Final Report

Composting Experience in Developing Countries: *Drivers and constraints for composting development in Ghana, India, Bangladesh and Sri Lanka*

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List of Abbreviations

3R	Reduce, Reuse and Recycle
ACARP	Accra Composting and Recycling Plant
ACI	Advanced Chemical Industries
ADB	Asian Development Bank
AMA	Accra Metropolitan Assembly
BBMP	Bruhat Bangalore Mahanagara Palike
BDT	Bangladesh Taka
BRAC	Bangladesh Rural Advancement Committee
BUC	Balangoda Urban Council
CBO	Community Based Organization
CCC	Chittagong City Corporation
CDM	Clean Development Mechanism
CEA	Central Environmental Authority
EAP	Ecological Agriculture Program
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EU	European Union
FASDEP	Food and Agriculture Sector Development Policy
FCO	Fertilizer (Control) Order
FS	Fecal Sludge
GDP	Gross Domestic Product
GH₵	Ghanaian Cedi
GHG	Greenhouse gasses
GIZ	German Society for International Cooperation
GoG	Government of Ghana
GoSL	Government of Sri Lanka
GSA	Ghana Standards Authority
HYV	High Yielding Variety
IBSRAM	International Board for Soil Research and Management
IDCOL	Infrastructure Development Company Ltd
IEISL	IL&FS Environment Infrastructure Services Limited
IFOAM	International Federation of Organic Agriculture Movements
INR	Indian Rupees
IRRF	Integrated Resource Recovery Facilities
IWMI	International Water Management Institute
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
JVL	Jekora Ventures Limited
KCC	Khulna City Corporation
KCDC	Karnataka Compost Development Corporation
KMA	Kumasi Metropolitan Assembly

KMC	Kaduwela Municipal Council
KUC	Kalutara Urban Council
LAs	Local authorities
LKR	Sri Lankan Rupees
LMC	Ludhiana Municipal Corporation
MCD	Municipal Corporation of Delhi
MCs	Municipal Councils
MESTI	Ministry of Environment, Science, Technology and Innovations
MHS	Metropolitan Health Services
MLGRD	Ministry of Local Government and Rural Development
MMDAs	Metropolitan, Municipal, and District Assemblies
MOA	Ministry of Agriculture
MOEF	Ministry of Environment and Forests
MOFA	Ministry of Food and Agriculture
MOUD	Ministry of Urban Development
MSW	Municipal Solid Waste
MWRWH	Ministry of Water Resources, Works and Housing
NESSAP	National Environmental Sanitation Strategy and Action Plan
NESP	National Environmental Sanitation Policy
NGOs	Non-governmental organizations
PPP	Public-private partnership
PURC	Public Utilities Regulatory Commission
RCC	Rajshahi City Corporation
SARI	Savannah Agricultural Research Institute
SWM	Solid Waste Management
UNICEF	United Nations Children's Fund
USD	United States dollars
VAT	Value-added tax
WaFo	Waste to Food
WC	Waste Concern
WMD	Waste Management Department
WPS	Wariyapola Pradeshiya Sabha
WUC	Weligama Urban Council
WWR	World Wide Recycling
YES	Youth Engagement in Service Delivery

1. INTRODUCTION

Management of municipal solid waste (MSW) is a major challenge faced by municipal authorities across the world. Current global MSW generation levels are approximately 1.3 billion t per year and are expected to increase to approximately 2.2 billion t by 2025 (Drechsel et al 2015). These numbers represent an expected significant increase in per capita waste generation rates, from 1.2 to 1.42 kilograms (kg) per person per day, in the next 15 years (Hoornweg and Bhada-Tata 2012). In sub-Saharan Africa, approximately 62 million tonnes (t) of MSW are generated per year. Per capita waste generation is generally low in this region, but it spans a wide range, from 0.09 to 3.0 kg per person per day, with an average of 0.65 kg per capita per day. In developing countries, urban waste remains a serious problem that causes contamination of soil and water bodies and endangers human health and the environment (Cofie et al. 2006). City authorities incur high costs for waste management, yet they achieve poor results. In total, developing nations spend about US$46 billion per year on managing MSW, and these investments could go beyond US$150 billion per year by 2025 (Durand 2013).

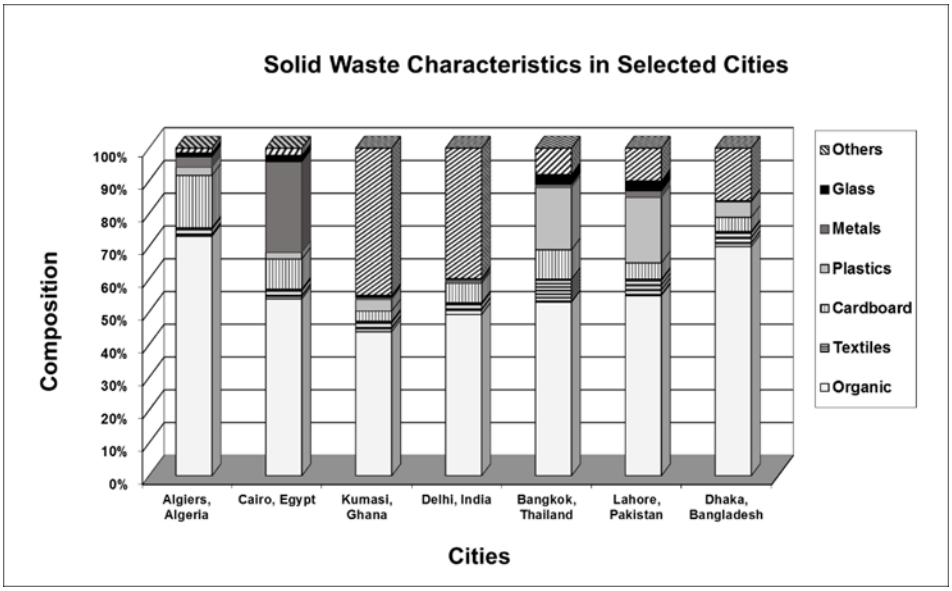
Municipal solid waste can be organic and inorganic and is generally categorized as organic, paper or cardboards, plastics, glass, metals, textiles or as 'other materials' (fig. 1.1). A large proportion of municipal waste in developing countries is organic material. In low-income countries, 65–75% of waste is organic, compared with an average of 28% in high-income countries (Hoornweg and Bhada-Tata 2012). Organic waste can be recycled for use in agriculture, and recycling can thereby become a win-win strategy for both the sanitation and agriculture sectors.

Composting is the process of decomposing or breaking down of organic waste materials by microorganisms such as bacteria, protozoans, fungi and invertebrates into a valuable resource called compost. Microbial degradation reduces the mass and volume of organic materials, thereby generating heat and creating an environment necessary for the deactivation of pathogens. The process allows for the recovery of nutrients and organic matter for use in agriculture. Urban and peri-urban agriculture represent a good opportunity for nutrient recycling, provided that technological and socio-economic strategies for optimum recovery are taken into account (Cofie et al. 2014).

The main types of composting systems that are generally distinguished between are: 1) open systems such as windrows and static piles and 2) closed 'in-vessel' systems. In-vessel or 'reactor' systems can be static or movable closed structures where aeration and moisture are controlled by mechanical means and often require an external energy supply. In developing countries, open systems are the types most frequently used, among which windrow composting is the most prominent. Different technological options for composting

require variable processing time, process control, human and financial resources and have different impact on environment and health (Cofie et al. forthcoming). The choice of a composting technology and the type of the facility (i.e., centralized or decentralized) depends on the available capital as well as the amount and type of waste available. The degree of compost stability attained within a certain time is a key indicator, which can be used to compare different composting techniques and quality of compost for use in agriculture (Singh et al. 2012).

Figure 1.1: MSW characteristics in select cities



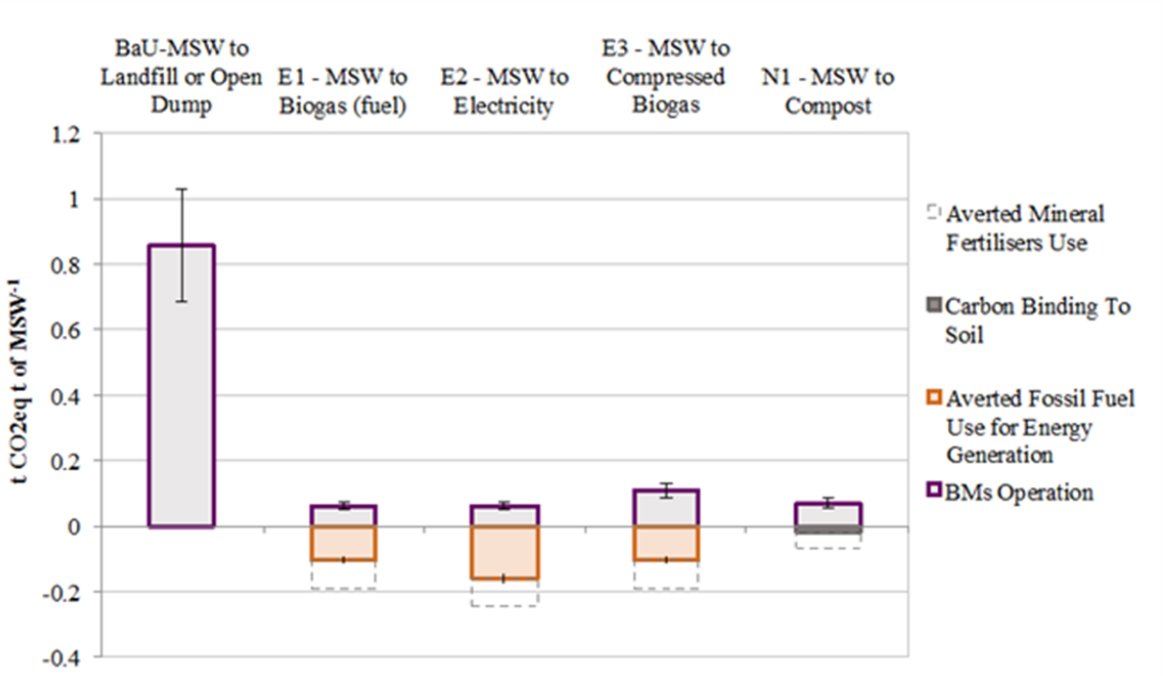
(Source: Cofie et al. 2006)

The potential benefits of organic waste recycling are particularly reduced environmental impact of disposal sites, extended capacity of existing landfills, replenished soil humus layer and minimized waste quantity (Zurbruegg and Drescher 2002; Cofie et al. 2006; Banegas et al. 2007; Gu et al. 2011; Shan et al. 2013). Other benefits, as adapted and summarized from Hoornweg et al. (1999), include that recycling of organic waste

- reduces overall waste volume, transport costs and landfill lifetime
- enhances waste collection, recycling and incineration operations by removing moist organic matter from the waste stream
- promotes environmentally sound practices, such as the reduction of methane generation at landfills. In fact, the environmental benefits of composting, e.g., greenhouse gas (GHG) aversion, exceed those of other waste management options (fig. 1.2)
- is flexible for implementation at different levels, from household efforts to large-scale centralized facilities, i.e., can also be started with very little capital and has limited operating costs

- addresses possible health impacts from fecal matter due to the composting (sanitizing) process can integrate existing informal sectors involved in the collection, separation and recycling of waste and contribute to the 'green economy' of a city

Figure 1.2: CO_2-eq emissions from different waste management options



(Source: Otoo and Drechsel, forthcoming)

Composting of municipal waste for agriculture has been going on for many years in several countries. Composting has been carried out at different scales (large, medium, small), conducted by various entities (municipalities, non-government organizations (NGOs), communities, individuals) and performed for various purposes (gardening, landscaping, and farming). In the 1970s, large-scale, centralized composting was prominent especially in the western world. In the 1990s, small to medium scale, decentralized composting-based initiatives evolved. Although composting seems an attractive option in many respects, it is also constrained by several factors. The lack of markets, unstable compost quality and the need to subsidize compost operations are the main reasons that have hindered private sector involvement, consequently preventing composting practices from being adopted at scale on a sustainable basis (Hoornweg et al. 1999; Drechsel et al. 2004; Cofie et al. 2006).
Current MSW management practices result in very small proportions of MSW being recycled, composted or both. The proportion of waste recycled or composted ranges from more than 30% in some high-income countries to as low as less than 2% in low-income countries (see table 1.1). On average, only 1.5% of MSW is composted in low- and middle-income countries (Drechsel et al. forthcoming). More than a decade ago, Hoornweg et al. (1999) had already

identified six common challenges preventing compost initiatives from going to scale: (i) Inadequate attention to the biological process requirements, for example under tropical climates; (ii) Overemphasis placed on electricity demanding and often fragile mechanized processes rather than on labor intensive operations; (iii) Lack of vision and marketing plans for the final product, i.e., compost; (iv) Poor feed stock which yields poor-quality finished compost, e.g., when feed stock is contaminated by heavy metals; (v) Poor accounting practices that neglect the fact that the economics of composting rely on externalities, such as reduced water contamination, avoided transport and disposal costs, etc.; (vi) Difficulties in securing finances since the revenue generated from the sale of compost will rarely cover processing, transportation and application costs.

Table 1.1: Global MSW disposal practices (by income levels of the countries)

	High income (%) (Total = 588.05 million t)	Upper middle income (%) (Total=135.78 million t)	Lower middle income (%) (Total=55.32 million t)	Low income (%) (Total=3.76 million t)
Dumped	0	33	49*	13
Landfilled	43	59	11	59
Composted	11	1	2	1
Recycled	22	1	5	1
Incinerated	21	0	0	1
Other	3	6	33	25

* including China

(Source: Drechsel et al 2015 based on Hoornweg and Bhada-Tata (2012))

Although the number of composting and recycling success stories is increasing, an overreliance on technical approaches and lack of business thinking was reconfirmed also in more recent studies. Based on experiences from composting projects in Africa, Drechsel et al. (2010) identified another key constraint: the financial gains from reduced transport volumes and costs are seldom made available to maintain the composting unit due to poor coordination among the involved institutions and the lack of an enabling institutional (e.g., private-public partnership) framework. While city authorities, among others, stress that composting is most welcome as a means to reduce waste volume and transport costs, the savings remain inaccessible to the private compost plant operator. However, in many situations, and especially for larger cities, these 'savings' would represent a higher benefit (i.e., a larger share of the revenue stream) than the actual sales of compost. This situation might be very different in smaller towns, where demand from the agriculture sector might surpass waste supply (Keraita et al. 2014).

In view of the challenges for achieving sustainable composting in developing countries, a

nutrient recycling analytical framework (Drechsel et al. 2004; Cofie et al. 2006; Cofie et al. 2008) was tested and recommended for selecting appropriate recycling technologies at the appropriate scale of intervention. This framework suggests including analysis of

- waste generation (quantitative and qualitative waste supply analysis)
  compost demand by potential users (market analysis, willingness and ability to pay)
  waste processing and scales (technical options considering supply vs. demand)
  economic factors (competing products, collection and processing costs, best locations, economies of scale and subsidy sourcing)
- options and constraints related to legal, institutional and local communal settings of composting plants

This framework was found to be a widely applicable decision-support tool, especially suited for use in developing countries.

This study aims to identify the barriers for the development of composting in developing countries, to recommend regulatory improvements and propose the most appropriate (or successful) business model(s) for specific cases. The methodology used involves the review of existing regulatory frameworks on waste management and on agriculture in selected countries, the analysis of selected composting projects in each country and identification of lessons from successes and failures of composting in developing countries.

The analytical framework used is presented in annex 1.

2. DESCRIPTION AND ANALYSIS OF COMPOSTING IN GHANA

2.1 Overview and Regulatory Setting

Ghana, located in the West Africa subregion (lat 8°00′00″ N, long 2°00′00″ W), has a population of up to 24,700,000 inhabitants (GSS 2010). Up to 42% of employed persons aged 15 and above are working in forestry, fishing or agriculture. Some of the major crops grown in the country are cocoa, rice, cassava (manioc, tapioca), peanuts, corn, shea nuts, bananas and timber. Ghana is divided into ten administrative regions, which are further organized into 216 metropolitan, municipal and district assemblies (MMDAs). Other important details on Ghana are presented in table 2.1. The country has a parliamentary system of constitutional democracy and relies on policies, legislations and other instruments for governance in order to respond to different needs in the country.

Table 2.1: Background information on Ghana

Parameter	Detail
Location	Western Africa,
Area (Total)	238,533 Km^2
Land	227,533 Km2
Water	11,000 Km^2
Population density	104.3
Annual Growth Rate	2.19% (2014 est.)
Gross Domestic Product (GDP)	$90.41 billion (2013 est.)(purchasing power)
GDP by Agriculture	21.5%
Agriculture land area	20.12%

(Source: CIA 2014; GSS 2010; World Atlas)

Figure 2.1: Map of Ghana (Source: World Atlas)

2.1.1 Overview of Solid Waste Management in Ghana

All solid waste management (SWM) activities, including collection, storage, transportation, disposal and treatment, constitute a great challenge in major towns and cities across the country. Consequences include contaminated water bodies, drains and gutters chock-full of garbage, a plastic waste menace, communities carelessly disposing of refuse and more. Waste is disposed of through house-to-house collection or in institutional and communal containers. Manually driven tricycles, donkey carts, small trucks and large trucks equipped

with compactors are used to collect mixed organic and inorganic waste. Under the Local Government Act 462, 1993, the MMDAs are mandated to contract private companies to offer waste management services. In Accra, for example, customers in high- and medium-income and low density areas request house-to-house waste collection services at a monthly fee, while low-income and high density areas use communal containers, which are managed by contractors under the supervision of district assemblies. Monitoring by the local government is often inefficient as containers can remain full for days or weeks before they are emptied by the service providers. In some places, residents do not pay any money for waste disposal because of the level of poverty, while in some other places, residents pay before disposing of waste into the central container. There are cases of special collection services provided by private waste management companies for commercial establishments, private companies, markets, car parks, government institutions, diplomatic missions, and others (Abraham 2011).

Some fractions of the MSW are recycled while the remaining shares are disposed in a landfill. Very few of the landfill sites are properly designed as engineered landfills; most are improvised sites. Some people go from house-to-house to buy scrap metals and plastics for recycling. Some small-scale plastic waste recycling enterprises, some of which are social enterprises, are scattered across the cities. Zoomlion Company Ltd, the largest waste management company in Ghana, carries out some recycling at a designated disposal site in Accra. The company recycles plastics and metals, but it also produces compost out of organic waste.

2.1.2 Overview of Regulatory Framework

Several policies and institutions that are of relevance to municipal waste composting in Ghana can be found in the water, sanitation and agriculture sectors. The most prominent ones include the 1992 constitution of the Republic of Ghana; the National Environmental Sanitation Policy; the Local Government Act 462, 1993; the Community Water and Sanitation Act 564; the National Water Policy; the National Urban Policy; the Environmental Protection Agency (EPA) Act 490, 1994; the Ministry of Water Resources, Works and Housing (MWRWH); the Ministry of Local Government and Rural Development (MLGRD); the Ministry of Environment, Science, Technology and Innovations (MESTI); the Public Utilities Regulatory Commission (PURC) Act 538, 1997; the Food and Agriculture Sector Development Policy II (FASDEP II); the National Fertilizer Policy, 2013; and the Pesticides and Fertilizer Act, 2010. Summary of the main issues addressed in each of the policy instruments is presented in table 2. 2.

Table 2.2: Selected policies, acts, and institutions related to composting in Ghana

Policy, Act, Institution	Key issue
Constitution of Ghana, 1992	With reference to environmental protection, it empowers the parliament to pass all laws on the environment. It directs the state to take appropriate measures to promote the development of agriculture and industry. It encourages all citizens to protect and safeguard the environment. The constitution does not make a direct reference to composting (GoG 1992).
Environmental Sanitation Policy, 2010	The policy seeks to promote benefits of alternative uses of waste through reduction, re-use, recycling and recovery._Reference is made to recycling through composting. It seeks to ensure that sites for treatment and disposal of waste (landfills, composting facilities, waste stabilization ponds, trickling filters, septage treatment plants, etc.) are safe and hygienic. It does not incorporate incentives that could attract private sector participation in composting (GoG 2010a).
Local Government Act, 462, 1993	It places waste management, including composting, under the responsibility of the MMDAs. It encourages private sector involvement in waste management. It encourages the MMDAs to ensure that there is drainage and sanitation in buildings. It mandates the MMDAs to set up waste management departments. The act does not include waste separation at source and this may affect compost quality (GoG 1993).
Community Water and Sanitation Act 564, 1998	A facilitating agency under the Ministry of Water Resources Works and Housing. No direct or indirect reference to composting (GoG 1998).
National Water Policy (2007)	It links water and sanitation by seeking to minimize the pollution of water sources from poor environmental sanitation services and thus contribute to improving the health of communities. It ensures the provision of water and sanitation services. No direct or indirect reference to composting (GoG 2007).
National Urban Policy, 2012	It recognizes poor sanitation in poor neighborhoods. It acknowledges that environmental deterioration arises from unsatisfactory collection, disposal and treatment of waste. It suggests the need for improving environmental quality of urban life. It makes no direct reference to compost (GoG 2012).
Environmental Protection Agency Act, 490, 1994	Main government institution or agency responsible for environmental protection and compliance. It demands environmental impact assessments prior to issuing a permit for compost plant construction, similar to any undertaking with potential impact on the environment. Responsible for controlling the generation, treatment, storage, transportation and disposal of waste. Its standard requirements must be met prior to approval of operations or issuance of permits. This can be restrictive (GoG 1994).

Ministries	• MWRWH: Coordinates water and sanitation • MLGRD: Coordinates waste management • MESTI: Oversees EPA and other agencies. Formulates sector policies. Connection to compost is indirectly provided through sanitation and waste management regulations.
FASDEP II, 2007	It refers to sustainable management of land and environment. It promotes science and technology in agriculture aimed at a modernizing agriculture, culminating in a structurally transformed economy and evidence in food security, employment opportunities and reduced poverty. Inorganic fertilizer is subsidized by the state, making it difficult for farmers to switch to compost, which may end up being more expensive without subsidies (GoG 2007). However, the program on fertilizer subsidies, re-introduced in 2008, was suspended starting in 2014 because the government could not raise the capital required for the subsidy. While the subsidy program lasted, the impact on compost price could not be ascertained.
PURC, ACT 538, 1997	It regulates utility prices. No direct reference to compost (GoG 1997).
National Fertilizer Policy, 2013	It directs overall approaches and practices in the compost sector. It acknowledges that "organic fertilizer" means fertilizer derived from non-synthetic organic material, including sewage, animal manures and plant residues prepared through composting, fermentation, mincing, grinding, soaking, drying or other similar methods to enhance the use of the plant nutrients it contains. Fertilizer is subsidized whereas compost is not. Compost does not enjoy the same level of active promotion by the state (GoG 2013a).
Plants and Fertilizer Act, 2010 (see Part III)	It directs that no person shall import, manufacture or distribute fertilizers in commercial quantities unless the person is registered. It further directs on how to register a compost plant and seek certification for a compost product. The steps for registration and certification are described in box 1 for the case of Fortifer.

2.1.3 Opportunities and Challenges

The main opportunities and challenges related to MSW composting within Ghana's regulatory setting are listed below.

Opportunities

- The constitution of Ghana recognizes the environment as very important and clearly indicates that the country will act appropriately and necessarily to protect the environment for both the present and future generations. The constitution places the responsibility for environmental management on all citizens, but it clearly specifies

the duties of key agencies.

- The parliament of Ghana has unlimited powers to introduce new legislation aimed at improving environmental management, including sanitation, waste management and thus compost related issues.
- The word "composting" and other related terms, such as waste stabilization ponds, trickling filters, septage treatment plants, etc., appear in the National Environmental Sanitation Policy.
- The National Environmental Sanitation Policy recognizes the participation of the private sector in sanitation services provision, under the supervision of the metropolitan, municipal and district assemblies, as important. This provision implies job opportunities for private sector stakeholders.
- The institutional structure and regulatory framework for sanitation and waste management services are set by the Local Government Act 462. Waste management departments exist to oversee sanitation and waste management services provision by private sector actors.

  The National Urban Policy also recognizes the synergies between water and sanitation and encourages private sector participation. Since urbanization increases sanitation and waste management challenges, composting of waste can be promoted as a way to restore and maintain environmental quality of urban life.
- The EPA ensures that appropriate best practices for environmental sustainability are considered in the initial stages of any infrastructure project, ensuring that society can accept its operations. The EPA supervises the evaluation of environmental impact assessments (EIAs), which is a mechanism that will also be referred to in monitoring private sector operators of compost facilities, allowing authorities to address any deviations from expected performance.
- The existence of a sound policy and institutional framework for water, environment and waste management makes it possible to consider other waste management options such as composting.
- The country's agriculture policy is comprehensive and establishes linkages with other development agendas. The promotion of all aspects of agriculture creates a congenial environment for promoting the use of compost by farmers and other users.
- As a consequence of being unable to afford inorganic fertilizer, even with state subsidies, farmers continue to search for low cost, effective organic fertilizer to improve soil fertility and enhance crop yields. This provides an opportunity to promote use of compost as fertilizer.
- The National Fertilizer Policy explicitly mentions and defines organic fertilizer, thus it fully recognizes the integration of compost into agricultural soil amendments. In addition, an institutional arrangement for compost certification is clearly laid out in the policy.

Challenges

- The word compost does not clearly appear in the constitution because the

constitution represents the state's broad commitments to both the environment and agriculture. However, the constitution seeks to protect the national environment for posterity, and the parliament is mandated to pass legislation with any focus that enables the state to achieve this commitment. Therefore, the parliament has in the past passed legislation to set up agencies that can focus on developing composting practices.

