Comparison of land requirement with and without composting in Dhaka (Waste Concern, 2005):



In the table in the text, total land requirements increase using composting, since 94.97 < 34.43 + 81.62 (measured in acres), whereas in this table, total land requirements decrease using composting.

Fifth and finally, research evidence shows that city waste compost has positive effects on soil quality and crop yield rates (Enayetullah and Sinha, 2003; Gani *et al*., 2001), as shown in the following exhibit.

Exhibit 7. Flow Diagram of the Influence of City Waste Compost on Soil Health (Gani *et al*., 2001)



Increased Growth & Yield

The government of Bangladesh has also acknowledged the positive effects of compost on soil quality and encourages farmers to use compost as preferred fertilizer to improve soil quality by increasing its organic matter content (Enayetullah and Sinha, 2005).

For farmers, compost is a substitute for chemical fertilizer, but it has the significant benefit of being cheaper and reducing the need for chemical fertilizer by 30% (Enayetullah and Sinha, 2003). With prices ranging from Tk 6 (US $ 0.1008) for raw compost to Tk 12 (US $ 0.2016) for enriched, and chemical fertilizer prices ranging from Tk 6 (US $ 0.1008) to Tk 20 (US $ 0.336), farmers have an incentive to substitute chemical fertilizer with compost. Furthermore, compost was also found to have positive effects on the colour and taste of crops (Enayetullah and Sinha, 2003).

Clean Development Mechanisms (CDM)

Because it reduces GHG emissions, composting is consistent with the goals stated and signed by 160 countries in 1997, known as the Kyoto Protocol. The 160 signatories agreed to take measures to stop climate change and create incentives for countries to decrease their output of methane gas. Countries are encouraged to reduce methane gas emission and 39 developed countries explicitly committed to reduce their GHG emission by 5.2% compared to 1990 levels. The Kyoto Protocol gave developed countries several options for meeting their emission reduction targets. One of them is a system for trading Certified Emission Reductions (CERs), or "carbon credits", between countries (Enayetullah and Sinha, 2004). This system, known as the Clean Development Mechanism (CDM), also involves developing countries in that it encourages developed countries to meet their targets by investing in methane gas reducing projects in developing countries. This CDM system offers a new source of revenue for Waste Concern by selling CERs (Waste Concern, 2005) to developed countries. Waste Concern can obtain revenue of US $ 6 per ton of methane gas reduction. Since composting one ton of organic residuals is equivalent to a reduction of half a ton of methane gas (Waste Concern, 2005), the total amount of waste generated daily in Dhaka (4634.52 tons) has a Green House Gas emission potential of 760 000 tons per year (Enayetullah *et al*., 2005). Therefore, there is a potential CER market of US $ 4.56 million (Tk 271 379 280). Based on this mechanism, under the supervision of the government of Bangladesh, Waste Concern entered into a partnership with the Dutch government. The Bangladesh government is about to approve the project, making this international partnership the first global composting project under the CDM. Although the DCC was reluctant to give an immediate sign-off for the project, their real influence in the project is going to be limited – they only allowed Waste Concern to collect and transport 700 tons of organic waste per day (Enayetullah and Sinha, 2005), thus reducing the total amount of waste to be handled by the DCC to 3934.52 tons per day.

Financial Aspects of the Project

Waste Concern's composting activity generates two types of costs. First, fixed costs to establish the composting plant include items such as construction costs of the sorting platform and composting shed with drainage facility, and building costs for office, bathroom, toilet and storage for recovered recyclables. They also include the water and electricity connection charge and the purchase of rickshaw vans for waste collection. Waste Concern does not include the cost of land in its fixed costs (Enayetullah and Sinha, 2003). Total fixed costs for a three-ton composting plant add up to Tk 1 008 000 (US $ 16 934.4) (Waste Concern, 2005). The second type of costs are operating costs, which are the costs of running the composting plant. They include the salaries of workers (Tk 11 000, or US $ 184.8), waste collectors and van drivers (Tk 11 750, or US $ 197.4), and the plant manager (Tk 6 500, or US $ 109.2). Raw materials for composting add a further Tk 8 000 (US $ 143.4) per month, and electricity, water and maintenance total Tk 8 685 (US $ 145.9) per month (Enayetullah and Sinha, 2003). Total operating costs of a three-ton composting plant amount to Tk 300 000 (US $ 5040) (Waste Concern, 2005).