- The low levels of funds allocated to the environmental sanitation sector, the economically unsustainable tariffs charged for services (i.e., many people are not paying the full cost of the services they receive) and the low levels of revenue collection by service providers remain key sector challenges.
- Incentives that encourage private sector participation in sanitation services provision do not exist, especially not in the areas of recycling, reuse and recovery, such as composting.
- Private sector participation in water, sanitation and waste management services provision mostly neglects the poor, who often do not receive such services or who are charged higher price than what the state charges for delivering similar services to other service recipients.
- The current policy and legislative framework on waste management does not promote separation of waste at the source, which thus affects the cost and quality of the composting process.
- The EIA process for new composting facilities could be prolonged or restricted, especially if a strong public resentment for the siting of a particular facility occurs. The standards specified by the Environmental Assessment Regulation, 1999 must be met before any permits will be issued.
- State institutions could come under political influence, which might not necessarily promote fairness.
- The country's agriculture policy does not provide specific incentives to motivate local and international entrepreneurs to venture into compost production.
- The process of compost certification is long, expensive and time consuming, and this can deter potential entrepreneurs.

2.2 Overview of the Composting Sector

This section presents an overview of the composting sector with particular emphasis on regulations for waste recycling; sources, volumes, and composition of waste; the status of sector development; main players; quality compliance for compost; health considerations for compost; incentives for composting; and factors that promote or constrain composting.

2.2.1 Regulations on Solid Waste Recycling and Consequences for Composting

The Local Government Act 462 and the Environmental Sanitation Policy, 2010 are the key policies that govern solid waste recycling in Ghana. The act and policy place waste management under the responsibility of the MMDAs. The act essentially expects any

composting firm to go through a registration process for it to be established. The construction and operation of compost plants is under the control of the MMDAs, while the EPA ensures that composting firms submit an environmental impact statement to enable an EIA of any proposed composting plants. The agriculture department of the MMDAs provides the avenue for collaborating on and testing compost before it is recommended to farmers. Sections 34 and 84 of the Local Government Act 462 are the legal basis for the introduction of a fee-financed waste collection scheme or the allocation of land required for construction of compost plants.

The National Environmental Sanitation Policy (NESP) addresses important sanitation issues in the country, and since its formulation an action plan has been developed to ensure its implementation. The strength of the policy is that it adopts an integrated approach by linking to other relevant environmental and developmental issues. The policy follows a range of problems and failures in the sanitation system that warrant action from all key sector actors. Relevant thematic issues have been identified together with stakeholders while developing the National Environmental Sanitation Strategy and Action Plan (NESSAP) for consideration, but development initiatives are required to translate the policy objectives into tangible results for the environment.

The EPA is an important regulatory agency and is involved in the set-up of any composting plant in the country. EPA uses other legislative instruments to compel the submission of an EIA before compost plant construction can be approved. Thus, the EPA has the capacity to offer various guidelines on environmental protection, conservation and preservation. The EPA has the mandate to enforce laws on the environment and ensures compliance by instituting legal actions against incompliant entities.

While Act 462 provides a foundation for appropriate institutional arrangements on waste management (and for composting), the challenge is that government departments often work independently and therefore inter-sectorial coordination of development initiatives is lacking. Very few composting initiatives driven by private sector actors exist in the country, but the policy provides opportunity for private sector participation in the sanitation sector. Moreover, the direct reference to composting and other related recovery methods in the NESP as well as its inclusion in other policies (such as the National Fertilizer Policy discussed below) presents a major opportunity for driving the composting sector forward. The explicit mentions represent an enabling institutional environment for scaling up composting as a waste management option in Ghana, provided all prerequisite conditions are met.

2.2.2 Sources, Volume and Composition of Waste Generated in Ghana

About a decade ago, the International Water Management Institute presented research results from the three largest cities in Ghana, which revealed that enough waste exists in the urban areas to warrant composting. Tables 2.3, 2.4 and 2.5 show the estimated amount of organic waste available for composting in Accra, Kumasi and Tamale, respectively (Drechsel

et al. 2004). Although the volume of waste has increased over the years, a high proportion of organic waste for composting continues to exist in every region of Ghana. More recent information from the Accra Metropolitan Assembly (AMA) Waste Management Department (WMD) reveals that Accra's municipal solid waste is estimated to be 2,000–2,200 t per day, with about 80% collected and disposed of daily. This means that between 730,000 t and 803, 000 t of waste are collected and disposed of annually, while a deficit of 20% is subject to alternative disposal methods, including burying, burning or disposal in open drains and other unauthorized locations. Accra's solid waste (measured by weight) consists of 65% organics, 6% paper, 3.5% plastics, 3% glass, 2.5% metals, 1.7% textiles, 17.1% inert and 1.2% other materials (CHF International 2012).

In Kumasi, approximately 1,500 t per day of waste is generated (Owusu-Sekyere et al. 2013). This gives an amount of 547, 500 t per y of waste. The waste generated by a community in Kumasi will usually comprise approximately 54.77% food, yard, and garden waste; 3.10 % plastics; 0.35% metals; 1.64% paper; 0.27% wood; 0.22% glass; 0.67 textiles; and 38.99 % of other waste, including sand, ash and other inert waste (Osei-Bonsu et al. 2014). However, in 2010, Zoomlion indicated that waste in Kumasi contained 40.2% organic material; 19.2% plastics; 1.2% glass/bottles; 7% cardboard; 2.2% metals; 6.9% textiles; 20.8 % inert materials (sand, ash and more); and 1.7% wood (Ofori 2013). In Kumasi, large amounts of household and market waste are available along with a very large supply of sawdust. In addition, the high poultry manure production around the city will influence the compost market in the Kumasi case.

Table 2.3: Total waste amount and estimated available amount of organic waste in Accra (manures from urban and peri-urban Accra)

Waste type	Amount in t per year		Nutrient Content N, P, K (t/y)		
	Total waste	Available for composting	N	P	K
Household waste	359,000–557,000	166,000–277,000	2,324–4,155	1,328–2,216	498–831
Market waste	97,700	73,300	953	367	220
Food processing	29,000	4,700	118	24	19
Fish processing	69,000	0	0	0	0
Sawdust	5,600	2,900	3	0	0
Sludge	91,500 (collected & transported m^3)	5,600 (settled sludge m^3)	17	10	2
Poultry manure	46,900	2,600	104	10	21
Other manure	136,000	0	0	0	0
Total (approx.)	830,000–1,033,000	255,000–366,000	3,519–5,350	1,739–2,627	760–1,093

(Source: Drechsel et al. 2004)

Table 2.4: Total waste amount and estimated available amount of organic waste in Kumasi (manure from urban and peri-urban Kumasi)

Waste type	Amount in t per year		Nutrient Content N, P, K (t/y)		
	Total waste	Available for composting	N	P	K
Household waste	260,000	64,000	900	510	191
Market waste	90,000	60,000	460	300	182
Abattoir waste	2,400	2,400	72–120	19	14
Brewery waste	11,000–12,000	0	0	0	0
Sawdust	230,000–290,000	105,000–121,000	105–121	10 - 12	10–12
Sludge	183,000 (on-site collected; m^3)	1,200 (dry, settled)	23	13	3
Poultry manure	34,000	2,200	88	9	18
Other manure	75,400	0	0	0	0
Total	885,000–946,000	230,000–250,000	1,650–1,712	860–862	418–420

(Source: Drechsel et al. 2004)

Table 2.5: Total waste amount and estimated available amount of organic waste in Tamale

Waste type	Amount in t per year		Nutrient Content N, P, K (t/y)		
	Total waste	Available for composting	N	P	K
Household waste	37,000–54,000	7,500–8,800	105–132	60–70	23–26
Market waste	2,900	1,900	25	10	6
Abattoir waste	400	400	16	3	2
Sludge (raw)	16,400 (generated m^3)	600(settled)	11	7	1
Livestock manure	48,500	0	0	0	0
Total	105,200–122,200	10,000–11,700	157–184	80–90	32–35

(Source: Drechsel et al. 2004)

In 2010, the population of Tamale was 371,000. Assuming a per capita solid waste generation of 0.5-0.6kg per day, the city generates 67,707-81,249 t per y of household waste.

In Tamale, organic waste for composting is scarce since a large share of waste is already used as inputs into agriculture. The existing reuse of municipal waste reflects an overall demand for nutrient inputs. One constraint is the expected seasonal variation in the supply of organic material.

A comparison between Accra, Kumasi and Tamale shows that Accra has a very high amount of compostable waste. As the supply of waste surpasses both demand and the capacity of composting schemes for the foreseeable future, the location of compost sites should be chosen in a way that reflects the demand rather than the supply, thus minimizing transport cost for those using the compost (farmers and real estate developers). It is most likely that at any given location within the city, sufficient supply of household, market or industrial waste will be available. The high manure production around the city will also influence the compost market.

Waste Collection and its Effect on Compost Quality

As MSW is collected unsegregated at source, the recycling process must necessarily involve sorting prior to composting. Sorting requires resources (time, finances and labor). In fact, Cofie et al. (2009) reported that sorting could represent close to 30% of the total cost of co-composting MSW and fecal sludge. When sorting is not properly done, the final compost quality is negatively affected: the compost may include visible inorganic materials that would require screening before being sold or that, if it were to remain part of the final product, dismay consumers. In more complicated cases, low-quality compost might constitute nonpathogenic health risks to consumers as it could contain metal contaminants, which can accumulate in soils and potentially be taken up by plants (Cofie et al. forthcoming).

2.2.3 Size of the Composting Sector in Ghana

Farmers use different types and forms of compost for agriculture in Ghana. In the northern rural areas, it is not uncommon to find household pits comprising food waste and animal manure. This kind of composting is usually practiced at a very small scale, and the compost is used for vegetable gardening around the homestead. Toward the southern part, from Kumasi to Accra, poultry manure composting has been carried out for many years. With the rising cost of inorganic fertilizer (subsidized only from 2008 to 2013) and concerns over its environmental impacts, farmers and other stakeholders are encouraging the development of a more sustainable way to increase soil fertility, such as by using compost and its derivatives.

Ankrah and Owusu (2012) reported that many organic fertilizers are being produced and distributed in Ghana. They include Humate Green OK, BIOPOWER PLUS, *Asaase Nofosuo*, Grow D.I., Grow Plenty and Deco Fertisoil. Tables 2.6 and 2.7 show the diversity of products available and producers that are currently active in Ghana while Figure 2.2 shows the location of some compost production sites. Awareness that organic fertilizers are important for crop production, horticulture and landscaping in the real estate development sector is

increasing. These sectors represent a vast market potential for scaling up production and use of compost in Ghana.

Figure 2.2: Compost production sites in Ghana

Table 2.6: Organic fertilizers in Ghana (already in distribution)

Product Name /Description	Producer/Importer	Source /Country of origin	Since when	Nutrients/Active Chemicals	Quantity Produced	Targeted Market
ACARP Organic Compost	Accra Compost and Recycling Plant	Ghana	June, 2012		31.5 t/day	Small-scale vegetable farmers, large-scale commercial farms
Asaase Nufosuo (packaged in 30 kg bags)	Farmers Hope Company Limited. (Kumasi)	Kumasi, Ghana	2010	N.P.K (3.2%-3.2%-1.3% +83.64%OM +1.38%CaO_2 + 0.51MgO). Produced from foodstuff sawmill, poultry farms and other agro industries	30 t/day. Produced based on demand from its clients	Small-scale vegetable and cereal crop farmers, dry season vegetable farmers, large-scale commercial farms
Cocopeats. Organic Growing Medium	Eco Fibre Ghana	Accra-Ghana	June, 2012	0.59%N, 187.50mg/kg P_2O_5, 3.7 – 37mg/kg K_2O, 2000mg/kg Ca, 600mg/kg, 22mg/kg etc	20 t/day	Small-scale horticultural farmers, gardeners
Humate Green OK Universal Pro-Concentrate	WA-Green OK www.greenok.lv	Latvia	18/11/2011	0.05%N, 0.001%P_2O_5, 1.2%K_2O		Small-scale vegetable, cereals crop farmers, large-scale farmers
Sampad Bio-Organic Fertilizer	Gbi-Hanjei Ghana Limited Hanjei Biotech Energies PVT Ltd	China		N – 1.62 – 2.5%; P – 0.8 – 1.2% P – 0.8 – 1.2% Cl – 0.21%; S – 0.27%		
Grow Plenty and Grow Safe	Green Grow ltd Philomena Brittian	Ghana		Coconut peats		Small-scale vegetable farmers, large-scale commercial farms

Deco! Fertisol	Deco NGO Ltd	Northern Region, Ghana		Poultry waste, fruits waste, neem tree leaves, waste from processing shea butter, corn cobs and groundnut	500 t/year	Small-scale vegetable farmers, tree crop farmers, large-scale vegetable and tree crop farmers, research institutes
Eco Fertilizer	Eco Products Limited	Greater Accra Region Ghana		N- 3.2%, P_2O5 – 3.3%, K_2O – 4.5%, OC – 30.6%, OM – 30%, Cl – 8.4g/kg, Mg – 84.7g/kg, Iron – 5.2g/kg, Mag – 4.2%	50 t/day	Small-scale vegetable and cereal farmers, landscape developers, horticultural farmers, commercial farmers

(Source: Modified from Ankrah and Owusu 2012)

Table 2.7: Organic fertilizers in Ghana (planned)

Compost in pipeline for production and distribution						
Product Name /Description	**Producer/Importer**	**Source /Country of origin**	**Since when**	**Nutrients/Active Chemicals**	**Quantity Produced/region**	**Targeted Market**
Fecal sludge fertilizer	Safi Sana Ghana	Greater Accra Region		Sludge from biogas production		
Jekora Fortifer	Jekora Ventures / Tema Metropolitan Assembly	Greater Accra Region	From 2015	Diverse composition. MSW + fecal sludge compost formulations, enriched and pelletized	1,000 t/yr	Small-scale and commercial farmers, landscape developers
Presank Fortifer	Presank Gh Limited / Techima Municipal Assembly	Brong Ahafo Region	From 2017	Diverse composition. MSW + fecal sludge compost formulations, enriched and	200 t/year	Small-scale and commercial farmers, in Brong Ahafo Region

				pelletized		
	Slamson Ghana Ltd.	Greater Accra			Can process 750m^3 of FS/day	To be determined
Self-produced Compost for own use						
Benso Compost	Benso Oil Palm Plantation (BOPP)	Western region		Agro-waste		For Benso oil palm plantation
Volta Compost	Volta River Estate Limited (VREL)	Eastern region		Agro-waste	15,000 t of compost/yr; (producing only 5,000 t/year)	For plantain plantation
Blue Skies Compost	Blue Skies Products Ghana Limited (BSGL)	Eastern Region		Agro-waste	Operational at 50% capacity (400 t/year)	For pineapple plantation
Twifo compost	Twifo Oil Palm Plantation (TOPP)	Central Region		Agro-waste		For oil palm plantation
Poultry Compost	Supplied by poultry farms			Saw dust, poultry droppings		Small-scale vegetable and cereal urban and peri-urban farmers
Cow dung Compost	Prepared locally by farmers	Northern Region		Cow droppings, farm waste		Small-scale cereal farmers, root and tuber farmers

(Source: Modified from Ankrah and Owusu 2012)

2.2.4 Main actors in the Composting Sector

Many actors are involved in the composting sector in Ghana, including composting firms, universities, district assemblies, international and local NGOs, ministries and national agriculture research institutes. Before the emergence of many of these actors in the composting landscape, Vasquez et al. (2003) investigated who should own, manage and be engaged in a hypothetically planned municipal waste compost plant in Kumasi. The authors listed potential stakeholders and their respective roles as shown in figure 2.3. They further clustered stakeholders into four functional categories:

- Regulators, i.e., institutions in power to draft bylaws, legal instruments and policies
- Organization and management institutions in charge of running composting plants
- Supporters of initiatives, i.e., institutions providing external support (financial, material or knowledge)
- Beneficiaries, i.e., users of sanitation services (households and markets), communities and workers receiving income through composting (composting producers), and farmers who use compost.

Figure 2.3: Potential institutional and stakeholder support for composting in Kumasi Ghana

		Institution taking action									
	Activity	EPA	MHS	MOFA	KMA-WMD	NGO GOAN	NGO GROWTH	WORLD BANK	Village Chief	Unit Committees	Assemblyperson
Activities proposed by the institutions	Support sanitation awareness creation	■	■				■		■	■	■
	Support waste collection initiatives	■	■		■		■		■	■	■
	Financial support of initiatives						■	■			
	CBO capacity building						■				
	Quality control monitoring	■		■							
	Monitoring & evaluation of operation	■	■		■		■			■	■
	Licensing operation	■									

	Monitoring safety & environmental impact										
	Promotion of sales of compost										
	Coordination of stakeholders										
	Education of farmers										
	Facilitate land to site the plant										
	Involvement in Management										

(Source: Vasquez et al. 2003)

Currently, municipal waste composting mainly takes place in the large urban areas in Ghana, especially in the regional capitals. Major composting firms are Zoomlion, Jekora, DeCo!, and Eco+ products (refer to table 2.6). The biggest composting plant is the Accra Composting and Recycling Plant of Zoomlion, which has the capacity to process up to 600 t of waste per day and which is founded on a public-private partnership arrangement with the district assemblies. DeCo! is run as a social enterprise composting initiative in Tamale, while Jekora composting plant is a private enterprise in Accra. At DeCo!, farmers are employed during the dry season to help with composting production. Farmers provide feedback that enables compost producers to upgrade their products. Training and research in composting is promoted at universities and research institutes, including at the University of Ghana in Accra, Kwame Nkrumah University of Science and Technology in Kumasi, the University for Development Studies, Savannah Agricultural Research Institute (SARI) in Tamale, as well as the International Water Management Institute (IWMI) based in Accra. Some NGOs (e.g., Global Communities, formally CHF) are also involved in training on, production and distribution of compost.

2.2.5 Health Considerations during Composting

Health implications are a major concern in the recycling of organic waste for agriculture. Since organic waste recycling is closely connected with the food chain, the health aspect is crucial for composting workers, for farmers who will use compost and for consumers of products derived from recycled organic waste (Cofie et al. 2006). Contaminants come from different sources, including excreta, which is often wrapped in plastic bags and included in the solid waste bins prior collection. Pathogens include viruses, bacteria, protozoa, helminths and heavy metals. In addition, when compost piles are badly managed, pathogens such as nematodes and parasite eggs that may be present in the organic waste could survive the decomposition process and be carried to farmers' fields and plots when composts are applied to soils (Birley and Lock 1999). Chemical contamination is another potential health risk associated with composting. Because organic solid waste is often stored and collected together with other kinds of waste, chemical constituents, especially heavy metals, can easily

contaminate the organic parts of the waste. Metals in municipal waste come from a variety of sources. Batteries, consumer electronics, ceramics, light bulbs, house dust, paint chips, used motor oil, plastics, some inks and glass can all introduce metal contaminants into the solid waste stream.

In the labor intensive windrow composting, which is commonly practiced in Ghana, manual sorting of solid waste and turning of compost are the two activities that could expose workers to pathogens and other contaminants. Simple health and safety protection measures, such as reducing the possible transmission pathways by using protective clothing, can mitigate many of these health hazards. Compost workers need to be equipped with rubber boots, work gloves, and mouth and nose masks to ensure protection. Training and education in the safe handling of waste and in basic first aid should be given to compost workers. Furthermore, on-site washing facilities and a first aid point should be provided at the workstation. At the Accra Compost and Recycling Plant, workers are screened for biological and other related infections on a regular basis for early detection and treatment (as per communication with the compost plant operators, 2014). In composting plants, regular monitoring of the final compost product is required to ensure that any pathogens present are inactivated during the decomposition process.

2.2.6 Quality Compliance System for Compost

Ghana's National Fertilizer Policy (2013) and Plants and Fertilizer Act, 2010 (Act 803) set the context within which a national quality compliance system on compost should be situated. Several of the steps involved in the compliance systems are described in box 1, based on the practical example of the Fortifer fertilizer material in Ghana.

Box 1. Process for the certification of Fortifer in Ghana

Fortifer is a product originating from co-composting of organic solid waste and fecal sludge in Ghana. The development of Fortifer as a product for reuse evolved through long-term research carried out by IWMI and its partners. Research results are being packaged as implementation guides and investment briefs, which are beginning to be used through a joint venture agreement between public and private organizations to commercialize Fortifer in Ghana.

The on-going registration process for Fortifer can broadly be separated into three main stages:

1) Registration with the Registrar General's Department

The Companies Code 1963 (Act 179) requires companies to acquire a ***certificate of incorporation*** and ***a certificate to commence business.*** The Fortifer Production Company (ProCom) must be registered before subsequent steps in the registration process can be implemented. Application forms are available at the registrar general's website *(http://www.rgd.gov.gh/en/forms.php)*.

2) Registration with the Environmental Protection Agency (EPA)

This registration is required for the purpose of obtaining an environmental certificate from the EPA. The process involves completing an environmental permit (EP) form. Based on the information provided on the EP Form, the EPA decides on the level of assessment required. A site inspection by EPA officers will be conducted, and a screening report will be presented to a technical review committee for decision making. The results of the screening will determine the next cause of action. EPA classifies projects into three types based on the potential impact on the environment: (a) no impact project (b) minimal impact project and (c) impact project. A full EIA is required for projects classified as impact projects. EPA publishes the environmental impact statement in the newspapers for 21 days to allow the public to make comments. Subsequent processing will then follow before a permit is granted.

3) Registration with the Ministry of Food and Agriculture (Plant Protection and Regulatory Services Directorate)

The third stage involves registering the ***ProCom*** and the ***Fortifer Product*** with the Plant Protection and Regulatory Services Directorate of the Ministry of Food and Agriculture. The steps are as follows:

- The applicant sends an application letter to the Minister of Food and Agriculture (MoFA), declaring the intention to register both the company and the product with the Ministry of Food and Agriculture.
- The Minister of Food and Agriculture acknowledges receipt of the letter and requests specific documents to be sent to the Plant Protection and Regulatory Services Directorate of the ministry:
  - A dossier of the fortifier (organic materials and nutrients);
  - The label of the product (containing three facts: product name, its uses and safety precautions);
  - A copy of the company's certificate of incorporation and certificate to commence business;
  - An environmental permit obtained from the Environmental Protection Agency.
  - To verify the content of the dossier, the Plant Protection and Regulatory Services Directorate (a) conducts laboratory analysis to verify the active ingredients and (b) performs field trials over two cropping seasons to test the effectiveness of the product.
  - The Fertilizer Technical Committee within MoFA makes the decision on registration of the company and fertilizer product. Registration fees are paid before the certificates are issued.

2.3 Overview of the Compost Market

Composting has evolved over the years in Ghana. The main market segments are farmers, horticulturists and real estate developers. Select compost plants are described in section 2.4.

2.3.1 Awareness of Compost and its Benefits

Composting of MSW has a long tradition. It has always been done at household levels in urban and rural areas. However, the development of composting at scale as a thriving business venture is missing. In this regard, the lack of proper information on composting as a business has led to failed enterprises and a lukewarm attitude toward the industry. In the early 1980s, when the use of chemical fertilizers ruled the day, composting was viewed as a backward method with slim prospects of becoming a vibrant business sector for agricultural development. However, fertilizer subsidies disappeared, and the use of chemical fertilizers failed to feed the growing population. Even with the restoration of subsidies from 2008 to 2013, the amount of fertilizer supplied (557,248 t of fertilizer subsidized at a total cost of GH₵281,239 million (GoG 2013b)) could not meet the need of the Ghanaian farmers. Levels of mineral fertilizer use are low in Ghana compared with other parts of the world. The average application rate of inorganic fertilizer is estimated at 8 kg per ha compared with 20 kg per ha in sub-Saharan Africa, 99 kg per ha in Latin America, 109 kg per ha in South Asia and 149 kg per ha in East and South-East Asia (MoFA 2011). The low application rate is in part attributed to the relatively high cost of fertilizer.

A survey of 700 farmers in three cities in Ghana (Danso et al. 2007) revealed the level of awareness and perceptions by compost and non-compost users. All compost users and 80% of the non-compost users acknowledged that good compost is a good material for soil amelioration and crop growth because of (i) the nature of the product, which resembles 'black soil', (ii) expected long-term effects on the soil and (iii) indirect benefits (including less waste and fewer diseases, as mentioned by urban backyard farmers). Only 6–9% of all farmers were not willing to handle compost derived from MSW and fecal sludge. About 20% of the non-compost users either expected the compost to be ineffective, or were concerned about health or religious implications of the fecal sludge component, independently of questioning the fertilizer value of the product. The farmers who were positive about the compost stressed their particular interest in 'organic' value.

No national level compost market strategy presently exists. However, IWMI is developing a national marketing plan for the distribution of Fortifer in the frame of an ongoing project, entitled From Waste to Food (WaFo).[1] Some compost plants have marketing departments responsible for sales strategy. For example, Accra Compost and Recycling Plant has a

[1] WaFo is an IWMI project, which is funded by the Bill and Melinda Gates Foundation from 2013–2016 (www.iwmi.org).

marketing department, which depends on word-of-mouth referrals as its main advertisement strategy. DeCo! works with NGOs that buy the compost for onward distribution to farmers; marketing is carried out largely through the bulk buyers, although some farmers are also involved in direct purchase.

2.3.2 Reasons Why Farmers Don't Use Compost

A past study by Danso et al. (2006) reveals several reasons why farmers do not use MSW compost (see table 2.8). Some farmers tried using compost in the past, but since the results were not encouraging they have withdrawn from it. Second, farmers are not certain of any particular source of compost that can deliver the results they want. They indicated that they cultivate to make profit and therefore are looking for more consistent and good quality compost to avoid losses in their farming business.