As stated above, the house-to-house collection service is already self-sustaining. Further financial data on a three-ton capacity plant (compared with a 10- and a 20-ton plant) is displayed in the following table:

Exhibit 8: Cost of Different Sizes of Composting Plants (Waste Concern, 2005)

Items	Composting Plant Capacity		
	3 tons / day	10 tons / day	20 tons / day
Land Required / Plant (Katha)	7	20	35
Fixed Cost / Plant * (Tk)	1,008,000	2,880,000	5,040,000
Operating Cost / Plant ** (Tk)	300,000	1,000,000	2,000,000
Total Labor / Plant ***	4	12	25
Compost Produced (kg/day)	750	2,500	5,000
Expected Revenue from Sale of Compost **** (Tk)	600,000	2,000,000	4,000,000
Expected Revenue from Sale of CERs ***** / Year (Tk)	205,312	684,375	1,368,750
Pay Back Period (Years)	2	1.71	1.5

* Without land cost / rent.

** Operating cost per year including salary of plant manager.

*** Labor required for composting purposes only.

**** One ton of organic waste produces 250 kg of fine compost.

***** CER means certified emission reduction (reduction of methane gas by composting). The methane gas reduced by composting can be sold at a price of US $6 / ton using the CDM. Therefore, revenues of Tk 205 312 correspond to a methane gas reduction of 574 tons.

Waste Concern's decision to install 3-ton, 10-ton or 20-ton plants depends on land availability. If land is available, preference is given to plants with a maximum capacity of five tons. If communities are unable to provide land for decentralized plants, Waste Concern prefers to install 10-ton or 20-ton plants that can be shared by several communities (Enayetullah and Sinha, 2005).

Public-Private-Community Partnership

Waste Concern's decentralized composting approach is very much focused on the integration of public agencies and private companies – and it is a win-win situation for all parties. On the one hand, decentralized composting reduces public agencies' need for land for landfill areas and creates employment. On the other hand, private sector companies like MAP Agro and ALPHA Agro can make a profit by selling compost –enriched and raw– via their distribution network (Enayetullah and Sinha, 2003).