Table 2.8: Constraints associated with compost use by urban and peri-urban farmers

Use of self-produced compost in Kumasi & Tamale	Use of government–produced compost in Accra
• **Labor requirements in compost preparation (especially for larger amounts) (57%)** • **Insufficient amounts of raw materials (28%)** • **Lack of market for "organically" produced crops (low incentive) (15%)**	• Poor quality of the product (presence of broken bottles, polythene bags) (40%) • Price of compost (35%) • Bad location of the compost plants (transportation costs) (12%) • High water requirements of crops after compost application (5%) • Heat built up in the compost immediately after application resulting in burning of the crops (3%) • Lack of market for "organically" produced crops (5%)

(Source: Danso et al. 2006)

Farmers who have been trained through development projects are generally more informed about the importance of compost. For example, farmers in the northern region do not depend solely on NGOs to supply DeCo! Compost; they also buy some of the compost using their own money. This was confirmed from an interaction with a key informant.

Which soil ameliorants farmers used depend on regional availability, but they mainly consist of poultry manure, chemical fertilizer (e.g., NPK 15-15-15, ammonium sulphate, urea, superphosphate and muriate of potash), 'black soil' (topsoil from refuse dumps), cow dung and human excreta. Poultry manure is quite abundant in Ghana, especially around Kumasi, and is the type of organic manure in highest demand in the southern part of the country, while farmers in the northern part rely on chemical fertilizers and cow dung. Poultry manure

was found to be preferred because of (1) its low price compared to fertilizer, i.e., US$0.1–0.3 per 30–35 kg bag at that time, (2) its effective release of nutrients for plant growth and (3) its long term effects on soil quality (Danso et al. 2006). In contrast, farmers stated that chemical fertilizer is expensive and supports post-harvest life of the products when compared to organic manure. Interactions with key players in the sector during 2014 also uncovered problems: Farmers consider compost to be of poor quality.

2.3.3 Compost Market Segments

IWMI carried out compost market analysis in five of ten regions in Ghana, namely in Greater Accra, Ashanti, and in the northern, western and eastern regions, reaching a total of 860 farmers. The purpose was to identify market segments (i.e., customers) for compost, quantify segment sizes and locations, and assess the perception and willingness to pay for compost (Nkasah 2006; Danso et al. 2006; Idrissu 2012). The studies show that the following customer segments for MSW compost and for compost comprising of MSW and fecal sludge exist:

- Farmers engaged in urban and peri-urban vegetable production. Farmers grow exotic vegetables such as carrots, cabbage, cucumber, lettuce, okra and local vegetables. The average farm size is about 0.5 ha., and these types of farmers are scattered across Ghana;
- Producers of cereal and tuber crops, e.g., maize, sorghum, cassava, yam, etc.
- Fruit and tree crop plantations producing pineapple, plantain, oil palm, rubber, cocoa, cotton and coconut;
- Landscape horticulturalists.

More than 70% of respondents show positive perceptions and are willing to use and pay for compost derived from MSW and fecal sludge And, except for in the Ashanti region, farmers in all other regions have used raw fecal sludge, especially for cereals and rubber cultivation, over periods ranging from one to twenty years

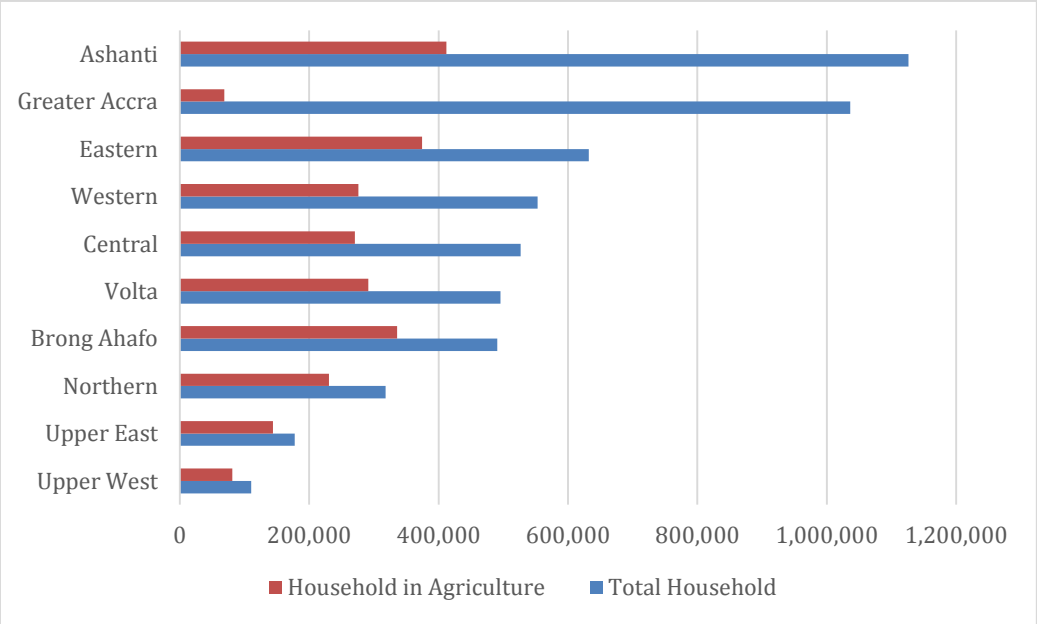
The willingness to pay significantly varies among different farming systems: Urban and peri-urban farmers are willing to pay less than US$1, whereas plantation owners are willing to pay up to US$8. This wide range implies the need for targeted production and promotion of compost use.

Landscape horticulturalists and plantations are premium customers for any significant compost sale. Moreover, plantations and real estate developers have their own transport capacity, which is very important for any revenue scenario.
Demand by smallholder farmers could be subsidized through the revenues from premium customers.

Based on farmers' general interest in compost (as expressed by positive willingness to pay),

Danso et al. (2006) estimated the theoretical annual compost demand from different farming systems in and around Kumasi, Accra and Tamale to be 11,000 t, 18,500 t, and 5000 t, respectively. Ankrah and Owusu (2012) further estimated the potential market demand for Fortifer in Ghana. They concluded that, given the interest that farmers show in compost, all farming households in each region (see figure 2.4) are potential targets for compost. Nevertheless, the actual demand for compost will depend on, among other things, the extent to which farmers' willingness and ability to pay for compost matches the selling price of compost and on whether better alternatives to MSW compost exist in the region. For example, current compost prices range from US$5.7 to US$14.3 (approximate exchange rate US$1=GH₵3.1) for a 50 kg bag in Accra (based on discussions with key informants at Zoomlion and Jekora Ventures Compost plants).

Figure 2.4: Regional distribution of farming households in Ghana



(Source: GSS 2010)

2.3.4 Organic Agriculture in Ghana

In Africa, and for that matter in Ghana, organic farming can be classified based on certification: certified organic production and non-certified or agro-ecological farming. Products meant for export beyond Africa are mostly the ones that require certification. One motivating factor for organic production in Ghana is the high demand for organic products in developed countries. In 2006, it was estimated that about 19,132 ha of land were under organic cultivation, which accounts for 0.13% of the total agricultural area in Ghana (IFOAM and FiBL, 2006). However, the area under organic agriculture increased to 28,162 ha in 2012 (IFOAM and FiBL, 2014).

Organic farming is largely led by the private sector, it is mostly funded by expatriates, managed by expatriates or both, and it is conducted on leased land or in partnership with

landowners. A study on organic agriculture, which involved 688 respondents including producers, marketers and consumers in Ghana, revealed that only a very small share of the organic farming products grown in the country is sold in the domestic market (Osei-Asare 2009). The study also showed that organic producers primarily used poultry droppings (57% of respondents n=133), followed by MSW compost (15%), cow dung (14.3%), green manure (6%) and black soil (4.5%).

The organic agriculture sector in Ghana cannot be considered developed. Locally produced materials are not labeled, but the imported organic products have labels. Ghana Standards Authority is responsible for certification of organic foods; however, their labeling is not yet similar to that of developed countries where more than 400 eco labels mark consumer products in nearly every category (Bogdan 2010). The codes of ethics that the Ghana Standards Authority requires practitioners of organic agriculture to observe was not well known among the organic producers surveyed. Only 14% (n=104) of producers were aware of the existence of such codes of practice. What does it say about compost or fertilizers in general? In the country and for this category of producers, only 40% adopted the recommendations (Osei-Asare 2009).

The code of practice for crop production was formulated in 2011 (GSA 2011). It has corresponding compliance criteria (GSA, 2011) that the regulator, in this case the Ministry of Food and Agriculture, is expected to enforce. The code of good practices for crop production indicates that fertilizer application, using either organic or inorganic fertilizers, must meet the needs of the crops as well as maintaining soil fertility. Application of fertilizers should be based on the nutrient requirement of the crop and on appropriate routine analysis of nutrient levels in the soil, the crop or the nutrient solution. Any application of nitrogen in excess of national or international limits must be avoided. The use of raw untreated human sludge is prohibited. It indicates that any use of treated human sludge on land marked for agricultural production must be supported by evidence.

Table 2.9 presents an excerpt of the compliance criteria for organic manure. It is not clear how the requirements are being enforced, but several compost products exist in the Ghanaian market and many more are in the pipeline.

Following the first international conference on municipal waste composting, organized by the International Board for Soil Research and Management (IBSRAM)/FAO in Accra in 1999, many research and development organizations have embarked on composting projects. Box 2 shows highlights from selected research and development projects in Ghana. Private companies are also taking advantage of the supportive regulatory environment to invest in composting. (Refer to table 2.6 for list of composting firms and products).

Table 2.9: Compliance criteria for the code of practices for crop production: Organic manure

Control point	Compliance criteria	Level
Has the use of human sewage sludge been banned on the farm?	No human sewage sludge is used on the farm.	Major Must
Has a risk assessment been carried out for organic fertilizer, which considers its source and characteristics, before application?	Documented evidence is available to demonstrate that the following potential risks have been considered: disease transmission, weed seed content, method of composting, heavy metal content, etc. This also applies to substrates from biogas plants in which case reference must be made to the legal requirements in the risk assessment	Minor Must
Has account been taken of the nutrient contribution of organic fertilizer?	An analysis is carried out, taking into account the contents of N.P.K nutrients in the organic fertilizer applied	Recommended

(Source: Ghana Standards Authority 2011)

In general, research and development initiatives on composting in Ghana have resulted in

- Increased awareness of the potential of compost as an alternative soil ameliorant
- Farmers concerns over compost use being considered in the development of appropriate compost formulations
- New business opportunities for compost production
- Farmers having access to organic nutrients, thereby enhancing the opportunity to develop organic agriculture in the country
- Increased individual and institutional capacity to produce compost as a result of several training programs
- Opportunities for further research and development in the composting sector

Box 2. Lessons from research and development projects on composting

Project: Improving the rural–urban nutrient cycle through urban and peri-urban agriculture, implemented by IBSRAM from 2000 to 2004 (IBSRAM was incorporated into IWMI in April 2001)

The project objective was to increase municipal authorities' awareness of feasible options for recycling organic waste for farmers' use in the rural–urban interface. The project covered three major cities: Accra, Kumasi and Tamale. It applied a nutrient recycling loop framework to study the supply of organic waste, the demand for compost, process options, institutional and legal aspects as well as the economics of composting and its alternatives.

Lessons: The amount and quality of organic waste available for composting is not a limiting factor. A detailed demand and stakeholder analysis appears crucial for compost sale and composting station setup. Major prerequisites for long-term success and project sustainability are careful financial planning and effective project partnerships that link public and private sectors, the community and research institutions. Composting is costly if done at a significant scale. However, large scale composting is less costly than incineration or landfilling. City authorities are satisfied that composting reduces waste volume and transport costs. Thus, compost production—even without any market—saves money for the municipalities that consider compost sales a bonus and prefer that the capacity of the stations should go far beyond actual demand for compost. While municipalities need large waste volumes composted for any significant impact, large sales are neither matched by farmers' willingness to pay, nor by the agricultural demand. For example, in Accra, the real estate sector (plus urban and peri-urban farming) could absorb about 20% of the available organic waste. Even considering these potential sales, a financial breakeven is unlikely, thus subsidies will be needed, especially for the set up of any compost station. If external support, subsidies or both are uncertain, compost stations do not appear to be sustainable because they will be unprofitable.

Project: Developing a value chain for compost in Accra, Ghana, implemented by USAID and Global Communities (formally CHF) in 2012

The CHF Ghana Youth Engagement in Service Delivery (YES) Program is an initiative funded by the Bill and Melinda Gates Foundation to support the creation of employment opportunities for youth, especially in low-income and indigenous communities in Ghana. The YES program utilized an inclusive value chain approach to identify youth employment opportunities in the solid waste management value chain.

Lessons: The compost value chain displayed a strong potential for job creation and income generation as well as the ability to address landfill challenges in Accra.

Project: Co-composting of Faecal Sludge and Solid Waste, implemented by IWMI since 2001

First, a pilot co-composting plant situated in the city of Kumasi was built to produce hygienic and nutrient-rich compost made from organic solid waste and fecal sludge and to test its use in agriculture for sustainable food production. Subsequently, the compost was enriched with inorganic fertilizer to increase the nutrient content and pelletized. This compost is now in the process of being commercialized under the brand name Fortifer.

Lessons: MSW compost is low in nutrient content and required in large amount for field application. Enrichment with inorganic fertilizer increased the nutrient content and crop yield and reduced the amount of fertilizer needed. Pelletization reduced bulk density, improved the ease of field application and made compost more attractive for users and business entrepreneurs.

2.3.5 Factors that Support or Constrain Composting in Ghana

Institutional settings

Supportive policy instruments provide an enabling environment for composting in Ghana. Therefore, private companies are embarking on composting, some in partnership with public entities. One example is the Accra Compost and Recycling Plant of Zoomlion Company Ltd, which is a public-private partnership (PPP) with Accra Metropolitan Assembly. Other PPP composting initiatives in the pipeline include Jekora Ventures with Tema Metropolitan Assembly, Presank Ghana Ltd with Techima Municipal Assembly and Safisana Ghana Limited. Nevertheless, poor institutional arrangements and logistics support for waste collection may continue to constrain the sector. Other constraints include solutions being heavily dependent on subsidies, minimal support for cost recovery models, failure to mobilize communities for participation, failure to understand the compost market and sufficient demand embedded into appropriate value propositions.

Incentives

The National Environmental Sanitation Policy, revised in 2010, provides some guidelines on composting but do not reference any fiscal incentives for composting. It provides a legal framework to enable the district assemblies to contract private waste management companies to any segment in the sanitation value chain. The Local Government Act 462, 1993, mandates the district assemblies to authorize private companies to manage waste. The cost of composting is recovered in different ways depending on the business model of the compost plant. For public-private companies such as Zoomlion's Accra Compost and Recycling Plant (discussed below), cost is partly covered by subsidies from the government through waste collection. Compost is also sold to generate additional revenue to pay for the compost production. For community-private companies such as Jekora, waste collection fees pay for compost production, albeit defaults in payment occur and thereby constitute a constraint to the revenue flow. For social enterprises such as DeCo! the sale of compost largely pays for compost production.

Furthermore, no state-driven incentives to encourage entrepreneurs to embark on composting exist. The few existing and planned PPP arrangements were either driven by entrepreneurs or supported by NGOs or development projects. Zoomlion and Jekora are waste management companies that have diversified into composting, which is viewed as an important trajectory for future development even though composting only minimally contributes to their profitability at the moment. Similarly, DeCo! originated from the perspective of solving important social needs.

Competition with other biowaste technologies

Bioenergy technologies are emerging in Ghana, though still at pilot scales so no full-scale technologies are in competition with composting. However, in the near future, bioenergy production may compete with composting over the use of available solid waste. For example,

in a recent proposal bid for a reuse enterprise, one metropolitan assembly declined to partner on a MSW composting project because they plan to use any waste available for energy generation. Although energy production is still at a preliminary discussion levels, it is noteworthy that the assembly preferred to convert waste into energy rather than into compost. The reason could be partially political: the government wants to become involved in projects with very high visibility to continue to secure their votes.

Availability of alternatives

Availability of better alternatives for soil amelioration will also constrain the use of compost. For example, the availability and use of cheap poultry manure constrain the demand for compost by farmers in Accra, Kumasi and Tamale. Some farmers' high level of confidence in the effectiveness of inorganic fertilizer also deters them from using compost, and reversing this sentiment will require much effort and many field demonstrations that showcase the better performance of compost.

Composting MSW with other products

Composting of organic MSW is one of the most successful methods for preventing organic waste materials from ending in landfills, while creating a valuable product suitable for agricultural purposes (Wolkowski 2003). The benefits are not only attributed to increased soil fertility, but, as mentioned in chapter 1, also to economic and environmental factors, such as saving the costs associated with landfilling and transportation, decreasing use of commercial fertilizer imports, and more (Hargreaves et al. 2008). Whether MSW composting is successful depends on the quality and quantity of compost. Farmers who produce crops for the urban market are willing to pay a high enough price for compost that compost stations can break even, while subsistence farmers are not (Danso et al. 2008). The crops for urban markets, especially exotic vegetables, are often of short rotation and need much more nitrogen fertilizer than is available in MSW compost. Even when growing crops on sandy soils, where compost as an organic soil ameliorant can help retain soil water, farmers complained about additional labor because the compost absorbed water and required more irrigation. In addition, these premium customers often have poor tenure security and prefer a short-term fertilizer supply over a long-term soil ameliorant (Danso et al. 2008). In terms of quantity, waste management departments are usually only interested in embarking on composting if this can significantly reduce the waste volume.

Therefore, composting for resource recovery, and not just for waste volume reduction, implies the production of high-quality product that can be attractive and competitive for different market segments. That is why various stakeholders in Ghana have been working to improve the nutrient content of municipal waste compost for use in agriculture. For example, IWMI has boosted the fertilizer value and attractiveness of the MSW compost through (i) co-composting organic MSW with dewatered but nutrient-rich urban fecal sludge, (ii) enriching compost with inorganic fertilizer or urine to create a 'fortified' organo-mineral material tailored to market needs, and (iii) pelletizing the compost to reduce its bulkiness and to

create a product similar in its appearance and handling to an inorganic fertilizer (Adamtey et al. 2009; Nikiema et al. 2014). These options for improvements can be selectively adopted so that any related increase in production costs is matched by the targeted customer segments' willingness to pay and the products remains competitive compared to alternative (and sometimes subsidized industrial) fertilizer. Jekora compost plant combined organic waste from fruit processing, separated at source, with sawdust to produce compost. DeCo!, a compost producing organization, also combines solid waste with manure to produce compost.

Quality standard and control measures

While nationally developed or accepted compost standards are lacking, cumbersome or unrealistic quality control measures have been established. According to the National Fertilizer Policy (GoG 2013a), the legal and regulatory framework for fertilizer quality control shall provide for following:

> Fertilizer inspectors undertake periodic quality control at the fertilizer production/blending plants, port of discharge, warehouse and other selling outlets; (ii) Fertilizer samples are drawn by inspectors for analysis in a designated and government approved laboratory or laboratories; (iii) Imposition of penalties on violators of the relevant aspects of the framework; such violations include, but are not limited to, plant nutrient deficiencies, misbranding, adulteration, short weight, bagging quality, failure to report tonnage and pay inspection fees, and/or operating without a certificate of registration or with an expired certificate of registration.

This formulation means that the testing laboratories will determine whether the compost is acceptable or not, which does not look realistic and is subject to bias.

Market for Organic Produce

Unlike in developed countries, no clearly defined local market and standard for organic produce exits. The lack of markets and standards discourages farmers from going into organic agriculture.

Cost

Composting is costly if done at any significant scale. Like in the developed world, it is hardly a profitable endeavor. This is even more the case where waste collection fees have to consider poverty and cover less than 15% of the collection costs. Subsidies will be needed especially for land acquisition, construction and at least the initial maintenance of any compost station. Moreover, compost prices have to be very low to compete with other organic inputs, which are hampering farmers' willingness to pay. These constrictions mean that transport cost and the amount of fertilizer required have to be minimal.

2.3.6 Viability of Composting Plants: Matching Composting Plants and the Compost Market

Determining the viability of a potential compost plant, the most economically feasible levels of MSW composting in a particular city and the capacity and siting of the most suitable compost station are major needs in the composting industry. Answering these challenges requires matching compost plants with the supply of waste and the demand for compost. Such economic analysis links the supply, demand and process segments of a waste recycling analytical framework described by Cofie et al (2006). The GTZ-GFA (1999) developed a model to assess the economic feasibility of compost stations. Analytical scenarios need to address different levels of technical sophistication and the actual and potential (but realistic) transport capacity of the city-specific waste collection system, including profitability and investment analysis for constructing and operating compost facilities in the specific city. Such an analysis was done for Accra (Drechsel et al. 2004), and the results provide two important insights with regards to viability of compost stations.

First, the overall cost of building and operating composting facilities in the Accra-Tema metropolitan area is much lower than costs for incineration and land filling. Furthermore, using landfills is about 95% cheaper than incineration under prevailing Ghanaian conditions as at of 2001. The unavailability of land for landfills, incinerators and their transfer stations and the requirements for meeting environmental quality standards are the major causes of the high capital cost of landfilling and incineration in the area. Composting urban solid waste appears to have the highest total economic benefits especially through labor absorption (Drechsel et al. 2004). The benefits derived from composting are about 213% of the benefits derived from incineration and 243% of those of landfilling. Comparatively, the benefits derived from incineration are about 114% of the benefits derived from landfilling.

Second, Drechsel et al. (2004) reveal a significant interest in and general demand for compost by different groups. In Accra, it was estimated that about 18,500 t of compost could be absorbed by the identified farming systems annually. The estimates for Kumasi and Tamale are 11,000 t and 5000 t, respectively. While these estimates represent maximum demands, the actual demands depended on farmers' ability and willingness to pay and the transport costs from the compost plant to farmers field. Spatial scenarios, which considered transport costs, were calculated to analyze the total compost demand with and without subsidies, using the breakeven compost production price of about US$5 per 50 kg compost from the pilot composting station in Buobai, Kumasi, as a reference. The study shows that farmers living beyond a 35 km radius of a compost station are unlikely to benefit from it because of high transport cost. Based on farmers' willingness to pay, it was possible to calculate the effective compost demand from agriculture and other sectors. However, additional information on the supply of waste, the composting technology as well as the institutional and economic aspects are required to be able to recommend compost plant sizes and locations. Such analyses are not presently considered in the siting of for example the country's largest compost plant, the Accra Compost and Recycling Plant, which is located

in Accra and plans to serve farmers in several regions far away from its location.

2.4 Select Compost Plants – Case Studies

This section presents an overview of four compost plants in Ghana: Jekora, Zoomlion, DeCo!, and Teshie.

Case 1: Jekora Compost Plant[2]

Initial interest

Jekora Ventures Limited (JVL) held the Accra Metropolitan Assembly (AMA) Franchise Agreement, under its fee- and performance-based solid waste collection service, to collect all solid waste generated within the Osu Klottey sub-metropolitan area and dispose of it at treatment sites designated by the AMA. JVL delivered its services under supervision of the Waste Management Department of the AMA and within guidelines established in the National Environmental Sanitation Policy. A similar franchise operation, although on a smaller scale, is undertaken in the Adentan Municipal Assembly in Accra.

The Jekora Ventures compost plant was originally built by CHF International for the youth of James Town in Accra as a community project. This was a facility granted to the community. However, the youth were unable to manage the plant: the lack of working capital for compost workers and unavailability of raw materials for composting hindered successful operation. Given this situation, Jekora took control of the plant in September 2013, as a private venture, while ownership still remained with the youth of James Town, Accra.

Jekora collected solid waste from communities around James Town, where the compost plant was located. All MSW collected by Jekora was transported to Kpone engineered sanitary landfill, which is about 90 km round trip from the compost plant. By sending some of the solid waste collected to the nearby compost plant, Jekora were able to cut down on transport cost. Transportation cost (excluding cost of refuse containers and landfill charges) ranges between US$ 0.21 and US$0.31 per ton per km. At full capacity, the compost plant processed 11 t of waste per month.

Though only 1% of the total waste collected by JVL was processed at the plant, JVL viewed the project as a pilot learning experience that prepared them for large-scale composting. Users of Jekora compost were flower growers, farmers and others.

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[2] Between the start and end of this study, Jekora compost plant at James Town was demolished. Jekora is planning to continue composting through a new joint venture agreement with Tema Metropolitan Assembly.

Business model

Jekora compost plant was managed by Jekora Ventures but owned by the community, in particular by the chiefs of Ga Mashie Development Agency and the Great Thinkers Association of James Town. Jekora supplied the organic waste and marketed the compost.

Economic, social and technological performance

The plant had limited space for waste storage. The technology was aerobic windrow composting. There were 11 chambers/windrows in the plant, and each chamber could hold 1 t of waste. Compost turning was done manually, and compost in the windrows was at different levels of maturity at any time. Composting lasted for two months, and the final compost material was 40% of the original waste volume. On average, compost production was 2.2 t per month. Organic waste was collected by JVL from hotels, restaurants and corporate organizations to feed the plant. Jekora promoted separation of waste at the source by giving a 20% discount on the service fee to those who separated their waste.

As a pilot project, Jekora sold about 70% of the compost produced, while it donated the remaining 30% to NGOs, schools and farmers to use for field trials and to solicit feedback from users. The donation of compost also fulfilled other social obligations, especially to schools within the operational area of JVL. Jekora sold compost in small quantities of 10, 20, 30, and 50 kg bags to two main clients (bulk buyers), who usually bore the cost of transportation to their respective locations. Though occasionally, Jekora Ventures delivered the compost to a designated point for the buyers. The cost of compost was GH₵1 per kg (approximately US$0.3 per kg or US$15.6 per 50 kg bag). The costs were incurred on allowances to drivers, laborers, supervisors, and vehicle operation and maintenance. Employees at the plant were hired from the community.