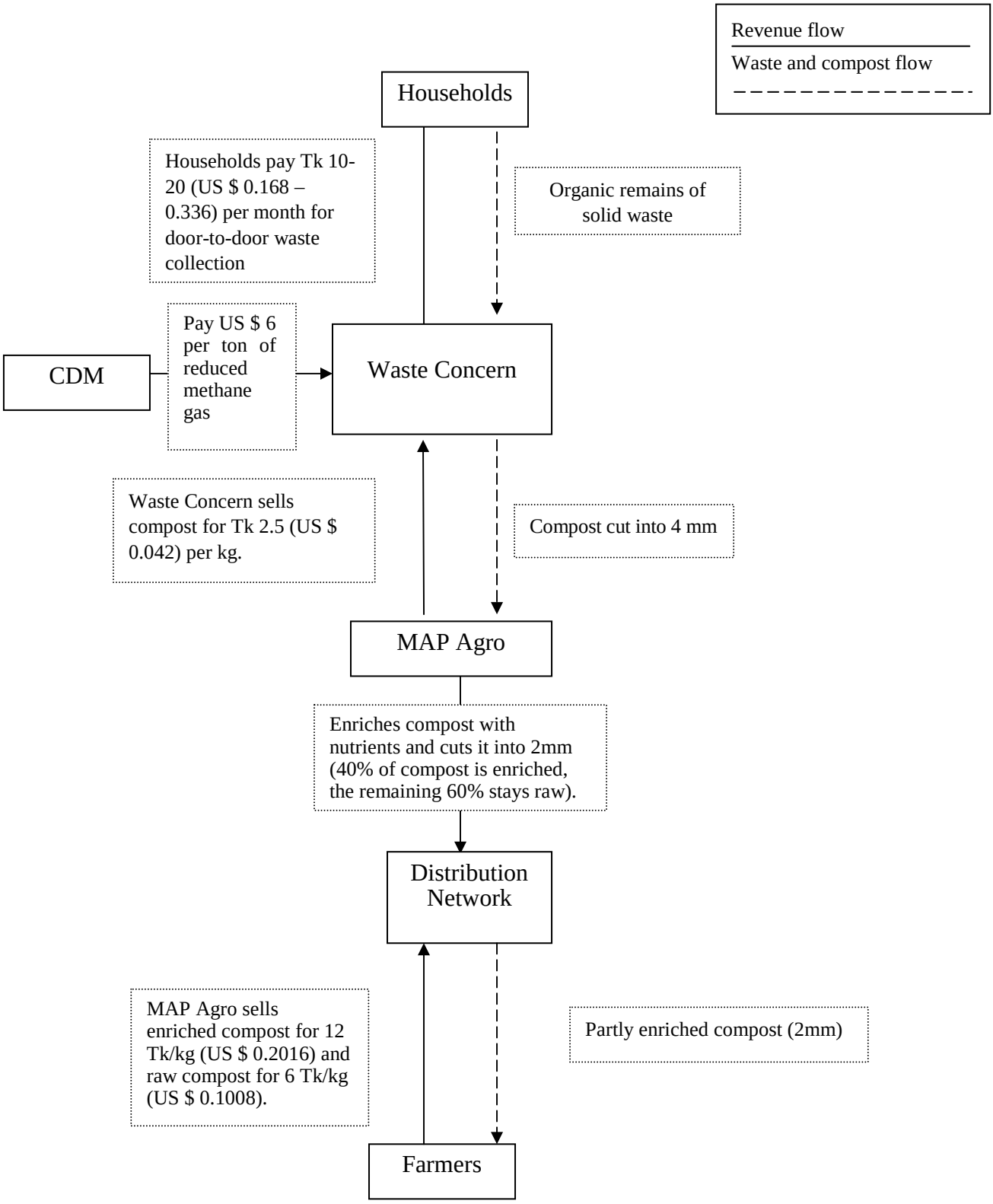
Waste Concern also has increased public awareness of the hazards of crude waste dumping and the potential value of organic waste. This has increased households' propensity to dump their waste properly, instead of leaving it on open streets. The house-to-house collection scheme has improved the city's environment, as areas where waste used to be dumped are now cleaner (Enayetullah and Sinha, 2003). Of course, other benefits follow, such as a cleaner environment, reduced health risks and an increase in the value of neighbouring real estate (Enayetullah and Sinha, 2005).

Replication of Decentralized Composting in Asia

In general, Waste Concern's decentralized composting approach is easily replicable in Bangladesh and other similar Asian countries. This stems from the fact that the technology used in the project is low-cost and based on locally available knowledge,

making it suitable to the country's economic and environmental conditions (Enayetullah and Sinha, 2003).

Exhibit 9: Flow Diagram for Composting Activity



The outlook for compost sales is very promising. Demand for compost in Bangladesh, as a substitute for chemical fertilizer, can be estimated based on total demand for chemical fertilizer of 4 million tons per year (Enayetullah and Sinha, 2005). With total waste generation in Bangladesh of 13,332 tons per day and 76% organic content (Enayetullah *et al*., 2005), a maximum of 924,574 tons of compost can be produced per year.[13] This means that city waste compost can capture a share of close to 25% of the national chemical fertilizer market.

The main constraint for scaling up the project is land availability for composting plants. In Dhaka, land prices are unusually high because Dhaka is a megacity. Waste Concern emphasizes that the project's feasibility and profitability depends heavily on public partners making plots of land available for free or at nominal rates. Still, in smaller towns in Bangladesh, given lower local land cost, the project might still be viable without public agencies providing free land (Enayetullah and Sinha, 2003).