Effect of legislation on operation

At the time of operations, Jekora was not aware of the certification procedure for compost in Ghana, so the compost was not certified by the Ministry of Food and Agriculture. In the meantime, through their collaboration with another forthcoming composting project, JVL is now informed about the certification procedure necessary for replicating or scaling up their composting experience.

Constraints along the composting value chain

Jekora observed that farmers need incentives to be interested in using compost. Farmers would not trust a particular compost product without demonstration of its effectiveness. As the sorting of waste at the source was not efficient, obtaining a consistent composition of the composting feedstock was challenging. Therefore, the waste generators were encouraged to improve the sorting of waste at the source and then additional sorting was carried out at the composting site. A lack of competent human resources to supervise the composting process resulted in the final compost containing high levels of moisture. Supervisors did not know

when the compost had matured. Another challenge was the lack of space for expansion and for conducting field trials and demonstrations.

Emerging issues from Jekora Compost plant

Jekora's initial interest to venture into composting was driven by a desire to reduce the volume of waste transported to the landfill and the cost of transportation. Jekora considered the project a pilot approach to deliver cost-effective waste management services through the '3 Rs', i.e., reduction, reuse and recycling. Composting was also seen as an opportunity to enhance Jekora's branding as a waste management company. However, being a young company, Jekora would need to strengthen its institutional capacity for composting, marketing and management of legal and institutional requirements for composting in Ghana to be able to replicate or scale up its composting experience.

Case 2: Accra Composting and Recycling Plant by Zoomlion

Initial interest

Zoomlion's Accra Composting and Recycling Plant (ACARP) is the only operational, large-scale waste processing facility in Accra, and it has the capacity to process 600 t of waste per day. The plant started operations in September 2012. Since then, the plant has been accepting up to 300 t of waste per day for its operations. The initial motivation was to help improve the waste management situation in Accra and to convert the waste into compost, which can be sold. By so doing, the company would be contributing directly toward reductions in emissions of greenhouse gases. Given the enormous waste generation in the country, Zoomlion started the composting business without necessarily thoroughly investigating the market requirements. The source of MSW is the Greater Accra Region of Ghana. Zoomlion is also constructing another compost plant in Kumasi, the second largest city of Ghana.

Business model

The plant is privately owned. A public-private partnership agreement with the government of Ghana exists, but it has not been working well. The plant was shut down for some time in 2014 because the government defaulted on its payment of services rendered to the metropolitan, municipal and district assemblies (MMDAs). The financial plan was to generate revenue from compost sales in addition to subsidy from the government. As of August 2014, the government's debt to the company totaled about GH₵20 million (approximately US$5,263,158).




The Accra Compost and Recycling Plant at Adjen Kotoku (Photo credit: Zoomlion Ltd)

Economic, social and technological performance

At ACARP, MSW received is loaded into a compartment and then transferred to the sorting section by means of a conveyor belt. At the sorting section, organic fractions are separated from the inorganic fractions by a combination of hand picking, air separation and by rotary screens. The organic fraction is then sent to the compost section and composted. The compost windrow is mechanically turned by a compost turner. The ready compost is then screened, stored for at least one to two months and bagged for sale.

ACARP compost plant receives about 300 t of waste daily while the capacity is 600 t of MSW. About 50% of the 300 t is processed into compost. Other recyclables, such as plastics and metals, are also recovered. About 30% of the composted waste ends up as compost before sieving. This results in 45 t of compost per day before sieving. When the sieving is done, only 70% is recovered as actual compost, and thus actual compost produced per day is 31.5 t. Though some stakeholders observed that compost from ACARP is of poor nutrient quality, Zoomlion claims that the quality is good.

Zoomlion works with private MSW collection companies that are contracted by the respective MMDAs to manage waste in their areas of jurisdiction. The companies convey the waste to ACARP to be treated on behalf of the state. The plant does not receive tipping fees from the companies. According to ACARP, it is the responsibility of the government to pay the tipping fees because this waste would have been taken to government landfill sites for management if not ACARP. Therefore, the state is expected to pay ACARP for receiving the waste and to pay also the contractors for conveying the waste as part of the waste management arrangement for the city.

Compost is packaged into 50 kg units and sold at a price of GH₵20 per bag (approximate exchange rate US$1= GH₵ 3.1 or US$6.5 per bag). Zoomlion takes care of the cost of transportation of compost. The compost is being sold in Accra, Kumasi and as far away as in Sekondi-Takoradi. Average sales are about 250 t of compost per month. The selling price is the same everywhere. ACARP staff noted that the plant does not make a profit at this price, but the plant is expected to break even by the third year. The plant targets the volume-driven market and major customers include crop plantations, individual smallholder farmers and real estate developers. Customers are located around the country (e.g., ACARP targets cereal

producers in the east, cash crop producers in the west, cotton growers in the north and vegetable farmers in the south). ACARP does not have its own distribution outlets but rather relies on existing agro product distributors such as Aglow Agric Product Limited, Accra; Parks and Gardens, Accra; Pure and Perfect Limited, Tema; and We-Care Farmers Company Limited, Kumasi.

Unsold compost is kept in a warehouse for future sales opportunities. Zoomlion is still developing the compost market. Samples of the compost are also given freely to reputable organizations for field trials. Zoomlion inspects the warehouses of bulk buyers to ensure that the quality of the compost does not deteriorate. Some NGOs purchase compost in bulk for onward distribution to farmers using grants from donor organizations.

The high cost items for the plant are labor, electricity and maintenance of the machinery. The project aims at creating about 1,000 jobs for the surrounding communities. As part of its social responsibility, Zoomlion plans to support the local hospital with some medical equipment and to donate waste containers to the community.

Effect of legislation on operations

No detail explanation of how the Ghanaian legislative instruments have been applied to this plant exist, but ACARP staff said the company has three certifications from the Plant Protection and Regulatory Services Directorate of MoFA. According to the staff, the plant has producer, product and distribution certifications as well as a certification from EPA and the host district.

Sustainability

The sustainability of ACARP is questionable because it seems to be threading the path of similar large-scale composting ventures that have failed in the past, including the old Teshi compost plant in Accra. Based on a review of different compost stations in Africa, Cofie et al. (2008) reported several reasons cause compost plants fail or perform poorly: (i) inadequate feasibility study and market analysis result in unsustainable compost sales; (ii) lack of crucial partners result in unsustainable waste collection or compost production and (iii) poor maintenance after the initial set up result in financial and technical breakdown. ACARP has not demonstrated good practices along the sustainability pathway. The compost sales are not even sufficient to cover operation costs, let alone make sustainable profit.

Constraints

Transport cost for the compost is a problem because the users are far away from the plant and ACARP pays for distribution. Down time frequently occurs due to maintenance schedules and disruption of the electric power supply. Manual bagging of compost is considered to be a slow process. Compost refinery is needed to remove unwanted particles.

Emerging issues from Zoomlion Compost plant

Key issues include a need for a comprehensive assessment of the value chain in the compost production, waste quality, plant capacity and performance, composting technology and its efficiency, marketing and collaboration with key stakeholders such as farmers as well as MoFA and its related directorates.

Case 3: DeCo! Compost plant (Decentralized Composting for Sustainable Farming and Development)

Initial interest

DeCo! is a social business (registered as a Ghanaian NGO) producing organic fertilizer for smallholder farmers in Tamale, Ghana. DeCo! is motivated to become a business is because it wants to promote sustainable farming by supplying farmers with an alternative to chemical fertilizer, which negatively affects soil properties. The company processes MSW fortified with other nitrogen sources such as fruit waste, vegetable waste, neem tree leaves, waste from processing shea butter, corn cobs, groundnuts and poultry manure.

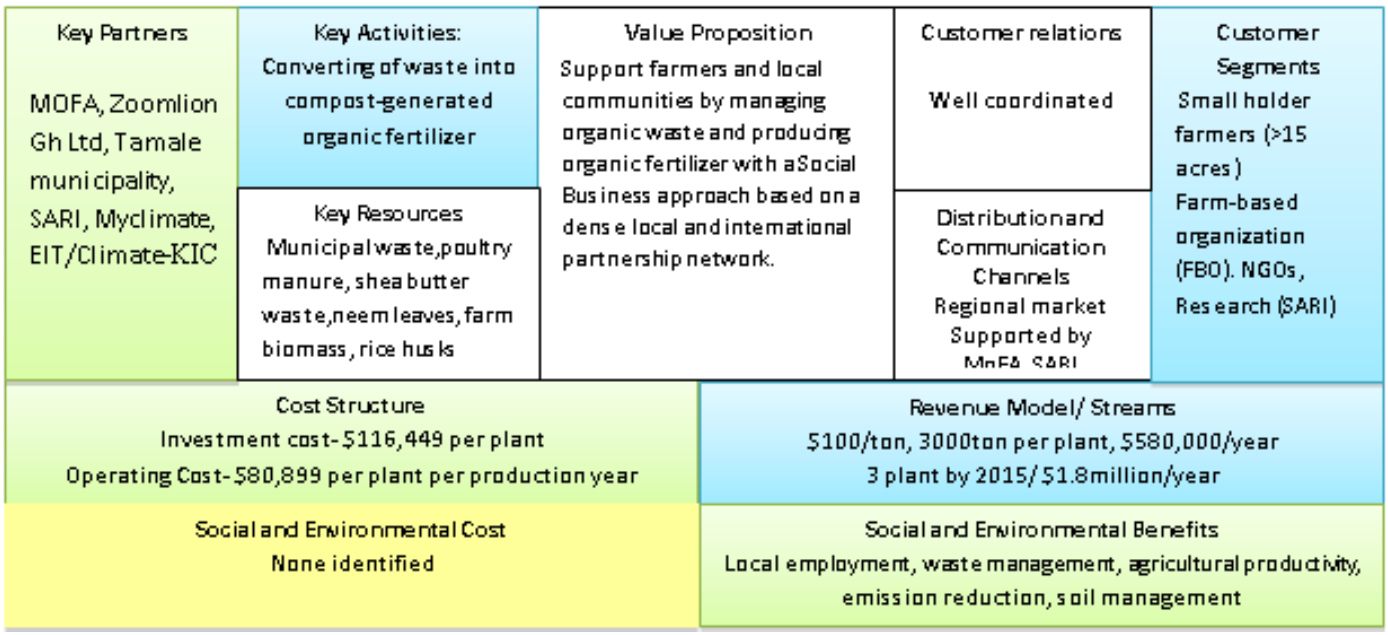
Photo credit: DeCo!

Business model

DeCo! runs its business activities under the social business model. The goal is to achive a social objective rather than profits. However, if operational costs are recovered, profits[3] are reinvested in the business. DeCo!'s business model is presented in figure 2.5.

Figure 2.5: Main features of DeCo!'s business model

[3] After questioning the Deco! manager, it is doubtful that the plant is making any profit. In fact, the plant's cost of operation was not known and the compost pricing was very arbitrary.



(Source: Otoo and Drechsel, forthcoming)

DeCo! received its initial funding from a SEED initiative award in 2010. Subsequently, DeCo! has been receiving offers of grants from development partners such as the German Society for International Cooperation (GIZ) and from EIT-Climate-KIC incubation grants. These financing facilities have contributed to stabilizing DeCo! as an organization and helped it cover some of its costs.

Economic, social and technological performance

DeCo! takes an established composting technology and adapts it to the regional conditions of the northern Ghana region by considering local input availability and soil conditions. Locating plants close to farming communities lowers the costs of production and lowers emissions by minimizing transport. In addition, a low-tech concept allows DeCo! to substitute expensive equipment with local labor force.

In terms of waste supply, DeCo! has a memorandum of understanding with Zoomlion for the supply of unsorted MSW, but supply is challenging because the plant does not always get sufficient and good quality solid waste. Zoomlion is the only private waste collector in Tamale, and it is mandated to collect waste from the central business district, which produces predominantly inorganic waste. Other types of waste include shea butter waste, which can be purchased from shea butter producing groups, neem leaves, biomass and farm residues. Rice husks are delivered by local people for a fee. Poultry manure is sourced down south, mainly from the Ashanti region, and transported up north to Tamale.

The production capacity is over 3000 t per year, and DeCo! is planning to establish two additional plants under a development project with other partners. DeCo! customers are predominantly farmer-based organizations; NGOs, such as Advance and Abokobi Society

Switzerland, and research institutions, such as the Savanna Agricultural Research Institute. These customers demand orders ranging from 1,000-3,000 bags of 50 kg FertiSoil (the brand name for DeCo!'s organic fertilizer). The farmer-based NGOs buy the compost and distribute it free of cost to farmers using grants from donor organizations. Interest in and demand for the compost is increasing. This promises a strong market reach for DeCo!, which already sells compost to about 3000–4000 small-scale farmers.

DeCo! is organized as an open-source project, which bundles the knowledge and commitment of people with different cultural and professional backgrounds. According to the management, Deco! encourages different perspectives. The management team of DeCo! consists of five members (three from Ghana, one from Germany and one from Switzerland), whereas the supporting team consists of a growing community with experts from various countries (Ghana, Germany, USA, Italy, Belgium and Switzerland) and backgrounds (chemical engineering, business management, international development, public policy, environmental sciences and agricultural sciences).

Effect of legislation on operations

DeCo! receives a lot of institutional support from MoFA and SARI. DeCo! collaborates with SARI to support research and field trials. MoFA advocates for sustainable farming techniques, thus it promotes the use of the compost through their extension services. Farmers are more open to change when MoFA or SARI is recommending the change to them. Although MoFA promotes this product, DeCo! management is not aware of the compost certification procedure. This is partly due to the fact that the fertilizer product was launched only recently, in 2013, but it also shows the lapses in the regulatory system in the country.

Sustainability

DeCo! plans to scale up by 2015 and to have three fully operational composting plants with expected earnings of about US$1.8 million. It envisions employing about 30–50 local unskilled laborers along with 15 experts to manage the plants. DeCo! identifies a lot of opportunities to integrate local farmers in its marketing channels, which would stimulate additional income generation. With DeCo!'s operational long-term goal of achieving Clean Development Mechanism (CDM) accreditation after 2015, DeCo! would receive carbon credits and exchange it for revenue on the carbon market.

Constraints

Compost is bulky and therefore transportation cost is usually a problem. How to reduce the bulkiness of compost is a major concern. DeCo! lacks expertise to improve the current quality of compost. Poultry manure used as a nutrient source is obtained from far away places such as Kumasi (a distance of about 380 km) with high cost of transportation.

Case 4: Teshie Compost Plant

The Teshie Compost Plant was managed by the Accra Waste Management Department. This capital-intensive compost plant was built in 1979, completely financed by the Swiss government. It was designed with a production capacity of 20 t per hour (circa 38,000 t per year), but due to lack of electricity, water supply, spare parts and inadequate maintenance, the plant never reached full production before it completely collapsed. Good quality compost was successful produced during the early years of installation. However, outputs dwindled to lower production rates during the latter parts of 1990s. The major mistakes in planning the plant, from today's point of view, was employing a too capital- and technology-intensive approach imported from Switzerland, which did not work under different maintenance and management conditions. The composting facility was strategically located to receive organic materials from within a radius of about 10 km. By 1980, the population of the catchment area was about 1.5 million, representing a population density of 4,300 per km^2, with the inhabitants generating about 224,000 t of municipal waste that year (Etuah-Jackson et al. 2001). The ambitious facility had two complementary and symbiotic operations: windrow composting and sewage sludge treatment (see photo below).

By 2004, the site was largely used as a dump site, also for liquid waste like human excreta. Some of the decomposed waste was retrieved as 'black soil' and used in landscaping by real estate developers. Another challenge was that, given urban expansions, the residents around the plant saw it as a nuisance to their community rather than a beneficial asset to the city and nation. The plant was finally decommissioned and seized operations in 2009.

Old Teshie compost plant (Photo credit: IWMI)

2.5 Conclusion

In Ghana, the environmental sanitation policy allows composting as part of a waste management strategy. In view of this, the practice is gradually gaining ground in the country, and a few compost products, either produced locally or imported, are in the market. Some producers do not disclose information, so it was difficult to get many cases for thorough analysis.

Composting operation is not currently optimized in Ghana, and gaps need to be addressed to put composting plants on a sustainable pathway.

Legislative Mechanisms on Waste Management and Agriculture

- The current regulatory framework needs to be strengthened through implementation of policies and programs on waste recycling and reuse in agriculture.
- Waste recycling transcends various disciplines and sectors. Therefore, an integrated, multi-sectorial approach is required at the governance level. Relevant stakeholders should be engaged in the implementation of policies and composting initiatives. Better integration is needed to enhance collaboration between the sanitation and agriculture departments and to better drive the composting agenda in the country.
- A need exists for a funding mechanism that allows partial subsidy, at least for the initial investment, and that ensures that composting plants aim for full recovery of maintenance and operations cost.
- A compost quality assurance advisory committee needs to be set up to ensure quality control. The members of this platform should be the compost producers and all relevant institutions, such as the EPA, Ghana Standards Board, Ministry of Local Government and Rural Development, the Ministry of Agriculture and its relevant Directorates and others. Guidelines, adapted and suitable to the local setting, should be prepared in a participatory manner by the platform, with inputs from experts.
- Labeling of organic foods should be established, so that people can tell the difference.
- In line with the national health and safety standards, compost production plants should set up and implement a health and safety plan. The advisory platform can provide a guideline on that.

Composting as Real Business with Private Sector Participation

- Greater private sector participation should be encouraged in waste management and sanitation, but it calls for instituting reasonable incentive packages to attract the private sector into waste recycling and reuse.
- Locally produced, affordable and manageable equipment should be encouraged.
- In business ventures, funding remains one of the most important components that may attract potential entrepreneurs. Sources of funding for composting can come in different forms, ranging from government exemptions on imported machinery and other taxes to government-supported loan packages. Others include a strengthening of the waste management system to compel individuals to pay for solid waste disposal, ensuring that compost production is carried out.
- The sale of the compost should be considered as a way to fund composting operations only in worst-case scenarios. Generating profit can be possible through increased compost sales. State-oriented funding has not been sustainable in the past. However, if the state creates a congenial atmosphere, the private sector can institute a cost

recovery model for compost production. The state must actively promote compost usage by farmers.

Markets for organic produce should be created, e.g., through instituting an organized labeling system and quality control, which could attract interested parties.

Planning for Sustainable Composting

Composting is not properly planned; hence, it tends to disappear as quickly as it is launched. The waste recycling analytical framework recommended by past studies in Ghana should be adopted. This framework was shared with relevant stakeholders at an expert consultation meeting in Accra a decade ago (Drechsel et al. 2004). However, the framework is not really being used, even though composting stations are being set up very frequently, most recently a new station in Kumasi was announced on December 29, 2014 and is now under construction.[4] The state must actively encourage composting initiatives that are informed by thorough analysis of

- waste generation (quantitative and qualitative waste supply analysis)
- compost demand by potential users (market analysis, willingness and ability to pay)
- waste processing and scales (technical options considering supply vs. demand)
- economic analysis (competing products, collection and processing costs, best locations, economies of scale and subsidy sourcing)
- options and constraints related to legal, institutional and local communal settings

Education

Knowledge is power. Stakeholders in the composting value chain need to be well informed and educated on various aspects of MSW composting. In particular

- Compost producers and planners of compost stations should be well trained.
- Agricultural extension officers and farmer-based organizations and NGOs should support farmers in compost application. One way of promoting knowledge and awareness of compost in agriculture is to strengthen the collaboration between compost producers and the directorate, ensuring that the extension officers will be in a very good position to support farmers. MoFa's Directorate of Agricultural Extension has the mandate to work with all MMDAs in the country. Thus, they have the capacity to reach out to farmers across the country. Field demonstrations, to show the effectiveness of compost, can be directed by NGOs and extension workers. Farmer-to-farmer knowledge sharing could also be effective.

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4 http://graphic.com.gh/news/general-news/36129-work-progresses-on-kumasi-compost-plant.html

- Farmers should make decisions on compost based on the amount of information available to them. Access to information should be improved. Information on the value chain of compost production, marketing and use should be packaged and made available to farmers in forms that they can understand and adequately apply. Usually, farm-based information is disseminated to farmers through various channels such as agricultural extension officers, farm-based organizations, NGOs and via demonstrations on individual farms.
- Education on the opportunities and constraints inherent in organic farming should be carried out. The code of conduct on organic foods should be made available to agriculture extension officers and other farmer partners, enabling them to help educate both farmers and marketers about the essential elements of organic farming.

Research and development

- Research and development need to accompany composting. Research institutes and universities should be encouraged to conduct applied research for development to constantly improve the sector. This will include research into appropriate technology for optimizing composting process, field application rates adaptable to different crops and soil types, marketing strategies, etc.
- Compost producers must also work closely with or employ people with expertise in compost quality assessment and assurance.

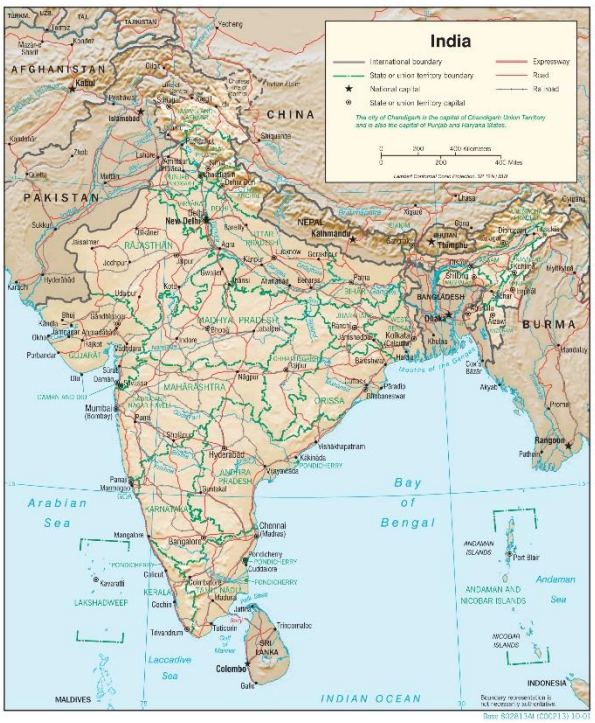
3. DESCRIPTION AND ANALYSIS OF COMPOSTING IN INDIA

3.1 Overview and Regulatory Setting

India, a country in South Asia (lat 20°00′0″ N, long 77°00′0″ E) borders the Arabian Sea and Bay of Bengal between Burma and Pakistan. India shares land borders with six countries. India covers most of the Indian sub-continent and has a variety of climatic regions ranging from tropical in south to temperate and alpine in the Himalayan north. The bulk of the country can be regarded as tropical. Related key details can be found in table 3.1. India's economy is tracked and driven by three sectors—agriculture, industry and services—and it ranks second worldwide in farm output. In 2012, 51% of the total work force in India was engaged in agricultural activities.

Table 3.1: India – country profile

Area	**3,287,263 km²**
Population	1.24 b (2014 est.)
Population Density	421 km²
Gross Domestic Product (GDP) official exchange rate	US$ 1.67 trillion (2013 est.)
GDP by agriculture	17.4%
Irrigated Land	663,340 km²
Agricultural land per 1,000 population	1.5 km² (2007)



3.1.1 Overview of Solid Waste Management in India

India is has been experiencing a change in its demography in the past two decades. The urban population of India is rapidly growing, and it accounts for more than one third of the Indian population. An effective SWM system is considered a basic service and duty of the urban local bodies in India. The government machinery has put in significant effort to improve SWM. During the past decade, a significant change in the process of waste collection, transportation and disposal has occurred. The MSW management activities in India are expected to be compliant to the MSW Management & Handling Rules of 2000 (MSW Rules 2000) issued by the Ministry of Environment and Forest of the Government of India. Significant improvement is still required to meet the expectation of the MSW Rules 2000; however, the stage is set for the next phase of implementation. A significant part of the next phase of implementation is the improvement in processing of waste, which still lags behind the improvements in the

collection and transport.

The waste generation in India in 2013 was assessed to be 133,000 t per day, increased from about 52,000 t per day in 2001 (CPCB 2013). India has about 8,000 towns and cities with a total urban population of about 350 million people, as per the census of 2011. The average per capita solid waste generation in urban areas has been assessed to be 450 grams per day. The MSW generated in India has about 60% organic matter, about 20% of recyclables and 20% of inert. Urban local bodies are responsible for the collection, transportation, disposal and processing of MSW in India. It is assessed that about 28% of the collected municipal waste is processed. The untreated, dumped municipal waste totals about 95,000 t per day across the country. In early 2014, about 480 municipal waste resource recovering facilities in India reportedly existed; about 279 of these are composting facilities practicing vermicomposting or aerobic composting, 172 are biomethanation plants (i.e., anaerobic treatment plants that produce biogas and compost), 2 are construction and demolition waste recycling plants, and about 29 are refuse-derived fuel production facilities, which prepare waste for energy plants.

Composition of Municipal Solid Waste in India

Waste composition is tough to measure in the Indian context because the waste from homes and other sources undergo some recovery at source, some at intermediate storage points and some during transport. The waste delivered at the processing facility or landfill site has less recyclable content than at the source. Data from studies done by the National Environment Engineering and Research Institute of India over the past two decades is presented in table 3.2 below, and the composition is based on the waste at the processing facility or disposal site. The change in the composition in the past two decades is due to changes in the nature of waste generation and changes in the waste collection practices. Over the past decade, with the implementation of the MSW Rules 2000, the collection systems have changed in that debris, construction and sweeping waste are transported separately, thereby reducing the total inert content in the waste being transported; the proportion of organic waste and recyclables has significantly increased. Moisture in the Indian MSW varies with the source and the season. The moisture content of the waste at the source varies: moisture content in organic matter ranges from about 50% to 80%, while the overall moisture content is between 40% and 60%. During the monsoon, the average moisture content will increase by another 10%–20%, depending on the amount of rainfall on the day of the collection. The increase in moisture during monsoon leads to increase in the tonnage of waste, but it does not reduce the absolute dry matter content.

Table 3.2: Waste composition in India

Year	Composition %							
	Biodegradable	Paper	Plastic/rubber	Metal	Glass	Rags	Others	Inert
1996	42.21	3.63	0.60	0.49	0.60	nil	nil	45.13
2005	47.43	8.13	9.22	0.50	1.01	4.49	4.01	25.16
2011*	42.51	9.63	10.11	0.63	0.96			17.00

Note: Biodegradable is wet basis, rest are dry. The total may not exactly match 100%.
*total is ~80% while other studies show biodegradable at about 60%.
(Source: Report on Waste to Energy by Planning Commission of India 2014)

Collection, Transportation and Disposal of Municipal Solid Waste

The collection, transportation, disposal and processing of MSW in India is primarily managed by the urban local agencies. The segregation of waste at the source as well as separate transportation systems for the segregated waste is limited to selected areas in some cities. Domestic and commercial waste accounts for the primary waste source in the country. In India, MSW can be classified as food waste, rubbish, commercial waste, street sweeping waste, industrial waste, commercial and demolition waste, and sanitation waste (Sharholy 2008). Organic farms are limited in urban areas, and they manage their own waste and are not part of the city waste composting facilities. The average waste composition in India for 1996–2011 is summarized in table 3.2. Observed changes of average composition of MSW, e.g., for glass, plastics and paper, indicate that formal recycling facilities emerge as an economically viable option. The municipal corporations use auto tippers, tractor trailers, dumper placers and compactors for transportation of waste from the generators to the disposal facility. Many of the cleaning staff are municipal employees, though in the past 20 years movement toward contracting has been significant. Labor contracting, works contracting and PPP-based collection and transport systems are observed. The usage of safety gears, such as masks, gum boots and hand gloves, is not common with these staff. The corporations' collection efficiency across towns is between 65% to 70%, and about 100,000 t of waste is collected and disposed by the urban local bodies across India per day. It is assessed that about 28% of the collected municipal waste is processed. The untreated, dumped municipal waste stands to be around 95,000 t per day across the country. This adds up to about 3.5 billion t of waste per year, which is not treated.

3.1.2 Regulations on Municipal Solid Waste Management and Compost

The thrust for improved SWM was provided by the supreme court of India based on a public interest litigation. The supreme court constituted an expert committee that formulated a report for improvement of SWM in 'class 1' cities (i.e., cities with a population above 100,000) in 1998. Subsequently, the Ministry of Environment and Forest notified the MSW Rules 2000, which lay out guidelines and standards for collection, transportation, processing and disposal of MSW. The judicial support for implementation has continued with the high courts in different states monitoring the progress of implementation. The Government of India included SWM in the Jawaharlal Nehru National Urban Renewal Mission (JNNURM),

which provided investments for urban renewal, and more than 60 cities received funding for improvement of SWM systems. The various state governments have dedicated 50% of their state finance commissions' grants to urban local bodies for SWM over the past decade to fund the improvement of SWM services.

MSW management is governed by the MSW Rules 2000, notified by the Ministry of Environment and Forests and arising out of the recommendations of the Bajaj Committee, 1995 and the Barman Committee, 1998. Implementation of the MSW Rules 2000 is poor on the ground, and a directive from the court to the municipal authorities asks to submit progress reports to the state pollution control boards each year. Urban local bodies in India are financially constrained to implement improved SWM practices, and to address this the central government allocates finances through budget transfers to improve SWM practices. Subsidies are also available for the construction of sanitary landfill facilities along with composting and vermicomposting. The Ministry of Urban Development (MOUD 2000) has developed a manual on MSW management to provide guidance to urban local bodies, and it includes planning for composting and waste-to-energy projects. Integrated waste management involves either composting or developing waste-to-energy projects; however, subsidies are exclusive to composting projects, while the waste-to-energy projects are completely funded by private investors. This exclusive subsidy has helped develop MSW-based composting as an integrated waste management solution in the country. The MSW sector has to conform to the following acts, rules and policy statements.

These acts and rules provide the basis for MSW management, including the roles, responsibilities, standards and penalties:

- The Municipal Solid Waste (Management and Handling) Rules, 2000: The base document under which the MSW management in the country is being undertaken. It gives details of the collection, transport, processing and disposal processes to be adopted. The document also gives the standards and annual reporting procedures.
- Hazardous Wastes (Management, Handling & Transboundary Movement) Rules, 1989: Hazardous waste are not included in MSW. However, household waste can contain hazard components, which ideally should be directed to hazardous waste treatment or disposal sites. These rules provide the procedures for classification, collection, transport and management of such waste.
- Plastic Waste (Management & Handling) Rules, 2011: The document gives a detailed plan for managing plastic waste. Plastic bags of less than 40 micron thickness are banned for use.
- Bio-Medical Waste (Management & Handling) Rules, 1998: The document gives the details of classification of biomedical waste and their transport and treatment. The biomedical waste are to be handled separately from MSW.
- The Constitution (74th Amendment) Act, 1992 and local municipal acts: The local municipal acts place the responsibility of SWM on the municipal bodies.

- State policies on SWM: Different states have brought out policies for MSW management. They build on the framework of the MSW Rules 2000 and define in detail how urban local bodies of different sizes should implement the MSW management to comply with the MSW Rules.
- National Urban Sanitation Policy, 2008, and Septage Management Advisory Note for urban India, 2013: These documents state co-composting of septage as a popular option, and similarly co-composting of sewage sludge with MSW is stated to hold significant opportunity. The city sanitation plans prepared under the National Urban Sanitation Policy include management of MSW as an integral component of sanitation improvement. The policy brings out the close relationship between sanitation and the MSW processing sector.

The quality of compost is controlled under the Fertilizer Control Act, which holds standards and guidelines on the facilities that MSW composting plants should contain. See table 3.3 and table 3.4, which specify the quality standards, including percentage of organic content, specification on heavy metal limits for compost and other components to ensure safety standards for both health and environment. The Fertilizer Control Act outlines the certification process for maintaining compost quality. For example, in the state of Karnataka, the compost manufacturer has to obtain a certificate from an authorized lab and submit the same in a specified format to the state government and provide details of the facility along with the process. The authority (typically the agriculture department of the state government) approves the application and issues a license, which is renewed annually. While a license is critical for the sale of compost, the state agriculture department does not conduct regular testing of batches.

Table 3.3: MSW compost quality specification

Parameters	Concentration not to exceed (mg/kg dry basis, except pH and C/N ratio)
Arsenic	10.00
Cadmium	5.00
Chromium	50.00
Copper	300.00
Lead	100.00
Mercury	0.15
Nickel	50.00
Zinc	1000.00
C/N ratio	20-40
pH	5.5-8.5

(Source: MOEF 2000, p. 12-13)

Table 3.4: Standards for organic fertilizer, FCO, 1985, schedule IV and FCO, 2013

Parameter	City Compost*	Vermicompost*	Phosphate Rich* Organic Manure (PROM)	Organic Manure**
Moisture % by weight	15.0-25.0	15.0-25.0	25.0	25.0
Color	Dark brown to black		-	-
Odor	Absence of foul odour		-	-
Particle size	Minimum 90% material should pass through 4.0mm IS sieve			
Bulk density (g/cm^3)	<1.0	0.7-0.9	<1.6	<1
Total organic carbon, % by weight, minimum	12.0	18.0	7.9	14
Total nitrogen (as N) % by weight, minimum	0.8	1.0	0.4	0.5
Total phosphates (as P_2O_5) % by weight minimum	0.4	0.8	10.4	0.5
Total potash (as K_2O) % by weight, minimum	0.4	0.8	-	0.5
NPK nutrients	-	-	-	>3%
C:N ratio	<20	-	< 20:1	<20
pH range or maximum	6.5-7.5	-	6.7	6.5-7.5
Conductivity (as dSm^{-1}) not more than	4.0	-	8.2	4.0
Pathogen	Nil	-	-	Nil
Heavy metal content (as mg/kg) % by weight, maximum				
Arsenic (as As_2O_3)	10.00	-	10.00	10.00
Cadmium (as Cd)	5.00	5.00	5.00	5.00
Chromium (as Cr)	50.00	50.00	50.00	50.00
Copper (as Cu)	300.00	-	300.00	300.00
Mercury (as Hg)	0.15	-	0.15	0.15
Nickel (as Ni)	50.00	50.00	50.00	50.00
Lead (as Pb)	100.00	100.00	100.00	-
Zinc (as Zn)	1000.00	-	1000.00	1000.00

(Source: *MOA 2003; **MOA 2013)

Health and safety measures in compost plants are carried out based on the commitment of the operator. The use of safety gear, such as masks, gloves, and more, is not common, and no specific enforcement of safety equipment usage exists. Guidelines and best practice

documents do exist, and some of the larger facilities do to some extent adhere to these best practices and provide routine health checkups for the employees. No dedicated regulator for composting in the country exists, and MSW composting is seen more as a responsibility of safe disposal by the urban local bodies. The Environment (Protection) Act and Rules, 1986, with its amendments form the basis of environmental regulation in India. It prescribes institutions, responsibilities and penalties for environment protection.

Key rules and acts under the Environment Protection Act that concern composting facilities are mentioned below:

- MSW Rules, 2000: The primary basis and regulatory mechanism for the composting facilities are established based on the MSW Rules 2000. The document provides standards and guidelines that the MSW composting facilities should adhere to along with specifications on heavy metal limits in compost. It also provides monitoring standards for leachate and air. See box 3 and table 3.5 for an extract of relevant standards and guidelines.
- Air (Prevention and Control of Pollution) Act, 1981, amended in 1987: Compost plants and other similar facilities need to meet the standards and requirements for minimizing air pollution.
- Water (Prevention and Control of Pollution) Act 1974, amended 1983: Compost plants have to meet the standards for discharged water quality as prescribed under the act.
- EIA Notification 2006, amended in 2012: Every project needs a prior environmental clearance and is required to undertake an environmental impact assessment. All centralized composting projects need to obtain prior environmental clearance.
- The Fertilizer (Control) Order (FCO) 1985 and Fertilizer (Control) Amendment Order, 2003, amended in 2013: The document specifies the quality requirements of compost from MSW facilities and the quality approval that is essential for sale of compost. The primary quality requirement for compost is the total organic carbon content, with a minimum of 12% specified. The quality requirements are presented in table 3.3 and table 3.4.
- Inter-Ministerial Task Force on Integrated Plant Nutrient Management: The Ministry of Urban Development of the Government of India constituted an inter-ministerial committee on integrated plant nutrient management for agriculture with MSW-based compost. The report submitted by the committee recommends promoting MSW compost along with fertilizer. The Government of India is promoting this new strategy of integrated plant nutrient management, which stipulates soil tests based on judicious use of chemical fertilizers (including micronutrients) in combination with organic manures and bio fertilizers. In addition, chemical fertilizer companies are mandated to co-market organic compost along with sale of the chemical fertilizer. India has a large fertilizer market, and the strategy applied is to use the existing supply chain, developed by chemical fertilizer companies, to promote compost and improve the stagnant agricultural productivity in India through improved organic matter in the soil.

All relevant regulations for MSW management and composting are highlighted below:

Municipal Solid Waste (Management and Handling) Rules, 2000: This document is framed under the Environment (Protection) Act, 1986, and covers collection, segregation, storage, transportation, processing and disposal of waste. It mandates urban centers to set up suitable MSW treatment and disposal facilities, and it specifies standards for compost quality, health and closure of landfills. Regulations provide specifications for landfill sites, including site selection, facilities, pollution prevention, water and quality monitoring, site closure and after care. It advocates specifically to process biodegradable waste by composting, vermicomposting, anaerobic digestion or other appropriate biological processing. The rules provide specification on MSW-based compost quality. The document also integrates regulations on the recovery of energy through incineration (MOEF 2000). However, it is interesting to note that for waste-to-energy plants, no air pollution standards are specified for MSW incinerators. These regulations have clear instructions on the management of liquid waste, such as floor drainage meeting the Central Pollution Control Board's effluent standards for disposal of industrial waste (MOEF 2000).

Plastic Waste (Management & Handling) Rules, 2011: This document regulates the manufacturing, distribution, sale, use and disposal of plastic bags, packets and sachets. According to the rules, the municipal authority is responsible for the segregation, collection, transport and disposal of plastic waste. Importantly, the document recognizes the role of the informal sector in collection, segregation and trading of recyclables. In addition, the rules specifically target manufacturers of any product and request them to provide proper environmental management, e.g., by registering their manufacturing and recycling units with pollution control boards; this control measure is referred to as the extended producer's responsibility. The State Pollution Control Board, under which all such facilities have to be registered, oversees the management of plastic units and annually monitors and consents to the continued operation of such unites. The urban local bodies undertake unscheduled monitoring visits to identify and seize plastic bags of less than 40 micron. Certain sensitive ecological zones, such as Nilgiris and individual towns driven by local urban bodies, have banned use of plastic bags in defined regulated region.

National Livestock Policy, 2013 and National Policy for Farmers, 2007: These policies encourage use of crop residue and livestock waste to make organic fertilizer. They recommend improved farm management through composting and biogas production. The national policy requires improving soil health as a key to enhancing agriculture productivity. The policy promotes balanced use of fertilizer and recommends using crop residues and other organic matter. The policies mention establishing appropriate production facilities and marketing of biofertilizers and organic manures

to promote soil health. The National Livestock Policy 2013 calls for better management of farm yard manure through composting and biogas production with awareness building for feed and waste management. In India, the fertilizer policy is based on ensuring fair prices and quality. The legislation includes registration of fertilizer producers and marketing businesses and quality specifications. Compost is included in the legislation, but is not a major part of the policy.

Box 3: Standards for composting, leachate treatment and incineration

1. The waste processing or disposal facilities shall include composting, incineration, pelletization, energy recovery or any other facility based on state-of-the-art technology duly approved by the Central Pollution Control Board.

2. In case of engagement of private agency by the municipal authority, a specific agreement between the municipal authority and the private agency shall be made particularly for supply of solid waste and other relevant terms and conditions.

3. In order to prevent pollution problems from compost plants and other processing facilities, plants shall comply with the following, namely:

   i. The incoming waste at site shall be maintained prior to further processing. To the extent possible, the waste storage area should be covered. If such storage is done in an open area, it shall be provided with impermeable base with facility for collection of leachate and surface water run-off into lined drains leading to a leachate treatment and disposal facility.
   ii. Necessary precautions shall be taken to minimize nuisance of odor, flies, rodents, bird menace and fire hazards.
   iii. In case of breakdown or maintenance of plant, waste intake shall be stopped and arrangements be worked out for diversion of waste to the landfill site.
   iv. Pre-process and post-process rejects shall be removed from the processing facility on a regular basis and shall not be allowed to pile at the site. Recyclables shall be routed through appropriate vendors. The non-recyclables shall be sent to well-designed landfill sites.
   v. In the case of compost plants, the windrow area shall be provided with impermeable base. Such a base shall be made of concrete or compacted clay, 50 cm thick, having permeability coefficient less than 10^{-7} cm per sec. The base shall be provided with a 1–2% slope and circled by lined drains for collection of leachate or surface run-off.
      a. Ambient air quality monitoring shall be regularly carried out, particularly for checking odor nuisance at down-wind directions on the boundary of the processing plant.

The disposal of treated leachates follows the standards presented in table 3.5.

Table 3.5: Standards for treated leachates

Standards for treated leachates	Standards (Mode of Disposal)		
Parameter	Inland surface water	Public sewers	Land disposal
Suspended solids, mg/l, max	100	600	200
Dissolved solids (inorganic) mg/l, max	2100	2100	2100
pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
Ammonical nitrogen (as N), mg/l, max	50	50	-
Total Kjeldahl nitrogen (as N), mg/l, max	100	-	-
Biochemical oxygen demand (3 days at 27^0 C) max (mg/l)	30	350	100
Chemical oxygen demand, mg/l, max	250	-	-
Arsenic (as As), mg/l, max	0.2	0.2	0.2
Mercury (as Hg), mg/l, max	0.01	0.01	-
Lead (as Pb), mg/l, max	0.1	1.0	-
Cadmium (as Cd), mg/l, max	2.0	1.0	-
Total Chromium (as Cr), mg/l, max	2.0	2.0	-
Copper (as Cu), mg/l, max	3.0	3.0	-
Zinc (as Zn), mg/l, max	5.0	15	-
Nickel (as Ni), mg/l, max	3.0	3.0	-
Cyanide (as CN), mg/l, max	0.2	2.0	0.2
Chloride (as Cl), mg/l, max	1000	1000	600
Fluoride (as F), mg/l, max	2.0	1.5	-
Phenolic compounds (as C_6H_5OH) mg/l, max	1.0	5.0	-

Note: Where discharging treated leachates into inland surface waters, quantity of leachates being discharged and the quantity of dilution water available in the receiving water body shall be given due consideration.

Fertilizer (Control) Order (FCO) 1985 and Fertilizer (Control) Amendment Order, 2003, amended 2013: These documents provide specifications for compost. They set out criteria for certificate of registration, with the exception of government entities and vermicompost producers. If a certificate of registration was granted before the Amendment Order, 2003, it is considered a letter of authorization. Certification is not required for state governments and municipality manufacturers or for manufacturers producing less than 50 M t of vermicompost. The certificates are valid for three years, unless suspended or revoked, and renewals must be made before expiration.

Packaging of compost must clearly display the content (MOA 2003). The Fertilizer Control (Amendment) Order, 2013, has specifications for compost to include minimum carbon, nitrogen, phosphate content, along with maximum heavy metal content and maximum pH. The compost needs to specify the source of raw material input.

Inter-ministerial Task Force on Integrated Plant Nutrient Management resulted from a Ministry of Urban Development and Ministry of Agriculture (MOA) study on production and marketability of compost. It recommends using compost from the biodegradable portion of city garbage along with fostering compost production by providing incentives such as tax holidays, provision of land and no tipping fees for composters.

Different programs at varying levels under central and state governments provide subsidies for composting projects to promote compost and organic matter. The subsidy program targets specific groups, for example certain compost companies, enabling these to improve the marketing of compost, or different groups of farmers, depending on crops cultivated, for improved livestock management. The subsidy can vary from 30% to about 80% of the capital investment and has been the key driver for development of the compost market, especially for use in the cultivation of grains. While the subsidy has helped other high-value crops, such as tea and fruits, it is not the primary driver for compost used by these farmers. In addition, there are two parallel schools of thought that promote new policies and practices in favor of composting: From the MSW management perspective, composting is considered as the best viable management solution because the organic and moisture content are high in the waste and required investments are lower. This triggers support for composting from urban planners and policy makers. Gradually, planners are observing problems related to sale of compost and to handling of the other waste components, which is a grey area currently, and these challenges are progressively causing a shift toward waste-to-energy projects, even though composting is still a preferred option. The other rationale is that agricultural productivity in India is stagnating, and the organic content in soils is dwindling. Therefore, numerous subsidies are provided for increasing organic matter in soil, and MSW-based compost is one of the organized sources of organic matter.

3.1.3 Opportunities and Challenges of the Composting Sector in India

Opportunities

Composting is one of the primary options for municipal waste management in the country. Four options for MSW processing are presently commonly available in India: a) composting, b) conversion to biogas, c) incineration/pyrolysis and d) landfilling. The option of landfilling is not preferred due to lack of land and suited sites. However, it is considered as option for the short to medium term until processing facilities are in place and fully operational. Biogas is a niche option for the highly organic fraction of waste and has yet to be proven viable for

large-scale facilities. Incineration/pyrolysis is viable at scale; however, complete commercial application of the technology has yet to be proven in India. In addition, approval of small-scale incinerators for meeting environmental safety aspects remains unclear, and major concerns for their application remain unclear. Given all the constraints from other available options, composting appears as best suited option in the Indian context. High organic content in the MSW composition and ability of the composting process to handle mixed waste are comparative advantages of the process. Key opportunities in MSW composting operations are as follows:

- Regulatory support: As per the MSW Rules 2000, it is mandatory that the waste generated in the urban areas should be collected, transported, processed and disposed of in a scientific manner. It is mandatory that the waste collected should be processed systematically and the rejects sent to the landfill. There is a clear mandate for recovering resources from organic waste by converting them into compost or biogas. Urban local bodies across India are looking forward to setting up and operating municipal waste processing facilities with composting as one of the foremost preferred option.
- Increased central and state government support and private sector participation: Central government programs, such as JNNURM, and funding by state governments to urban local bodies for improved MSW management strongly encourages the private sector to make investments. The present strategy, adopted by significant number of urban local bodies, is to outsource waste processing facilities to the private sector through public-private-partnership initiatives. Two trends have been observed: Either, the urban local body makes the investment and sets up the facility and operations is then handed over to a private operator. Or, a private operator operator is asked to set up the facilities on its own and receives tipping fees to cover the operation costs. IL&FS and Terra Firma biotechnologies, cases discussed in this report, have been set up by private operators. JNNURM's plants, such as the A2Z plant in Ludhiana featured in this report, are examples of the urban local bodies making the capital investment made and the private sector handling operations.
- Promotion of decentralized composting: As per the regulations, bulk waste generators and gated communities are expected to manage their own waste. This provides opportunity for decentralized waste management solutions; however, the scale and numbers are small at present.

Challenges

The key constraints in the development and promotion of MSW compost are lack of awareness, high transportation costs, seasonal market demand, longer term payback, a perception of the business as very attractive, unsegregated waste inputs, higher transaction cost and efforts required for quality maintenance, consistency and so on. The MSW composting industry is still at a nascent stage, and it is operating with less than 10% of the overall potential. Building a compost industry in India requires redefining the role of

composting not as a waste management solution bus as a business model and making the industry viable through market development, provision of capital support to compost companies and enforcement of tipping fees. A minimum technical requirement needs to be established with objective of improving the composting activities. In addition, companies require necessary research support to produce specific compost niche products applicable for specific crops. Some of the major constraints in the development of MSW-based compost in India are described below:

- Lack of awareness of compost use: This constraint limits the size of the market. The majority of the compost plants operating across the country have huge piles of compost stocks that they are not able to sell, leading to space constraints and resulting in business viability concerns. As compost piles up, it is either given away for free or sent to landfills. With limited support, and in the absence of tipping fees from urban local bodies, the composting plant becomes a dumping ground over time.
- Transport costs: The market for MSW compost is generally far from the compost plant location, and typically these plants have to transport the compost product at a distance ranging from 70 km to 600 km. Some of the plants transport compost by train to locations more than 1,000 km away. It is observed that the transport cost ranges from INR400 to INR1,000 per t of compost (approximately US$6 to US$16). Although the sales price ranges from about US$30 to US$65 per t, the net value at the compost factory gate is between US$22 to US$30 per t; the added cost is primarily driven by transport and packing costs.
- Organic certification and seasonal demand: The crops grown using MSW compost are not considered under organic produce certification in India. The market for the compost is dependent on the monsoon. The agricultural season lasts four to five months, and during this time the demand for compost is high, whereas demand is low during the remaining part of the year.
- Quality consistency: Limited control on the quality of the compost challenges quality. The input of MSW quality varies, leading to changes in the final compost product. Typically, compost plants include additives like poultry litter, press mud and other organic materials to increase the organic content. The demand for compost is seasonal, while production is consistent on a daily basis. Compost has to be stocked due to seasonality of demand, and stocking also impacts product quality. Quality consistency needs to be ensured by the operator and is a critical constraint.
- Absence of special products: MSW-based compost is a generic product in India. Branding of this compost has been done by many compost producers, but special compost products for different crops and soil conditions are not common. Research needs to support the manufacturers to develop niche products. Granulated compost is produced by a few companies, and they are getting a higher sales price. The absence of special products minimize sales of compost through targeted market segments.
- Low business attractiveness: Composting facilities in India have a longer payback period. Therefore, MSW composting is not considered as an attractive business venture by the

banking sector and access to loans is becoming more difficult. The problem is compounded by the composition of MSW generated, which has a high ratio of inert waste, up to 20%. The inert waste does not generate revenue, but it requires additional investments for scientific disposal and management, which significantly hampers the profitability of the facilities.

3.2 Composting Sector in India

Composting is the preferred municipal waste processing option in India. The majority of the MSW processing facilities in India are either aerobic composting facilities or vermicomposting facilities. Vermicomposting is mostly practiced at small scales, processing from 200 kg to 10 t per day. Small-scale composting is becoming a trend in India and is primarily used for individual facilities generating large amounts of waste. The city scale composting facilities are aerobic windrow facilities. Typical aerobic composting facilities have an installed capacity of 200–400 t per day, and larger composting facilities have an installed capacity of around 500–750 t per day. Two facilities have a capacity of over 1,000 t per day. The quantity of waste processed is about 28% of the total collected waste, meaning that in India the existing capacity to process waste is at 25,000 t per day. The quantity of waste processed through vermicomposting and biomethanation is less than 500 t per day in the country. The waste-to-energy plant processes about 1500 t per day. Based on these figures, the total capacity of about 23,000 t per day of MSW can be processed by many processing units using aerobic composting technology and operating at varying efficiencies in India. Giving an average plant operation at 30% plant load factor, yielding about 7,000 t per day of MSW with aerobic composting, a total of 350,000 t of compost is produced per year. In India, about 14% of the incoming MSW is converted into compost. The potential compost generation from MSW in the country is assessed to be 3,220 t per day, or 1,175,000 t per year. Typically, a compost plant that cannot sell or dispose of its compost may have to stop producing compost at some point. All compost that is not sold is given away for free or sent to landfills. Compost companies that do not receive any tipping fees will have selling all the compost as a higher priority, and they would not proceed with the production if there are no sales. However, compost companies that receive tipping fees could produce smaller quantities of compost and, if sale is not possible, they could give compost away for free.