Using available information from Dhaka's decentralized composting plants, one can see that a replication of Waste Concern's model could have measurable effects on unemployment in Dhaka. With 20 people, mainly from the informal sector, working in each three-ton plant (Enayetullah and Sinha, 2003) and waste generation of 4635 tons/day (Enayetullah *et al*., 2005), the following calculations estimate the employment potential of decentralized composting.

Assuming that all the organic portion of Dhaka's waste is treated in composting plants (a 100% composting rate),[14] 76% (Enayetullah *et al*., 2005) of total generated waste would be recycled using composting mechanisms. With waste generation of 4634 tons/day (Waste Concern, 2005), the organic fraction of total waste amounts to 3522 tons. Dividing this quantity by three to account for three-ton capacity composting plants, a total of 1174 composting plants would be needed to process Dhaka's organic waste. Since each three-ton composting plant employs 20 workers, a complete replication of the decentralized composting approach in Dhaka could create up to 23 480 jobs for people in the informal sector. The scaling up of this project is therefore very likely to decrease unemployment in Bangladesh and thus alleviate poverty (Enayetullah and Sinha, 2003).

Replication Status

Currently, Waste Concern runs 38 composting plants in 20 towns in Bangladesh, five of which are in the DCC area. As a next replication step, the local engineering department of the Bangladesh government is planning to replicate the decentralized composting project in eight towns, starting October 2005. Waste Concern is furthermore planning to install composting plants in 34 towns and cities in Bangladesh at the beginning of 2006 in cooperation with UNICEF and the government.

[13] For reasons of simplicity and to demonstrate the maximum potential of decentralized composting, we assume that 100% of organic waste is treated in composting plants. This is a purely theoretical assumption, as a 100% composting rate does not seem to be achievable for two reasons. First, it may be impossible to separate all the organic waste. Second, 100% composting assumes a 100% collection rate. Since Dhaka's current collection rate is stable at around 37% (Enayetullah *et al*, 2005), a 100% collection rate does not seem realistic in the short run.

[14] To demonstrate the maximum potential production of compost we assume that all urban organic waste is treated in composting plants.

Exhibit 10: Project Milestones (Enayetullah and Sinha, 2005)

1995	1997	1998	1999	2000	2004
Waste Concern starts pilot community-based resource recovery project in Dhaka	Regional Urban Development Office (RUDO)-South Asia supports Waste Concern to increase project capacity and further test the model	With support from MoEF & UNDP, Waste Concern replicates the model in (five) communities in Dhaka City, under SEMP (Sustainable Environment Management Programme)	Partnership agreement signed between public and private sectors and the local community to implement the project	The model is replicated in Dhaka, Khulna & Sylhet cities	The model is replicated in 18 cities and towns in Bangladesh. City-scale landfill gas extraction and composting project under CDM for Dhaka

Discussion, Relevant Questions and Uncertainties

As shown above, decentralized composting is associated with several benefits and clearly fits the economic and environmental conditions of a developing country like Bangladesh, entering a previously neglected niche. However, there are still several risks and uncertainties associated with Waste Concern's decentralized composting approach.

First, public agencies and their influence on Waste Concern can have ambiguous effects on the project. By not including land costs in its calculations and expecting public agencies to provide free plots of land for project replication, Waste Concern is creating a dependency on the public sector. As a result, public agencies may be the crucial bottleneck for successful replication of decentralized composting. In a cooperative environment, with a public agency in favour of decentralized composting, this public partnership benefits and facilitates project implementation and replication. Without cooperation, however, the NGO's dependency on public agencies may inhibit successful replication and slow down process implementation, leading to missed opportunities and benefits for the whole community. Furthermore, local governments also play a decisive role in project globalization and the integration of foreign countries using CDM mechanisms under the Kyoto Protocol. They need to sign off the projects to be implemented and therefore have considerable influence on the direction of foreign investment for the reduction of methane gas. Again, public agencies' power and influence may be useful, but any blockade in implementation can ruin the positive outcomes associated with successful involvement.