3.2.1 Key Players in the MSW Composting Sector

The main players in the MSW composting sector in India can be classified as public institutions, private institutions, public-private partnerships and partnerships with fertilizer companies.

- Karnataka Compost Development Corporation in Bangalore is the only state-owned company in the MSW composting sector and has been operating for the past four decades. The company trades over 40,000 t of compost annually. There are a large number of projects set up by various city municipalities, which are being operated by local actors

across the country.

- A number of private actors are operating at various scales, and some actually operate multiple plants across the country.
  - Terrafirma Biotechnologies in Bangalore is one of the oldest MSW composting companies and has been operating for more than two decades. It handles more than 500 t of MSW per day.
  - Eastern Organics Kolkata is an old processing unit (more than ten years old), which handles more than 300 t of MSW per day. It is one of the few successful composting plants in India. Success is defined in this case as the capability to maintain a continuous and functional operation and processing a certain minimum waste input over time. Composting companies are able to cover their operational cost through the sale of compost. In the case of Eastern Organics, even though they do not yet receive any tipping fees, the company has managed to run its composting production profitably.
  - IL&FS Environment Infrastructure Services Limited (IEISL) entered the composting sector in 2008 and has multiple plants operating across the country. It is one of the few country-wide actors in composting.
  - Hanjer Biotech , Ramky Infra and Subhash Projects are some of the other major private sector players in the sector.

Many fertilizer companies have taken up city compost sale in the country. Some of the major players in this segment include Coramandel Fertilizers and Nagarjuna Fertilizers based in Hyderabad. It is assessed that they in sum trade over 200,000 t of compost annually, of which a significant component is compost produced from MSW. Their interest in compost started with the policy of integrated plant nutrient management pursued by the Government of India, which demands organic matter to be for sale along with chemical fertilizer. Currently, this practice has become business as usual for these fertilizer companies. Most of the fertilizer companies act as traders and are buying and selling compost. They place an order and provide branded bags for packing (all compost is sold in 50 kg bags), undertake quality checks and transport it based on demand.

3.2.2 Composting Technology for Processing Municipal Solid Waste in India

In India, private composting facilities obtain waste concession agreements from the urban local bodies. MSW is delivered at the processing facility by the urban local bodies, and those facilities receive a tipping fee from the urban local bodies. The composting facilities receive mixed waste and are not being supplied with segregated waste because no back-end supporting system for collection of segregated waste exists. This determines the choice of technology used for processing MSW to compost. There are three types of compost technology used: vermicomposting, small-scale aerobic composting and windrow aerobic composting.

The windrow process is the dominant type of technology used. It is carried out on concrete

platforms with incoming waste either directly piled on the platform or sieved in 80–200 mm sieves prior to placing on the platform. The windrow is formed and turned using front-end loaders and backhoes. The composting period ranges from 30 to 60 days, depending on the operator. The composted waste is then sieved through 40 mm, 16 mm and 4 mm sieves. Material passing the 4 mm sieve is sold as primary compost and material passing between 16 mm and 4 mm is sold to plantations, agro-forestry or sent back for further composting. All materials larger than 16 mm are used for recovering recyclables or sent for refuse-derived fuel production. The compost yield ranges from 12% to 22% of incoming waste. Another 20% to 30% is available as refuse-derived fuel, 2–3 % are recyclables and 20% is sent to the landfill. In plants where refuse-derived fuel is not produced, 30% to 50% of incoming waste is sent to the landfill. There are four major suppliers of compost sieving equipment in the country: a) Mayo Vessels in Aurangabad, b) the Monica Processing plants in Indore, c) Alfa Therm in Delhi and d) Hyquip Equipments in Hyderabad. In addition to these, many other local suppliers exist.

3.3 Compost Market

A market for compost in agriculture in India already exists. Commonly traded compost products include cow dung, poultry litter, anaerobic compost made in rural areas, press mud from sugar factories, vermicompost from cow dung and other locally available organic materials. There are no studies and publications on the compost market, but estimates show that the quantity of compost demand is about 270 million t per annum[5], excluding the in situ mulching. According to the integrated plant nutrient management's inter-ministerial task force report, estimated MSW generation in India is about 150,000 t per day. If 100% of MSW can be collected and processed to compost, it would result in 6 million t of compost production per year, which is about 2% of the estimated annual market demand of 270 million t per year in India. At present, the net quantity of compost processed from MSW is about 0.1% of the compost market. The majority of the remaining market for compost is either decentralized, unorganized or informal.

Excessive use of chemical fertilizer and intensive agricultural production has resulted in deterioration of the humus content in Indian soils. With a decreasing land to people ratio in the country, the pressure on food production leads to high usage of chemical fertilizer in efforts to sustain food production. In the past two decades, the marginal increase in productivity of crops has stagnated or decreased. Increasing availability of organic matter in soil has become a constraint for agricultural production. There is a shift in focus from traditional addition of nitrogen, phosphorous and potassium to integrated plant nutrient management in agriculture. Furthermore, a concurrent trend promotes organic agriculture and organic foods. The policy shift toward compost has translated into support for farmers

5 Report of the inter-ministerial task force on integrated plant nutrient management using city compost , 2006

to receive a subsidized supply of compost by some state governments and marketing of compost along with fertilizer to create stronger markets.

Two different types of markets for the MSW organic waste can be identified: a) urban markets where the compost is purchased for gardening and b) rural markets where the compost is sold to the farmers for the cultivation of food and plantation crops. The demand in the urban areas is marginal, less than 5% of the total demand, but it is, however, consistent. The compost price in the urban areas is INR10 to INR12 per kg (approximately US$160 to 200 per t). The demand for compost in rural areas occurs mostly during the pre-monsoon season (May to July) and just before the annual second crop season (October to December). The compost is sold in bags to the farmers at a price ranging from INR2,000 to INR4,000 per t (approximately US$30 to US$65 per t). The selling price at the factory gate varies from INR1,400 to INR1800 per t (approximately US$22 to US$30 per t). A new market is gradually developing for compost as feed for aquaculture. This market is currently very nascent and has limited use of compost.

The major constraint for the development of MSW compost facilities is the absence of awareness of MSW-based compost. The MSW-based compost markets have gradually developed across the state of Karnataka, the tea gardens in West Bengal, the coastal districts of Andhra Pradesh and some areas in the state of Uttar Pradesh. In other parts of the country, the market is not developed. Farmers in India are used to making payments for provision of nutrients. The cost per kg of nutrient is very high in compost compared to in chemical fertilizer. Farmers need to be aware that the soil conditioning properties and other micronutrients in compost provide long-term benefits for crop productivity. Farmers need to be provided with the economics of soil conditioning and the reasons for lowering the use of chemical fertilizer and adding compost.

3.4 Selected Composting Plants – Case Studies

Karnataka state has been a pioneer in MSW management in the country. The state has supported its urban local bodies to set up MSW processing facilities with composting as a preferred option for waste management. The state has two pioneering companies involved in composting operations, and case studies of these two companies are presented below.

Case 1: Karnataka Compost Development Corporation

Karnataka Compost Development Corporation (KCDC) is located in Bangalore and is one of the pioneering companies in the composting sector in India. The company has a successful combination of indigenous technologies for composting and an efficient marketing system for the MSW-based compost. The company was set up in 1975 as a state-owned corporation and has been operating continuously since inception. Currently, the KCDC plant operates at a production capacity of 100 to 300 t of compost per day and plans to expand its operations to about 1,000 t of compost per day.

Business Model

KCDC receives waste from the Bruhat Bangalore Mahanagara Palike (BBMP), i.e., the local municipal corporation, at its premises at no cost, which means that KCDC is not paid any tipping fees. The company converts the waste into compost using the aerobic windrow technology. The organic portion from the MSW is segregated. The rejects from segregation are sent to the landfill owned by the BBMP. The compost is sold to the farmers in Karnataka at a rate subsidized by the Government of Karnataka. The company also procures additional compost from other compost producers in the state to meet the demand. The revenue is solely from the sale of compost. Recyclables are not part of the revenue stream because the disposal costs of the rejects are incurred by the BBMP.

Economic, Social and Technological Performance

In the financial year 2012-2014 (April 2013 to March 2014), KCDC sold about 45,000 t of compost, with about 15,000 t of compost produced at its processing facility and the balance sourced from other facilities in the state. The compost is sold at a price of about INR3,000 to INR3,200 per t (approximately US$50 per t). KCDC is able to sell its product throughout the year, with the majority sales occurring between May and July, moderate sales from July to January and the fewest sales from February to April. KCDC sells its product only to farmers in various districts in the state of Karnataka. The market demand for compost is generated by the agriculture extension workers of the state government. Because the sale is done in collaboration with government departments, the subsidy available for compost sale is provided to KCDC directly, while the sales price of the product is collected from the farmers.

Operations costs incurred by KCDC originate mostly from manpower for operations, electricity and fuel, packing materials, additives for enrichment of compost, administration expenses, taxes, bank charges, contract service charges and marketing expenses. The operations costs are covered by the revenues generated from the sale of compost. KCDC has about 40 staff and about 10 management staff. The total operations costs incurred by KCDC are about INR2,700 (approximately US$44) per t of compost manufactured. As a minimum, a net margin of INR100 (approximately US$1.6) per ton of compost sold is made, and the margins are higher when KCDC trades compost sourced from other companies. KCDC receives mixed waste, which is sent directly for aerobic windrow composting. After composting, the MSW undergoes sieving to enhance compost quality. KCDC has semi-automated processing technology. The input-to-output ratio of MSW waste and compost is about 15%–20%, with the rejects sent to the landfill.

Key challenges faced by KCDC include the growth of residential areas close to the production facility. This limits the company's expansion plan, and the surrounding residences demand cleanliness in the plant's processing of waste. Moreover, as a state-owned company, management of KCDC changes regularly, causing discontinuity in vision and operational management. This also threatens the overall financial and managerial performance of the

company.

KCDC, as part of the SWM system of Bangalore city, contributes to safe disposal of the urban waste. The company has survived various challenges over the years, including adaptation to the changing composition of the municipal waste. Most importantly, KCDC has developed an indigenous technology suitable for the changing composition of MSW. The company consistently produces high-quality compost, which is in demand, and it is probably is the largest compost manufacturer and seller in India. Thus, KCDC is the ideal, replicable model from the Indian context; It offers opportunity to source composting technology for India, and it can serve as a reference point for composting operations and management.

Case 2: Terra Firma Biotechnologies Private Limited

Terra Firma Biotechnologies is a private company in Bangalore, and it is involved in recovery of nutrient resource from MSW. The company was set up in 1995 by a group of professionals with chemical engineering and agriculture expertise. The company set up a vermicomposting facility and successfully operated it from 1995 to 2007. From 1998 to 2003, the company promoted franchises for processing MSW across 38 locations in the country. In 2007, the company scaled up its operations with a new 42 ha integrated solid waste management facility .

Business Model

Terra Firma's business model is built around processing MSW, producing compost and recovering recyclables from the waste. The company owns the land and receives waste from BBMP and other major waste generators. It receives tipping fees for accepting the waste. The rejects from the composting process are put in a landfill on-site. The business is built around revenues from tipping fees, sale of compost and sale of recyclables. The expenditure on operations is primarily for maintaining the infrastructure and production of compost and processing recyclables. The company makes a conscious effort to find value in the different waste streams.

Economic, Social and Technological Performance

The company produces and sells over 15,000 t of compost per year. Terra Firma has established distribution channels to sell its compost under its brand name. It also supplies compost to other companies. The company has built a network of buyers for sale of processed plastic and other recyclables. The compost produced is marketed across the four southern states of India: Karnataka, Andhra Pradesh, Tamil Nadu and Kerala. However, the market for recyclables is within Bangalore city.

The primary cost components at Terra Firma are labor charges, fuel and energy, freight and transport, which account for more than 60% of the operations costs. The company employs 230 workers at the facility, including 10 management and 15 administration staff. The operation costs incurred are about INR3,100 (approximately US$50) per ton of compost

produced. Earned revenues are almost equally spread across different sources: revenues from compost, recyclables and tipping fees. The company has been making profits since inception, except for a few years where significant capital investments were made.

Terra Firma has gained a lot of experience through aerobic windrow composting of MSW since 1995. The company has developed its own cultures for degradation of organic waste. The degraded waste is sieved through 4 mm sieves to recover compost. Recyclables are separated through manual and mechanical processes and made into various components to maximize the value of the materials as per market demand.

Key challenges faced by Terra Firma are the following:

- Solid waste management projects become unviable if they have a high capital cost. The experience at Terra Firma is that a large portion of the capital cost should be covered through equity because it becomes difficult to manage cash flow while serving debt through interest payments. The constraint for growth is poor access to capital. Lately, the government has set up schemes to provide full capital support for facilities development. However, Terra Firma has invested completely on its own, including in purchase of land.
- The pressure from municipal bodies to accept more waste than the firm's capacity to process waste.
- A major market constraint in recent times has been the significant control exercised by the fertilizer companies on marketing of compost. From the perspective of a MSW composter, the fertilizer companies serve as source of bulk order, which mitigates the payment risks. However, the price paid by the fertilizer companies is lower than direct sale. Also the fertilizer companies have alternative sources of compost (like sugarcane press mud), and thus they exercise control on the compost companies. The acceptability of MSW-based compost was a significant constraint during the initial period of the company. However, this has changed over time and today MSW compost is purchased and used by the farmers.
- So called not-in-my-back-yard constraints have significantly increased lately. The villages around the facility protest when there is an increase in the number of trucks carrying MSW through their villages.
- With the changing nature of MSW, there is a significant quantity of waste that cannot be processed.

Notwithstanding these challenges, Terra Firma was willing and able to process excess waste from BBMP, especially the waste that were generated as result of hazards or emergencies, thereby reducing the pollution loads within the city of Bangalore. The company has also supported introduction of innovative waste transportation solutions. Apart from 230 direct employees, Terra Firma has created about 150 jobs through compost distribution supply chain. Furthermore, Terra Firma recycles large volumes of other waste fractions that are not composted, thereby reducing the overall volume of waste put in landfills.

Case 3: A2Z Infrastructure Private Limited

A2Z Infrastructure Private Limited (A2Z), established in 2011, is a subsidiary business of the A2Z Group and one on India's leading waste management companies. Its core mandate is to provide sustainable waste management solutions to municipalities across India. A2Z currently operates 21 integrated resource recovery facilities (IRRF) across India, processing a total of 8,000 t of MSW per day. One such project, which has shown significant success, is the 900 ton IRRF in Ludhiana, Punjab, which is run through a partnership agreement with the Ludhiana Municipal Corporation (LMC).

Business Model

A2Z's business operations cut across the entire MSW value chain: from collection and transportation of waste to processing and disposal. The value chain involves three key actors: a) waste suppliers (LMC and informal waste collectors), b) compost clients, i.e., fertilizer companies and farmers and c) inorganic material clients i.e., plastic manufacturers and energy-producing industry units. LMC has contracted A2Z to collect, transport, process and dispose the MSW generated in five jurisdictional zones in Ludhiana. The revenue of the processing facility originates from sale of compost, recyclables, refuse-derived fuel and a tipping fee for receiving waste. The compost produced is sold to fertilizer companies such as Indian Potash Limited, Indian Farmers Fertilizer Corporation Ltd., Krishak Bharti Cooperative Ltd and local farmers. The refuse-derived fuel is sold to the state electricity board and the plastics and metals to the private sector.

Economic, Social and Technological Performance

Compost produced by A2Z is sold mainly to chemical fertilizer companies, which either process the compost further or sell it as it is through their established distribution network. A2Z is fairly new in the compost market and is therefore dependent on fertilizer companies for market access. A2Z also undertakes product branding strategies and field demonstrations to validate the product quality and in the process gradually increases its market access and share. On the other hand, the demand for inorganic materials (i.e., refuse-derived fuel and high density plastics) is high and growing.

A2Z's operation and maintenance costs comprise wages, salaries, fuel and other consumables estimated at US$5,250 per day. Collection fees of US$7.4 per ton of collected waste is paid by LMC, which is sufficient to cover the costs of waste collection and transportation, whereas surplus revenue result from the sale of compost and other recyclables. A2Z in Ludhiana makes a net profit of US$450-550,000 per year with a 3–3.5 year payback period on its investments.

The company uses windrow composting technology for production of compost. First, the waste received at site is sieved through a 50 mm sieve. The components larger than 50 mm is used as refuse-derived fuel for power generation, and the components smaller than 50 mm

are taken for composting. The windrow is turned and also forcedly aerated. Subsequently, the material is sieved. Recyclables are recovered after composting and from components larger than 50 mm. Materials rejected after the compost screening are sent to landfills.

Composting is a promising business in India, and although the market in Ludhiana is nascent, A2Z has been particularly successful by implementing innovative business partnerships with different actors across the entire value chain. The use of a simple technology, which takes advantage of cheap labor, has been a contributing factor to their success. With increasing wages, A2Z will have to consider other alternatives for future expansion plans. Increasing governmental support, training on compost use along with growing demand for normal and enriched compost will represent key opportunities for replication and scaling up of the business.

A2Z's business activities have created 300 jobs (both skilled and unskilled) along the entire MSW value chain. The waste management activities of A2Z have reduced the risk of spreading diseases related to poor sanitation. Moreover, improved collection systems have resulted in minimal indiscriminate disposal of waste into nearby Budha Nala water bodies.

Case 4: IL&FS Environment Infrastructure & Services Ltd.

IL&FS Environment Infrastructure & Services Ltd (IEISL) is a subsidiary of a leading non-banking financial institution, namely Infrastructure Leasing and Financial Services Ltd (IL&FS). IEISL is structured to support and enhance the urban environmental infrastructure of Indian cities, especially in terms of SWM. The Okhla composting facility in Delhi is one of the projects under IEISL, and the plant is designed to process 200 t of MSW per day.

Business Model

IEISL receives MSW from the MCD (Municipal Corporation of Delhi) and process it through composting. It also undertakes segregation of waste, whereas recyclables are sold to recover the operation cost along with sales of compost. Waste that is rejected after composting and segregation is transported to the nearby landfill site. MCD provides the waste and also provided land to set up the facility. The business model is based on revenues from compost, recyclables, refuse-derived fuel and from CDM. The compost is sold to farmers through fertilizer dealers and distributors, but compost is also sold directly to urban households and institutions for utilization in their gardens. IEISL holds contracts with cement companies for supply of refuse-derived fuels as an alternative to coal.

Economic, Social and Technological Performance

The products and markets for the company are summarized below in table 3.6.

Table 3.6: Products and markets for IEISL

Products	Customer	Sale Volume (units /year)	Price (INR)/ ton	Contract
Harit lehar Compost	Farmers of Haryana, Uttar Pradesh, Punjab	6,000 t/ year	1,500	The company has marketing contracts with fertilizer companies like Coromandel, FACT, etc.
Eco smart home garden	Urban users and institutions	500 t/ year	10,000	The company is involved in direct sales.
RDF	Cement industries		1,200	The company has a contract for sale.

As per the data for the financial year 2011-12, the business had not yet achieved breakeven because earnings before income tax were still negative. The company is currently in its fifth year of operations, and based on its current business operations the company is expected to achieve breakeven in six to seven years. Its annual expenditure is INR37.1 million (approximately US$0.6 million) and revenues are INR23 million (approximately US$0.37 million). The manufacturing, marketing and admin overhead costs per ton of compost is pegged at INR4,600 (approximately US$75) per ton of compost.

The company uses mechanized aerobic composting. The waste carried by the trucks is weighed and undergoes pre-sorting to separate large inorganic materials. During this period, the waste is sorted into windrows, and heaps are turned periodically and shifted once a week using loaders for aeration and temperature control. The composting takes place on a concrete platform. A bio culture is sprinkled on the waste heaps to support faster growth of microorganisms for the composting process. The leachate from MSW is pumped to a separate treatment tank, and the treated water is reused in the composting process. After four to five weeks, the composting heap is shifted to a monsoon shed for further stabilization. At compost maturity, processed waste is sent through sieves. IEISL has a two-stage screening system to achieve maximum screening efficiency, using one vibrating screen of 35 mm and one trommel of 14 mm size. Cascading action inside the trommel ensures better screening of the waste. Screened, composted material is uniform in texture and contains pure compost, while the larger organic components are recycled back to the windrows for further degradation. The organic manure is then refined and packed in bags.

The major challenge for the company is the unavailability of qualified and dedicated manpower to operate the facility. The seasonality of the product market, despite the

production being regular, requires stocking and affects company's working capital. Creating a market for compost is a long-term process, and developing partnerships with existing channels is critical. In addition, MSW-based compost has many substitutes, such as press mud, which are available at lower costs, and thus compost sales requires extra marketing and branding efforts. The company processes about 200 t of MSW per day, reducing the burden of waste management for the city and producing compost to improve soil fertility. IEISL conducted agro production tests with the compost products, and the results show about 25–30% increase in yield.

3.5 Conclusion

Municipal solid waste composting in India has a long history. The Indore method of composting (a traditional procedure systematized into a method of composting) was practiced extensively prior to 1970. In the mid-1970s, about 12 municipal waste composting plants with mechanical composting were established in India, but only KCDC has survived. KCDC has survived because it has constantly improved its operation, from both technology and management perspectives. Another wave of about 60 composting plants were set up in the 1990s and early 2000s. Out of these 60, only 6 have survived and continue their operations. In the past decade, starting in 2005, about 270 compost plants have been operating and additional facilities are under construction. Key lessons learned from the collapse of composting plants from 1990 to 2000 are

- Most of the compost plants were operated by the public sector, which struggled to run the operations in a business-like manner
- Poor marketing of compost, little awareness and lack of marketing strategies by the compost companies contributed to their failures
- A shift from considering composting plants as a strategy for waste management to integrated SWM resulted in developing industry benchmarks, e.g., that MSW-based composting companies have a maximum of 20% rejects sent to landfill.

The changes and development in the past decade has resulted in a large number of MSW-based compost plants across the country. Increased awareness and policy support for improved nutrient management has resulted in an increasing growth trend for the compost market. Simultaneously, composting companies are struggling to market compost and therefore alternatives, such as waste-to-energy options, become increasingly interesting. However, waste-to-energy projects still remain elusive, and composting continues to be the primary solution for MSW management among policy makers and urban local bodied.

In spite of the experience in MSW composting, the industry is still in a nascent stage and operates at less than 10% of its potential. Overall, the MSW processing industry in India is slowly developing, and MSW enhancement started only after the MSW Rules 2000 were ratified. It has taken about a decade to rectify and streamline collection and transport systems and to develop waste processing facilities and disposal sites across the country. The

thrust is now toward establishing cleaner and sustainable processing facilities. The new government has made cleanliness and sanitation a main focus. It is expected that in the next decade waste processing will become a major activity and the MSW composting sector will significantly benefit and achieve the necessary growth. Significant opportunities are embedded in the supreme court of India, the MSW Rules 2000 and other government regulations, which will make it mandatory for the urban local bodies in India to systematically collect, transport, process and dispose of MSW generated in urban centers and produce compost from MSW.

Building a compost industry in India may require a redefinition of the role of composting, from being considered a waste management solution to a social business venture. The strategy has to shift to making the industry viable through e.g., market development, supporting composting firms with capital investment and tipping fees. Compost firms require technical support to constantly improve the composting process, rather than relying on waste segregation, which is essential as well. Research support for composting and preparation of compost-based niche products for specific crops and markets is critical. The compost firms need to also gradually move toward granulation of compost for long-term storage. The development of the MSW compost industry has to be a joint effort by private entrepreneurs, the municipal agencies, the state governments and the research sector. The industry has a role to play in both waste management and in provision of organic matter for soil improvement and increased crop productivity for India.

4. DESCRIPTION AND ANALYSIS OF COMPOSTING IN BANGLADESH

4.1 Overview and Regulatory Setting

Bangladesh (lat 24°00′0″ N, long 90°00′0″ E) borders the Bay of Bengal between Burma and India. Bangladesh has a subtropical monsoon climate with three distinct seasons. Related key details can be found in table 4.1. Agriculture plays a crucial role in the economy because it employs most of the country's workforce. Rice, jute and tea are primary crops cultivated in Bangladesh, and gradually maize and vegetables are assuming greater importance. Bangladesh has highly fertile land and ample water supply, which makes it possible to harvest rice harvest up to three times a year. Other than agriculture, textile and manufacturing form the backbone of Bangladesh's economy.

Table 4.1: Bangladesh – country profile

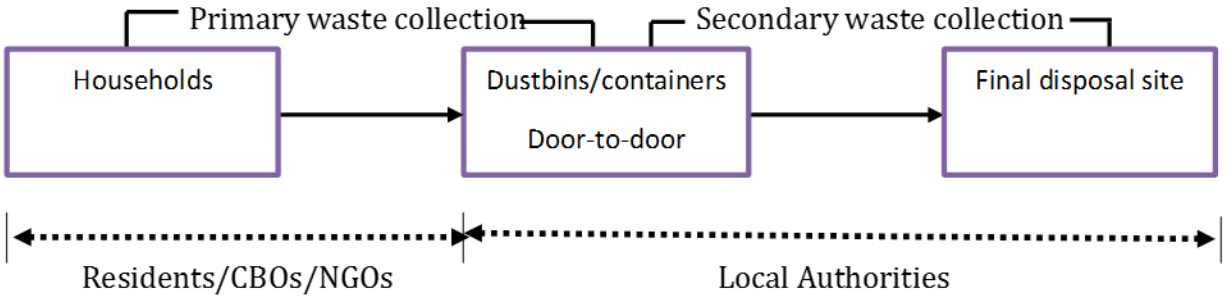
Area	**143,998 km²**
Population	166 million (2014 est.)
Population Density	1,203 km²
Gross Domestic Product (GDP) official exchange rate	US$140.2 billion (2013 est.)
GDP by agriculture	17.2%
Irrigated land	50,500 km²
Agricultural land per 1,000 population	1.5 km² (2007)

4.1.1 Overview of Solid Waste Management in Bangladesh

Solid waste is one of the most visible and pressing urban environmental problems in Bangladesh. Urbanization, demographic growth and economic development all contribute to the generation of waste, which the local authorities struggle to address given their limited resources in terms of manpower, equipment and budgets. Waste is collected from community bins and from directly from households. Community bins are located on the streets for direct use by residents and commercial or institutional waste generators. In some areas, communities have in collaboration with the local authorities introduced door-to-door waste collection systems. The local authorities use trucks to collect waste from the secondary storage point and transport it to the disposal site. During the secondary collection stage, the

recyclable materials are collected by waste pickers and sold to interested buyers. The SWM system is depicted in Fig 4.1.

Figure 4.1: Solid waste management system by local authorities



In door-to-door waste collection systems, the residents benefitting from the system pay a monthly service charge to the CBOs or NGOs that are engaged in primary waste collection. Waste is disposed of on lowlands belonging to the local authorities or sometimes on privately owned lands, without attention to health hazards and environmental safety. Tipping fees for the operation and maintenance of disposal sites are not collected in Bangladesh.

Private agencies have been active in the SWM sector in Bangladesh, especially in door-to-door waste collection and recycling. In some parts of Dhaka city and in Mymensingh town, solid waste collection and transportation service has been contracted out to private contractors. The recycling sector is mainly informal and encompasses waste pickers, itinerant buyers, small traders and recycling factories.

Waste is generated from domestic, commercial, institutional and industrial sectors. These are collected and deposited as mixed waste. In the metropolitan areas, waste generation rate range from 0.47 to 0.5 kg per cap per day and in the small municipalities waste generation rate is from 0.25 to 0.30 kg per cap per day. In Dhaka, Chittagong and Khulna city, waste is collected by mountable container carriers. In Dhaka City, sophisticated compactors have been introduced, with the support of Government of Japan, as part of the implementation of the Clean Dhaka Master Plan. Two engineered landfill sites with leachate collection, treatment facility and gas venting system are operational in Dhaka.

In Bangladesh, like in most developing countries, a greater part (75–85%) of MSW comes from households, while 15–20% comes from the commercial areas. These two entities are the major sources of organic solid waste. Organic fraction is estimated to represent 70-85% of the total MSW generated. Despite its potential reuse value, the recycling of organic waste by composting has been limited; currently only 2% of the total waste generated is being

composted (BMDF 2012).

Although source segregation is hardly practiced in the country, newspaper and used materials such as cans, bottles, etc. are kept separated at the households for direct sales to itinerant buyers. During waste collection, recyclable materials are further segregated by waste pickers.

Recovery and recycling is practiced informally without the control of any statutory body (Yousuf et al. 2010). Recovery occurs in three ways: (a) waste generators separate waste such as newspaper, bottles and plastic containers that still have relatively high market value and sell them directly to street hawkers; (b) scavengers search through waste near the bins for recyclable materials of low market value such as broken glass, cans and polythene; (c) waste pickers collect recyclable materials immediately after waste has been discharged at the dump sites.

4.1.2 Regulations on Solid Waste Management and Composting

In Bangladesh, each municipal authority is expected to manage MSW. The policy and regulatory documents on SWM express the need for waste reduction and recycling, with particular reference to composting and the use of compost in addition to fertilizer for the replenishment of soil fertility. The National Environmental Policy 1992, National Policy for Water Supply and Sanitation 1998 and National Agriculture Policy 1999 are some of the guiding documents that support composting and compost use in agriculture. Moreover, the National CDM strategy 2005 and National 3R Strategy 2010 also promote composting in order to reduce greenhouse gas emissions. The Fertilizer Act 2006 and Fertilizer Management Rules 2007 do favor compost and organic agricultural production. The Bangladesh Climate Change Strategy and Action Plan 2009 and the Poverty Reduction Strategy Paper emphasize a waste management strategy that focuses on organic waste recycling.

The National Policy for Safe Water Supply and Sanitation 1998 states that measures should be taken for recycling of waste as much as possible, and organic waste should be used for compost and biogas generation. The policy document encourages planning for engineered landfills with proper lining and leachate treatment. It places the responsibility of solid waste collection, disposal and management on city corporations and municipalities. In addition, it encourages private sector participation by allowing city corporations and municipalities to transfer, where feasible, the responsibility of SWM to the private sector.

The Urban Management Policy Statement 1998 recommends private sector participation in SWM and recycling activities. In seven wards (lower administrative units) in Dhaka city, street sweeping and waste transport has been privatized, and primary waste collection is in most places carried out by community-based organizations (CBOs) and NGOs.

The National Urban Sector Policy 2006 emphasizes that public utilities should increasingly recover costs from their customers, so that they may extend their coverage and reduce the burden on municipal budgets. It also states that the government should support recycling by imposing user fees for waste disposal, encouraging composting and formalizing the function of scavengers. It proposes the adoption of a PPP model for providing urban environmental services and recommends inclusion of NGOs, CBOs and the informal sector along with formal sector.

The Bangladesh Environmental Conservation Act 1995 is the parent act for environmental issues, including SWM. This act identifies the need for controlling the discharge, disposal and dumping of solid and other types of waste that can cause environmental pollution. It lays the basis for a 'polluters pay' principle for waste treatment. In addition, it states that the government may formulate and publish environmental guidelines to control and mitigate environmental pollution and conserve and improve the environment. It also allows the government to make necessary rules for carrying out the purposes of this act, including for SWM.

The Bangladesh Environmental Conservation Rules 1997 specify the disposal standards that guide landfill operations and composting practice. The National Environmental Policy 1992 restricts the use of chemical fertilizers and pesticides that pollute water bodies and destroy the ecosystem, *encouraging the use of organic fertilizers and promoting organic farming*. It also discourages the daytime collection of waste from waste bins, transportation by open trucks and storage in open places. In the National Environmental Management Action Plan 1995, waste reduction and recycling of waste is promoted, and pilot projects on community-based composting were undertaken in Dhaka and Khulna city as part of the Sustainable Environmental Management Programme (SEMP). In the Environmental Management Plan 2005, waste reduction and recycling is given priority.

Following the provisions of the Environmental Conservation Act 1995, the Government of Bangladesh prepared the Draft National Solid Waste Management Handling Rules 2010. This document has yet to be ratified. The rules include an extensive list of definitions covering all aspects of SWM. It clearly defines the objectives of SWM, including

- ensuring the protection of public health and environment
- promoting of environmentally friendly and cost-effective SWM
- encouraging recycling, resource conservation and recovery
- encouraging private sector participation and citizens' participation in SWM

The rules clearly define the responsibilities of residents, municipal authorities and the Department of Environment. The document encourages reduction of waste at the source and also envisages segregation of biodegradable, non-biodegradable and hazardous waste at the source to assist in recycling. It makes specific recommendations on every aspect of SWM,

including segregation of waste, collection, storage, transfer stations, transportation, processing and disposal at landfills. It prohibits the use of open dumps for solid waste and provides specifications for landfills. It also gives standards for waste processing, leachate quality and compost (see table 4.2). In addition, it includes formats for application for and approval of waste processing or disposal facility operation, monitoring and review, and accident reporting.

A National 3R (Reduce, Reuse and Recycle) Strategy for Waste Management was formulated in 2010. It sets goals for higher levels of waste reduction, reuse and recycling, and minimizing waste disposal in open dumps, rivers, flood plains and landfills by 2015. It recognizes waste as a resource and advocates for segregation of waste at the source. The strategy encourages use of emission-reducing technology and tapping of the potential of CDM provisions. It promotes the 'polluters pay' principle. It supports the participation of the informal sector operators, who are engaged in the recycling of various materials. To promote 3R principles, the strategy recommends raising public awareness, employing appropriate technology, setting up a 3R secretariat at Department of Environment, involving all stakeholder groups, PPPs, CDM funding and segregation and special treatment of hazardous waste. It also defines the roles of government agencies, citizens, private sector, NGOs and the media.

Bangladesh's agriculture policy promotes compost. As mentioned in the National Agriculture Policy 1999 and the Fertilizer Act, 2006, awareness programs and agriculture extension workers have promoted compost and organic fertilizer among farmers to improve soil productivity and food security. In the policy documents, farmers are encouraged to use compost from any sources, including local organic materials such as cow dung. Based on the directives in the Fertilizer Act 2006, the Ministry of Agriculture has formulated the compost standard. It provides standards for compost as set by the government in 2008 by the provision of the act (see table 4.2). A circular by the Ministry of Agriculture was issued on April 23, 2008, to promote use of compost among farmers. The Fertilizer Management Rules 2007 emphasize fertilizer quality management and standardization, including the integrated nutrient management of both organic and inorganic matters in soils.

The National CDM strategy 2005 promotes pro-poor CDM projects in the waste sector. It encourages waste reduction and recycling projects with emphasis on composting, which have potential for earning carbon credit in developing countries such as Bangladesh. In the Bangladesh Climate Change Strategy and Action Plan 2009, management of urban waste has been classified under the thematic area of Mitigation and Low Carbon Development because a major portion of urban waste is composed of organic materials, which produce methane. Methane emission from urban waste may be controlled by organic waste recycling or capturing of methane.

In the Poverty Reduction Strategy Paper and the Sixth Five Year Plan (FY2011-2015) for effective waste management, segregation of waste at the source along with the promotion of

3R (Reduce, Reuse & Recycle) is targeted, with emphasis on the increased use of compost and farm yard manure for increasing soil fertility and agriculture productivity.

The Private Sector Infrastructure Guideline 2004 of the Government of Bangladesh recommends private sector investment in the waste management sector, which includes all types of waste. It also identifies the waste sector as one of the priority sectors for private investment. The Private Sector Housing Development Guideline 2005 recommends allocating land for waste management, including waste recycling for composting and biogas generation, in new housing areas.

Table 4.2: Compost standard of Bangladesh

Physical Properties		
Sl. No.	Parameters	Standard Condition
1	Color Dark	Gray to black
2	Physical condition	Non-granular form
3	Odor	Absence of foul odor
4	Moisture Content	Maximum 15%
5	Inert materials	Maximum 1%
Chemical Properties		
Sl. No.	Parameters	Standard Range
1	pH	6.0–8.5
2	Organic carbon	10– 5%
3	Nitrogen (N)	0.5–4.0%
4	C:N	Maximum 20:1
5	Phosphorus (P)	0.5–1.5%
6	Potassium (K)	1.0–3.0%
7	Sulfur (S)	0.1–0.5%
8	Zinc (Zn)	Maximum 0.1%
9	Copper (Cu)	Maximum 0.05%
10	Chromium (Cr)	Maximum 50 ppm
11	Cadmium (Cd)	Maximum 5 ppm
12	Lead (Pb)	Maximum 30 ppm
13	Nickel (Ni)	Maximum 30 ppm

(Source: GoB 2008)

Regulations are gradually influencing composting sector, and it is increasingly seen as necessary for an integrated waste management program. Implementation and monitoring of regulations are currently weak: getting the initial license and registration certificate is not easy and requires significant effort and time.

The policies referenced above have undoubtedly paved the way for improving SWM services, but implementation of the policies requires further clarity and detailed guidelines for municipal authorities on how to improve SWM services. The city corporations and the municipalities are mandated to provide SWM services to the people by the Local Government (City Corporations) Act 2009 and Local Government (Pourashavas) Act 2009. In both acts, no guidelines are provided for the design and operationalization of waste management facilities. The Draft National Solid Waste Management Handling Rules 2010 has been pending ratification for a long time and needs to be expedited. The rules highlight technical assistance and support from the government, including support to the municipal authorities in terms of finances, training and capacity building. For municipal authorities to implement the rules, step-by-step guidelines need to be prepared and circulated and capacity building needs to be provided to ensure skilled technical labor.

4.1.3 Opportunities and Challenges of the Composting Sector in Bangladesh

Opportunities

The opportunities for the composting sector are as follows:

- The Ministry of Agriculture has developed and released a compost standard in 2008. To ensure compost quality and facilitate marketing of compost to the agriculture sector, the government enacted a regulation in 2008, which allows only certified and registered compost that has been approved by the government to be marketed commercially. Government certification of compost helps ensure higher quality of compost.
- The government approved the National 3R (Reduce, Reuse and Recycling) Strategy in 2010, which made source segregation mandatory and gave directives to municipalities to pursue organic waste recycling projects, including composting.
- To maintain a sustainable agriculture in Bangladesh, integrated nutrient management or balanced fertilization has been promoted. These strategies seek to both increase agricultural production and safeguard the environment. They incorporate both organic and inorganic plant nutrients to attain higher crop productivity and to regenerate soil fertility. They provide technical (through awareness and training programs) and financial support in the form of credit to farmers to practice balanced fertilization.
- Co-marketing of compost with chemical fertilizers also represents an opportunity. Fertilizer distributors sell both compost and chemical fertilizer from the same outlet to ensure balanced fertilization. Certain compost companies, such as Faruk Fertilizer Ltd. and Northern Agro Service Private Ltd., produce nutrient enriched organic fertilizer from poultry litter and cow dung. However, no special incentive for producing blended fertilizer exists. The government actively promotes compost and encourages integrated plant nutrient systems, and such systems developed for Bangladesh specifies use of chemical fertilizer along with compost.
- To promote organic waste recycling, the Government of Bangladesh, through the

Ministry of Finance, has allowed all waste treatment and recycling plants, including composting facilities, a tax holiday of five to ten years. Compost products are exempted from value-added tax (VAT) and sales tax. In addition, import duties on environment friendly technologies have been reduced.

- The Department of Environment has started issuing environmental clearance certificates for composting plants. Plants that fall under the 'red category' need to carry out environmental impact assessments, social impact assessments and environmental management plans to qualify for an environmental clearance certificate.
- The Ministry of Information is promoting source segregation of waste and raising awareness on the positive impact of compost application to crops via electronic and print media.
- The Department of Environment is promoting source segregation by implementing a 3R pilot project in Dhaka and Chittagong, where three types of bins are distributed to households. These cities plan to set up composting plants in the near future.
- The Department of Environment has taken up composting projects for 64 districts through a programmatic CDM under the United Nations Framework Convention on Climate Change, and three municipalities have already established composting facilities. The project is financed by the Climate Change Trust Fund of the Government of Bangladesh.
- The Ministry of Agriculture has, with the support of some NGOs such as the Bangladesh Rural Advancement Committee (BRAC) and Proshikha, promoted organic farming since 2008.

Challenges

Composting in Bangladesh is confronted with several obstacles that threaten the development of the sector. Key challenges are highlighted below:

- Poor source segregation and waste collection is a primary constraint to the sector. Communities have little awareness of the importance of source segregation and of recycling organic waste.
- An apparent lack of awareness is combined with numerous reservations regarding compost. Compost often has a negative connotation due to the types of input materials used, such as MSW.
- End users lack of knowledge on compost benefits and application. The nutrient value of compost is often compared with that of subsidized chemical fertilizers. In addition, compost has to compete with low-cost, traditional products like manure.
- The long distances between production (composting plant) and application (fields and gardens) prevent the sale of compost.
- Inappropriate regulations and policies (e.g., subsidies of chemical fertilizers) hamper the compost market. Chemical fertilizers are sold at subsidized prices, which distorts the market for compost.

- Municipalities do not prioritize and do not have the financial means to invest in composting. Moreover, municipalities have little capacity to operate and maintain composting facilities or to market compost.
- Unavailability of government land for organic waste recycling as well as local resistance (the so called not-in-my-back-yard phenomenon) to set up composting facilities in city areas.
- Weak regulatory enforcement systems with poor monitoring capabilities fail to ensure proper waste management systems and standards.
- Compost quality standards, complemented by registration and certification, build confidence in and demand for compost among farmers. However, the certification process is complex and time consuming, and it discourages the compost producers. The process usually has two stages: a laboratory analysis and a field trial of compost on crops for two agriculture seasons. It takes one to two years to obtain the permit to market the compost. The current licensing procedure involves the following steps:
    - The compost company needs to apply and report (on each step of the application procedure) to the fertilizer sub-committee. The committee meets approximately every three to five months.
    - Certification involves field testing and completion of laboratory tests (Bangladesh requires three such tests, other countries in Asia typically require just one). In other Asian countries, which use field trials, temporary licenses are issued to allow production and sales after the successful completion of laboratory tests. Bangladesh has no temporary licensing mechanism. A technical sub-committee, through one of the Bangladesh research organizations, undertakes this evaluation including field tests for a minimum of one season in two locations.
    - After satisfactory completion of field trials, licenses are issued, and they are valid for five years. However, no procedure for the renewal of the license has been defined.
- According to a thought piece by Katalyst in 2009, one of the largest market development projects in Bangladesh supported by Swiss Contact, obtaining a full or temporary compost product license in Bangladesh takes well over 600 days. Some of the compost companies took more than three years or sometimes longer to get the certificate. If a compost company makes multiple compost products, it needs to get separate certification for each product. These regulations are applicable for companies that sell branded packaged compost, while no monitoring or restriction for unpackaged compost exists. Until 2008, about three to five compost companies had certification, and currently, as per Bangladesh Fertilizer Association and Bangladesh Organic Products Manufacturer Association, 32 compost companies have government certification and about 200 companies are in the queue.

4.2 Composting Sector in Bangladesh

Around 4.86 million t of solid waste is generated in urban areas of Bangladesh each year. A

very insignificant amount of waste is treated, and the remaining waste is dumped or put in landfills, emitting GHG of 17 million metric t CO_2-equivalent as of 2005. It is projected that the GHG emissions will increase to 20 million metric t CO_2-equivalent by 2020 (CCAP 2013). The motivation behind composting of urban waste in Bangladesh is to reduce and recycle waste. Most of the composting projects are small scale (one to five t capacity per day), and they are designed to demonstrate composting as an option for SWM. However, the sustainability and scalability of the composting plants are not satisfactory. This is because composting activities are initiated and run by a variety of organizations, and most of them do not have skills either on process and technologies or on business and marketing (Ali 2004). Composting is seldom put high on the agenda of local authorities. Most of the failures in composting projects arise from a lack of attention in the planning stage and failures to understand the demand and marketing aspects (Ali 2004). In spite of visible market potential and economic prospect, composting of solid waste has not become a popular method in Bangladesh. Some NGOs and private sector actors have started small-scale, decentralized composting projects, and one private, large-scale, CDM supported composting project exists. The waste composition, climatic conditions and labor force are favorable for composting according to Yousuf (2005).

Apart from compost, Bangladesh has high potential to convert waste into value-added resources such as biogas and refuse-derived fuel. It is estimated by the Asian Development Bank (ADB) (ADB 2011) that MSW generated in Bangladesh can produce 0.95 million t of compost worth US$80.75 million, 190 million m^3 of biogas, and 380 million kWh of electricity worth US$79.8 million, as well as 0.15 million t of refuse-derived fuel of an estimated value of US$7.5 million. Additional carbon credits could generate US$24.83 million from reduced GHG emissions. The total potential market value of products from recycling of organic waste is estimated at around US$192.88 million. Furthermore, apart from this income earning potential, improving organic waste management, by diverting waste from landfills, would save around 2.85 million m^3 of landfill space and associated landfill operational costs.

4.2.1 Present Status of Compost Production

Solid waste composting is relatively new in Bangladesh. Both the public (municipalities) and the private sectors are involved in compost production, promotion and sale. Waste Concern, a local NGO, first started community-based composting project in Dhaka in 2001. It then replicated the model through PRISM Bangladesh in Khulna City. Through the United Nations Children's Fund (UNICEF), composting plants were constructed in 14 municipalities. The composting plants were located either in the community or in the dump site of the municipalities. The capacities of the composting plants ranged from one to five ton. Most of the composting plants in Bangladesh were found to be operating below the design capacity (Yousuf 2005). The only large size composting plant (130 t per day capacity) is operated by World Wide Recycling (WWR) and Waste Concern in Dhaka. However, at present most of the plants have become redundant or have scaled down operations because of a lack of compost marketing initiatives. The total compost production from the composting plants is very

insignificant; only 2% of the total generated MSW is composted.

Composting of MSW is limited to the municipalities and a few authorized commercial producers, such as Annapurna Agro Service, Waste Concern, Grameen Shakti and Rural Development Academy. Some development facilitators (e.g., Katalyst, Innovision Consulting Pvt. Ltd., etc.), enterprises (Rash Agro Enterprise) and research and extension institutions (Bangladesh Agriculture University, Bangladesh Agriculture Research Institute) are giving farmers access to the most appropriate and cost-effective composting technologies, such as pit composting and vermicomposting. Farmers sometimes produce their own compost from green manure and farm yard manure. Nursery farms use cow dung or poultry litter to make their own compost. The other organic sources used by the nurseries are bone meal, burned clay, oil cake, tea leaves, ash and blood meal. Organic matter deficiency in soils indicates a potential demand and market for compost. However, the production of compost and the market are not really linked. The potential users of MSW-derived compost lack knowledge and awareness, and some users have the perception that compost contains pollutants and impurities. Furthermore, the compost market is not organized, but it is regulated as a chemical fertilizer market.

A few anaerobic digestion plants process solid waste into biogas in Faridpur and Gaibanda municipalities in Bangladesh. Biogas is utilized for cooking and lighting purposes, and the bioslurry from the anaerobic digester is processed and used as compost in vegetable gardens. Bangladesh is also well known for producing biogas from cow dung and poultry liter. The government is providing funding support to promote biogas plants through the Infrastructure Development Company Ltd (IDCOL). Biogas plants not only provide gas for cooking, but they also produce compost for crops. IDCOL has financed construction of more than 33,000 biogas plants all over the country, which are operated and managed by farmers through its 24 partner organizations. Through this initiative, IDCOL produces 200,000 t of organic fertilizer, thereby reducing the use of 28,000 t of chemical fertilizer worth US$20 million. Moreover, it saves 80 thousand t of firewood annually, estimated to be worth US$2 million (IDCOL 2014).

Farmers in Bangladesh mostly rely on chemical fertilizers for intensive crop production, which tends to further deteriorate soil conditions. It is estimated that 83% of cultivated land in Bangladesh has less than 2% organic matter content. Balanced application of compost and inorganic fertilizers can improve soil fertility. Rashid (2011) found that the use of compost resulted in a 30% reduction in the use of chemical fertilizer and a 35% reduction in irrigation required in Bangladesh.

4.3 Compost Demand and Marketing in Bangladesh

Compost demand and marketing are essentially part of any successful composting program. Most of the composting projects are successful in producing compost, but they fail to sustain their activities due to a lack of demand and poor marketing strategies for the product (Ali

2004; Zurbrugg 2003). While most compost plants found it difficult to market their compost, WWR and Waste Concern have been successful by using the distribution network of Advanced Chemical Industries (ACI). Compost produced by these companies is sold solely through ACI.

Factors Influencing Compost Demand and Marketing

Perception: There is a general lack of awareness, knowledge and experience as well as a lack of confidence in the effectiveness and benefits of compost use. These challenges create initial barriers that hinder compost use. However, promotional programs, such as farmer meetings and field demonstrations, support the use of compost and organic agriculture. In particular, Innovision, a private company, has been promoting compost using communication technology and mass media (see box 4).

Box 4: Promotion of compost by Innovision

Innovision has been promoting compost among farmers by highlighting its benefits, including improved crop yield and soil amelioration. Through its mobile van screening, it is conducting docudrama in partnership with Annapurna Agro Service. With around 240 screenings in 7 months, they have reached out to more than 16,000 farmers on the benefits of using compost. This audio-visual tool has effectively changed farmers' mind-set toward reduced dependency on chemical fertilizers and increased interest in applying more compost (Rashid 2011).

Agriculture practices: Farmers in Bangladesh mostly use chemical fertilizers due to a government program on the green revolution. This program aims to increase food production and foster self-sufficiency through the use of high yielding variety (HYV) seeds, chemical fertilizers, pesticides, mechanical plowing and large-scale irrigation. Because of the 'HYV' boom in production, the government conducted a massive campaign that promoted the use of chemical fertilizer. The government provided tax incentives to import chemical fertilizers and to build fertilizer factories as well as loan and credit facilities to farmers. Organic agriculture is gradually growing and beginning to gain acceptance by the farmers. With rising awareness and consciousness on environmental, ethical and welfare issues, consumers are now gradually beginning to demand organic products.

NGOs are the pioneers in the campaign for organic agriculture in Bangladesh. Forum for Regenerative Agriculture Movement has enlisted 138 organizations: 47 are engaged in organic agriculture, 87 are intending to practice sustainable agriculture and 3 are involved in advocacy, lobbying and campaign for sustainable development (Uddin et al. 2010). Among these NGOs, PROSHIKA, with its Ecological Agriculture Program (EAP), is the largest organic agriculture body in the country. Since 1978, PROSHIKA began to spread ecological practices among its group members by growing varieties of seasonal vegetables. PROSHIKA's EAP has involved about 800,000 farmers in organic agriculture across 220,000 acres of land

(PROSHIKA 2004). Another NGO, UBINIG, an organic agriculture movement, has involved and organized 20,000 farmers in substituting chemical fertilizers with compost. BRAC, a large NGO, is promoting organic agriculture and gradually presenting its organic food and vegetables in supermarkets.