Second, Waste Concern does not include land costs in its calculations of financial performance. Land is always assumed to be provided for free or at nominal rates. One might argue that this selective consideration of cost factors does not reflect the real world and that the conclusions regarding financial feasibility may be biased.

Third, we do not know what effects Waste Concern's activity will have on waste collection services in the long run. On the one hand, Waste Concern's project suits the specific environment at Dhaka and its incorporation into the local systems works well. On

the other hand, Waste Concern also collects the waste at source for treatment in the composting plants. Thereby, Waste Concern may increase the DCC's overall waste collection rate. As this improvement in collection services is acknowledged by many citizens, credit for the service may still go to DCC and not to Waste Concern, which is the party that effectively implemented the collection scheme. Furthermore, increased collection services by Waste Concern may lower the incentive for DCC to increase its waste collection percentage.

Fourth, some of the benefits associated with decentralized composting seem ambiguous and its effects unclear. As said above, composting reduces the costs incurred by DCC in acquiring landfill area to dump waste. With increased composting activity, less waste needs to be dumped in landfill sites and the need for land for landfill sites is reduced. But the land used for the composting plants may be much more expensive and less readily available, as the decentralized approach requires that the plants be near or in urban residential areas, whereas the big landfill sites can be situated outside the city in less populated areas. Therefore, the effects of decentralized composting may be blurred. The available numbers do not take different land prices in different areas into account.

Fifth, local communities may be opposed to the idea of having a composting plant in their neighbourhood. Enayetullah and Sinha (2003) report that several communities appreciate decentralized composting plants in theory but rejected actually having one in their own neighbourhood due to concerns about bad smells. Indeed, improper handling of the composting process may lead to problems with smells. Therefore, aerobic conditions during the process must be strictly maintained to address this risk.

Sixth, for successful replication and marketing of city waste compost, the quality of the compost must be thoroughly assured and any deterioration must be avoided to maintain confidence in the product. Therefore, further replication of the product may require greater resources for quality assurance, and the organizational requirements may soon exceed Waste Concern's resources.

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Appendix

Exhibit 11: Available Logistics for Waste Management

Manpower	**Other Logistics**
Cleaners/Sweepers: 7156 (Male: 4048, Female: 3108) Supervising staff/officer: 190 Average Cleaners/Ward: 80 Total Vehicle Operators: 370 **Total: 7796** Dustbins/Containers Brick/Concrete Made: 2500 GI sheet build: 2000 Demountable: 420 **Total: 4920** Hand carts: 3000 Hand Broom: 1/Sweeper/Month Baskets: 1/Cleaner/Year	Transport Supervision: 1 Motorbike for Inspectors: 122 Wireless Set: 55 Truck/Container Carrier: Trucks: 242 Container Carrier: 128 **Total: 370**

Source: DCC (Dhaka City Corporation) (still to include in Endnote and references!).

Exhibit 12: Average Composition of Solid Waste Collected from Different Locations in Dhaka

Location Type	**Vegetable matter and remains of fruits (%)**	**News-paper (%)**	**Card (%)**	**Tree trimmings and straw (%)**	**Metal (%)**	**Glass (%)**	**Stone, ceramic and debris (%)**	**Plastics and Polythene (%)**	**Clothes (%)**	**Other (%)**
Mixed area	70.12	4.16	0.16	10.76	0.13	0.25	4.29	4.71	4.57	0.85
Industrial	26.37	7.59	0.00	4.32	0.00	0.00	9.49	6.03	46.20	0.00
Commercial	62.05	6.28	0.00	2.86	0.28	0.37	3.79	4.62	18.93	0.82
Residential	59.91	11.21	0.00	8.76	0.15	0.00	2.30	17.67	0.00	0.00

Source: DCC (Dhaka City Corporation).