Moreover, private companies have begun investing in organic farming. Kazi and Kazi Ltd. has established an organic tea garden at Tetulia in Panchagarh district. This tea is certified by the SGS[6] organic production standard in accordance with the EU Regulation 2092/91, and it is marketed as Meena Tea. This company also produces fresh organic vegetables and herbs for sale in their supermarket, Meena Bazar, in Dhaka city. Recently, other private companies and chain shops (such as Agora and Nandan) have started selling organic vegetables. The compost produced here is primarily from cow dung.

Landownership patterns: Many farmers in Bangladesh are either landless or own less than 1 ha of land. Farmers are either sharecroppers or work as laborers for large landowners. According to the tenancy arrangement, sharecroppers cultivate the lands of other people and get only half of the produce, the other half being enjoyed by the landowners, although they do not share the cost of irrigation and fertilizer. Another prevailing tenancy arrangement is to take land on a lease for cultivation at a fixed rent. In this land tenure arrangement, the renters and sharecroppers do not have any incentive to think of the long-term sustainability of the land productivity. They are more inclined to use chemical fertilizer for higher yields and quick return on their investment and thus hardly give any importance to soil health.

Competition: MSW compost has to compete with subsidized chemical fertilizers and locally available organic manures in terms of both price and availability to develop its market. Chemical fertilizers have advantages, including ease of transport and application on crops, while nutrients in compost are released slowly throughout the growing seasons. Compost has to compete with other locally available organic materials such as poultry litter and cow dung, which are readily available and cheaper. Most farmers have their own livestock, which allows them to make compost by themselves. Poultry firms are expanding in Bangladesh, and poultry litter is in high demand among farmers due to its low cost and availability. At the local market, farmers buy cow dung or poultry manure at BDT0.50 per kg (approximately US$6.50 per t) and chemical fertilizer, especially urea, at BDT6.59 per kg (approximately US$86 per t). However, compost is being sold at BDT7 to BDT8 per kg (approximately US$90 to US$104 per t). The compost blended with chemical fertilizers is being sold at BDT15 per kg (approximately US$195 per t). The product is primarily bought by nurseries and vegetable growers. Nevertheless, opportunity for the use of compost in exclusively organic

[6] SGS is an inspection, verification, testing and certification company. More information can be found here: http://www.sgsgroup.com.bd/en/Our-Company/About-SGS/SGS-in-Brief.aspx

farming exists because up to 22,260 hectares of land have already been brought under organic agriculture in Bangladesh.

Distribution supply chain: Location of a compost facility and its market is important when considering the availability of raw materials and transport issues. Compost facilities are most commonly located in urban centers, but the urban market for compost is limited or undeveloped. Large users of compost are often in rural agricultural settings. A reliable and effective distribution network, involving the wholesalers, dealers and retailers, is important for a reliable supply of the compost to the end users. Marketing is most reliable when existing distribution channels of chemical fertilizer companies are utilized. Most of the compost product sold nationally is sold through these channels. Fertilizer or pesticide dealers traditionally have distribution networks. They have good perceptions of the needs of the various user groups they serve and are able to sell compost. In addition, farmers prefer to deal with specialized fertilizer companies to get the product on credit from local retail branches instead of having to pay cash on delivery. Farmers pay back after harvesting their crops.

4.4 Selected Composting Plants – Case Studies

Composting has been tried in Bangladesh by municipalities, communities, NGOs and the private sector. Most of the composting plants in Bangladesh are good demonstration models but have not been able to sustain or scale up operation after a few months. This is due to most operators not having the skills, neither on processing technologies nor on business and marketing. As a consequences of the lack of large, individual compost plants in Bangladesh, the sections below primarily highlight different compost business models in Bangladesh, most of which are operating at small scale. The typology of prevailing composting plants in Bangladesh is described below:

Case 1: Municipality-Owned and Municipality-Operated Plants

In this case, compost plants are constructed by the municipality, either through their own finance or through use of an external grant. The municipality is involved in the operation of the plant and marketing of the product. Chittagong City Corporation (CCC) has a compost plant with a 10 t per day capacity; however, the production is 1 ton per day. The plant is located at the Halishahar landfill site and was built in 2000. As a pilot project with financial support from UNICEF, the plant was planned to have a 2 t per day capacity, but the CCC used their own funding to increase the capacity to 10 t per day. The composting technology used is aerobic composting with passive aeration. CCC has purchased blowers and is planning to shift into forced aeration. CCC sells the compost directly to farmers at the factory gate. CCC cannot sell it directly in the open market or through dealers since they do not have any license for the compost product from Ministry of Agriculture (MOA). The selling price of compost is BDT15 per kg (approximately US$0.19). CCC's annual income from compost is BDT4–4.5 million per year. Expenditure incurred by CCC for compost production is BDT4.1 million per year. Sale of compost is the sole revenue component in the business model.

Another example of this business model is Rajshahi City Corporation (RCC), which has constructed a composting plant with a capacity of 2 t per day under the same UNICEF-funded project. However, the plant is not operational because RCC could not get a license for marketing compost.

Case 2: Municipality-Owned and NGO-Operated Plants

In this model, composting plants are constructed on municipality land, and an NGO manages the operations, including door-to-door waste collection services. Service charges for waste collection and sale of compost are the primary revenue sources under this business model. This business model is heavily funded by donors. Examples include the Faridpur composting plant and the Gaibanda composting plant by Practical Action as well as the Mymensingh composting plant by UNICEF, which was later revived by Practical Action with the support of GIZ. These composting plants have been constructed to have a compost production capacity of 1.5 ton per month for Faridupr and Gaibanda while Mymensingh has a capacity of 3 ton per month; however, they are not running at full capacity. Almost, all the compost produced is sold to local farmers, nursery owners and homestead gardeners. The compost is packaged in 1–2 kg bags and 40 kg bags with a sale price of BDT8–25 per kg (approximately US$104–325 per t). In most cases, compost is delivered to the customer by the plant operator. The plant's capital cost is covered by development project funds, and the operation and maintenance is covered by the service charge for waste collection and sale of compost. The success of the plant is the cost recovery and the marketing approval for compost sale.

Case 3: Municipality-Owned and Community-Operated Plants (with NGO Intermediaries)

In this model, the composting plants are planned and implemented by the municipality; however, the operation and maintenance is handled by the benefitting community. This model works well in low-income communities in urban areas. In slum areas, the passages are narrow and there is no waste collection service. Barrels of two different colors are placed within the community: green/blue barrels for organic and yellow barrels for inorganic. An intermediary, e.g., an NGO, provides technical and management support to the slum community to produce compost. The main incentive behind this model is the problem of waste collection and disposal. The model has helped segregating waste at the source and thus solved the waste disposal problem in the slums. This model is operational in Vasuntek slum at Mirpur in Dhaka and in a slum at Faridpur district, where it is supported by Practical Action Bangladesh. The compost is used in homestead vegetable gardens and some is even sold to nearby communities, which use it in their vegetable gardens.

Case 4: Municipality-Owned and Privately Operated Plants

Composting plants are constructed on municipal land and owned by the municipality. The operations and maintenance is contracted out to the private sector through a bidding process. This model has been promoted in UNICEF-supported programs in 14 towns of

Bangladesh. The municipality tenders primary waste collection and composting schemes for a contract period of five years. The target is to make the compost plants operational, therefore the municipality does not take any security deposit, nor does it get a share of the revenues from waste collection and composting. In most cases, after a few months, the operation of the plants was stopped because the private companies did not receive a regular supply of waste and the quality of waste for composting was poor. The communities were reluctant to provide service charges to companies for waste collection as the community was not consulted or mobilized before project inception. In addition, the private companies did not have any previous experience with the composting process and had not planned any marketing strategy for sale of compost. Practical Action, with the support of GIZ, has taken on the responsibility of running the Mymensingh plant commercially by developing market opportunities for compost. The plant started its operations recently, and it intends to operate commercially. Currently, it is working on establishing a market by targeting farmers as their primary customer segment.

In another instance, RUSTIC, a private company, is operating a compost plant owned by the Khulna City Corporation (KCC). The plant is situated in the Rajbandh landfill site of KCC on 0.2 hectares of land. RUSTIC receives about 65 t of MSW per month. It produces about 25–30 t of compost under the name of RUSTIC Compost Jaiba Sar. RUSTIC received its certification from the Ministry of Agriculture in 2012. RUSTIC undertakes door-to-door waste collection service for 800 households, engaging 4 rickshaw vans, and collects BDT30–50 per month (approximately US$0.4–0.65) in service charges. RUSTIC sells the compost at BDT7 per kg (approximately US$91 per t) on a wholesale rate basis. In addition, the company also sells the product through ACI, Sikder Seeds as well as through Reza & Sons, which sell the compost to farmers in Khulna, Satkhira, Natore, Munshiganj, Mollhat and other areas at rates of BDT15–25 per kg (approximately US$195–325 per t).

Case 5: Privately Owned and Privately Operated Plants

Worldwide Recycling (WWR) and Waste Concern registered the first CDM composting project with the United Nations Framework Convention on Climate Change in 2008. WWR is a Dutch company, and Waste Concern is an NGO. WWR brought investment funds, while Waste Concern manages operations and marketing of the product. A 15-year concession agreement was signed with Dhaka City Corporation in 2007 to collect organic waste amounting to 700 t per day from the wholesale vegetable markets. The project started in November 2008 with a composting plant capacity of 100 t per day. Land was rented outside of Dhaka, around 30 km from the city, and no tipping fee was charged. The project was financed by the Entrepreneurial Development Bank of the Netherlands (FMO), High Tide Investment of the Netherlands and Dutch Bangla Bank of Bangladesh. The total investment cost of the project was US$3.6 million. The issuance of certified emission reductions began in 2011.

The plant uses aerobic composting with forced aeration using the box method. It has eight

composting cells and one big maturing area, and its equipment consists of a weighbridge, a drum screen, a wheel loader, blowers, measuring equipment, a crusher and a bagging machine. Compost produced from the plant has been approved and certified by the Ministry of Agriculture. Advanced Chemical Industries (ACI) purchases the packaged compost from the plant at a price of US$85 per t for 40 kg bags and US$145 per t for 5 kg bags. ACI distributes compost through its established dealers and distributors network. ACI also undertakes other activities, such as promotional branding (leaflets, posters, stickers, and television advertisement), brand awareness (farmers meetings and demonstration farming), product launchings and seminars and meetings with the Department of Agriculture Extension. According to ACI, there is high demand for the product. ACI sells it to the farmers at US$130 per t, and this price covers transport, storage and promotional costs. The production cost per ton of compost, including the waste collection, is about US$63. Apart from sale of compost, the project earns 25–30% revenue from the sale of carbon credits. During the monitoring period (August 2010 to December 2012), 50,486 t of organic waste was collected from the vegetable markets in Dhaka, and a total of 2,486 t of compost was produced. The estimated amount of GHG emission reductions in the registered project design document (PDD) was 386,236 t CO_2 and actual GHG emission reduction achieved during this period was 22,786 t CO_2 (Monitoring Report F-CDM-MR Version 03.1)[7].

Case 6: Community-Owned and Community-Operated Plants

Value for Waste, a project implemented in Baridhara Residential Area by Swiss Contact together with Baridhara Society, the local resident's association, is a good example of a community-owned and community-operated model. The project aims to encourage source segregation of waste in households and to ensure separate collection and treatment of recyclables, including organic waste. About 1,900 households are participating in the source segregation practice, and each household was informed by Baridhara Society about the source segregation and separate collection mechanisms. They were equipped with one green plastic bin for compostable organic waste, one yellow reusable plastic bag for inorganic recyclables, three red, disposable paper bags for hazardous waste and one blue plastic bin for the remaining mixed waste. Also, each building is provided with four plastic containers at the ground floor.

The project area is divided into four zones, and each zone is provided with two rickshaw vans: one collects only compostable organic waste, the other collects inorganic recyclables as well as hazardous waste and the remaining mixed waste. The bins, bags, containers and information materials were selected in consultation with the residents, and designed and financed by Value for Waste, Swiss Contact. RFL Ltd., the company producing the bins and

[7] Monitoring Report F-CDM-MR Version 03.1, Composting of Organic Waste in Dhaka, CDM Monitoring Report , United Nations Framework Convention on Climate Change.

containers, has provided eight new rickshaw vans to Baridhara Society as part of their corporate social responsibility activities. Value for Waste, Swiss Contact has been providing Baridhara Society with equipment, raising awareness, providing trainings and technical advice for source segregation and separate collection as well as for small-scale composting. Eight tumbling composters are being used by Baridhara Society, which is operating the plant for free, and the compost produced is not sold but used in the parks and also distributed to interested citizens as an incentive to continue waste segregation efforts. The tumbler is made of a barrel that can be rotated to mix the materials and facilitate aerobic composting. Each tumbler can accommodate 55 kg of organic matter (35–40 kg of compostable organic household waste, 7–8 kg of soil and 7–8 kg of dry leaves). The decomposition process reduces the weight by 50%, allowing each tumbler to produce 28 kg of compost in each batch of 6 to 8 weeks. Each tumbling composter costs around BDT8,000 (approximately US$104). Baridhara Society owns and operates the tumblers, and the waste collectors and gardeners manage the whole process from collecting compostable organic waste to the application of compost. A gardener who is experienced in compost preparation is in charge of the operation and maintenance of the tumbling composters under the supervision of Baridhara Society and the Value for Waste project team.

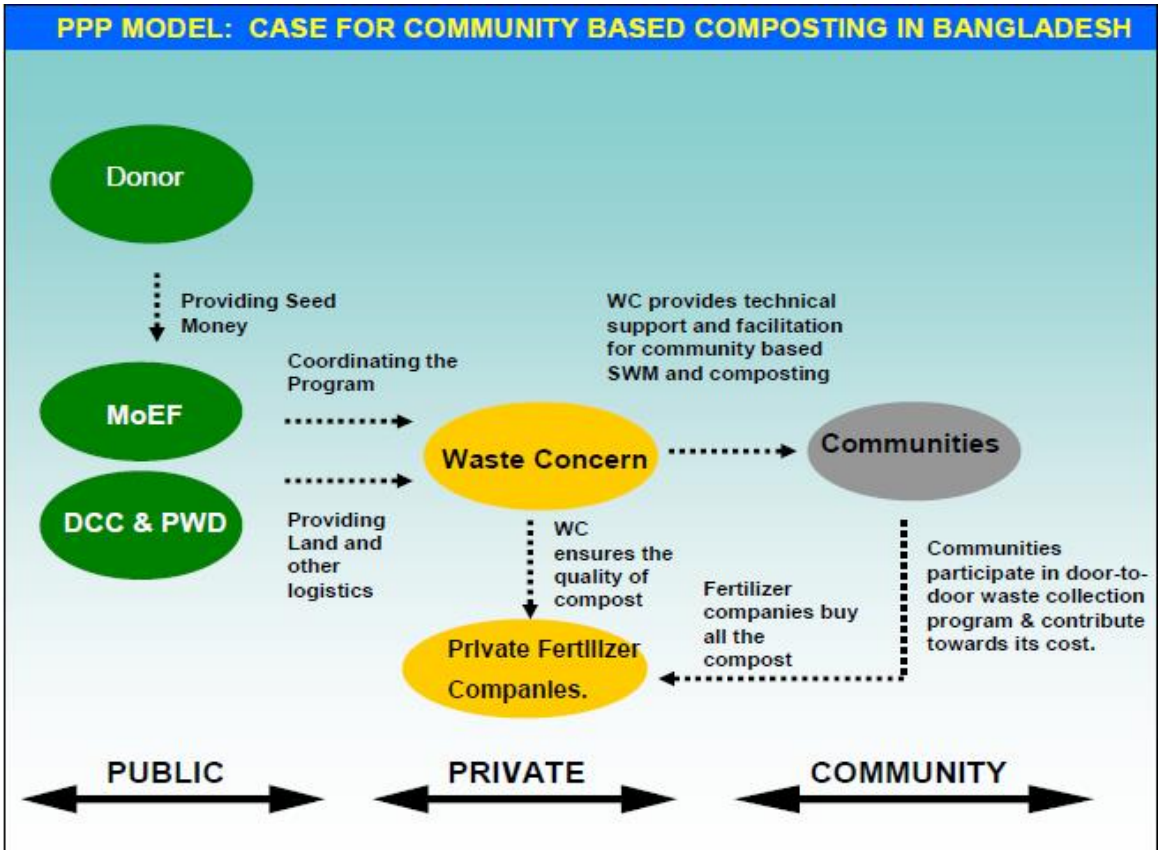
Case 7: Public-Private-Partnership Composting Model

Waste Concern, a local NGO in Bangladesh, was the pioneer in developing the PPP composting model in Dhaka, involving the municipality and the community. Waste Concern has established more than 60 plants of varying scale (3 t per day, 10 t per day and 20 t per day) across Bangladesh. The composting plants are decentralized and community based. Waste is collected from households through door-to-door waste collection systems and brought into a composting plant located within the community. The land is provided by the city corporation. Households pay a monthly service charge for waste collection. The poor from the community are involved in the waste collection and composting activities. Waste Concern provides technical assistance and capacity building support and collects compost produced by the community, which is sold to a private fertilizer company (ACI). ACI sells the product to an end customer segment at a margin. This model has been replicated in different cities of Bangladesh as well as in the neighboring countries.

Nine such composting models are operational in Bangladesh, managed by other private sector players. Most of the composting plants are small in size, located in the community or located on municipal land. Community waste collection is part of the composting projects, and the waste collection fees collected from the beneficiaries are included in the plant operational cost. Since source segregation is hardly practiced in these communities, sorting of waste is done at the plant. The quality of the compost is difficult to maintain because of the mixed waste collected from households. Marketing of the compost is the primary challenge faced by these plants. Municipality-operated projects are subsidized, and compost is used in public parks and gardens. A significant part of the income comes from the waste collection fee, and the remaining share comes from the sale of compost.

The PPP model developed by Waste Concern (figure 4.2) has interesting financial features that make it viable through community involvement and public-private cooperation. The communities receive door-to-door collection service and share the cost of waste collection by paying a monthly fee, based on their affordability. The private stakeholder has a joint venture partnership, which includes Waste Concern and its financial partners (banking institutions). A private sector company, ACI, is involved to ensure the sale of compost by carrying out enrichment of the compost with nutrients and managing its subsequent distribution in the market. As a result, 75% of the project's total revenue comes from sale of compost. The remaining 25% of project revenue is from community contributions in the form of a user fee and from sale of certified emission reductions, thus making the project financially viable. The project heavily relies on close community partnership and is firmly integrated with house-to-house waste collection efforts.

Figure 4.2: Public-private-community partnership composting model



(Source: Waste Concern, www.wasteconcern.com)

4.5 Conclusions and Recommendations

In Bangladesh, SWM is a mandated responsibility of the city corporations and the municipalities under the local government act. The provisions in the act on SWM are very typical and traditional, and the waste reduction and recycling issue is not spelled out. With

the current provisions, it is difficult for the municipalities to provide a sound and scientific SWM solution. The continued generation of solid waste, increasing waste management cost and scarcity of landfill space has compounded solid waste problems. Local authorities are struggling to meet the collection targets and are hardly able to plan for waste reduction and recycling. Composting is seen as a potential solution for waste reduction and recycling. However, composting has experienced multiple problems in the forms of a general lack of environmental concern in the community, local government priorities, feed stock material, compost plant operation, quality and price of the product, consumers' perception of the product and institutional support and marketing.

Framing the rules as in the policy and regulatory framework for SWM and organic agriculture has undoubtedly paved the way for improving SWM services, but implementation of the act and rules need more clarity. Besides, there is need for detailed guidelines for municipal authorities to implement action on the ground. Step-by-step guidelines on how to implement the rules need to be prepared and circulated to the municipal authorities, which will also need capacity building and technical manpower to expedite implementation.

The following are recommendations on how to further improve composting:

- It is essential to identify the goals of each composting project, i.e., whether it is to be a demonstration of a waste minimization program or a it is to produce compost for commercial marketing.
- Political support is needed for composting projects to succeed. Enactment and implementation of policies and legislation, incentives and disincentives for organic waste recycling could have a positive impact on overall SWM, including composting.
- Communities need to be encouraged to organize primary waste collection and the private sector to participate in operating compost facilities.
- Composting can significantly reduce waste stream volume and offers economic advantages to the local authorities. Inadequate understanding of the economics of composting is a challenge for the composting projects that base their viability strictly on financial terms.
- Chemical fertilizers enjoy large subsidies, which affects the demand for compost and distorts the market. Production of compost must be associated with appropriate incentives to create a level playing field for compost and allow widespread use.
- A policy to co-market compost with chemical fertilizer should be encouraged to make compost more competitive in the agricultural market.
- Mixed waste is the primary cause of inferior compost quality. Public awareness is required to encourage segregation of waste at the source.
- Quality compost increases confidence and creates demand among farmers. Registration and certification of compost should be made mandatory and enforced, but at the same time the certification process should be made easier and less bureaucratic.

5. DESCRIPTION AND ANALYSIS OF COMPOSTING IN SRI LANKA

5.1 Overview and Regulatory Setting

Sri Lanka is an island situated in the Indian Ocean (lat 6°54′0″ N, long 79°54′0″ E) close to the equator. The climate in Sri Lanka is tropical and monsoonal, but it varies from warm in the coastal plains and lowlands to temperate in the hills and mountain regions (figure 5.1). Related key details can be found in table 5.1. Sri Lanka's economy has traditionally been dominated by agriculture. Rice is the staple crop, and the country is self-sufficient in rice production. The country is also rich in cereals, legumes, vegetables, roots and tubers, fruits, medicinal plants, leafy vegetables, spices and more. It produces various plantation crops, including tea, rubber, coconut, cocoa and spices for the export market. In 2012, 31.8% of the total labor force were engaged in agricultural activities in Sri Lanka (CIA 2014).

Table 5.1: Sri Lanka – country profile

Area	**65,610 km²**
Population	21.9 Mn (2014 est.)
Population density	323 km²
Annual population growth rate	1%
Provinces	9
Districts	25
Local Authorities	335
Inland Water	870 km²
Gross Domestic Product (GDP) by agriculture	13.69%
Agricultural Land Area	26,200 km² (2011)
Families engaged in farming	1.8 million

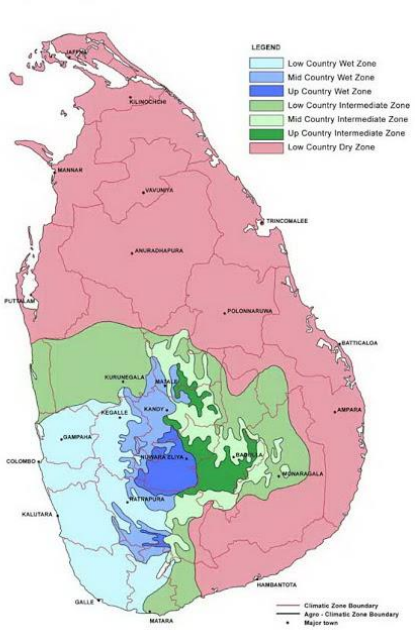


Figure 5.1: Agro-climatic zones, Sri Lanka

5.1.1 Overview of Municipal Solid Waste Management

Generally, waste collection services only cover the urbanized and commercial areas of cities and towns. In areas where households have larger land plots, households manage waste by themselves on their own premises. In rural contexts, it is common to use food waste as an animal feed and organic waste for home composting, using the pit composting method. In such cases, inorganic waste is burned, and organic waste is composted or buried. On average, 62% of the waste consists of biodegradable components. The average waste composition for Sri Lanka can be found in table 5.3. The biodegradable fraction of the MSW is 66% in urban

areas, but only 40% in rural areas (MENR 2005). This can be explained by the greater waste collection coverage in urban areas, which has now been expanded to the residential areas. In semi-urban and rural areas, the collection coverage is mostly limited to the town centres, which produce comparatively less organic waste.

Sri Lanka's administration consists of nine provincial councils (i.e., regional administrative bodies). The Western Provincial Council is the most populated province, containing a quarter of the country's population and most of the nation's industries. The Western Provincial Council collects 60% of the total waste collected in the country. The country consists of 335 local authorities, which are the local-tier administration bodies for MSW. There are four local authorities with a waste collection greater than 100 t per day, and three municipal councils with waste collection rates between 50–100 t per day (table 5.2, MENR 2005). The Colombo Municipal Council alone collects 680 t per day, which is the maximum collection and amounts to 25% of the whole country's collection.

Most of the collected waste in Sri Lanka ends up in open dump sites. These sites are usually located close to water streams, marshy lands and forest areas, and they can create adverse impacts on the environment and public health. Only one engineered landfill site, operated by the Central Environmental Authority, exists in Sri Lanka at present. There aren't any special designs or methods to separate and dispose of collected hazardous waste. The main hazardous waste is hospital waste, and it is managed without employing any special precautionary practices or safety measures. It is collected with MSW and is dumped in open dump sites along with other MSW in most cases.

Table 5.2: Waste collection according to local authorities as of 2005

Waste amount collected	No. of LAs	Percentage of LAs
Up to 1	111	35.70%
1 to 2	48	15.40%
2 to 5	75	24.40%
5 to 10	26	8.40%
10 to 20	23	7.40%
20 to 50	19	6.10%
50 to 100	5	1.60%
100 to 150	3	1.00%
Greater than 150	1	0.30%
Total	311	100%

(Source: MENR 2005, only covering 311 local authorities)

Industrial waste from designated industrial zones is managed separately. However, the sustainability of the disposal methods is questionable. For example, major industrial zones, such as Katunayake Free Trade Zone (18 t per day) and Biyagama Free Trade Zone (10.5 t per day), are currently disposing of industrial waste in open dumps located within their respective zones. Many industries are also located outside of the designated industrial zones within the country. Waste from these zones is managed with MSW.

The local authority is the local body responsible for MSW collection, and there is no separate charge or fee for waste collection in general. MSW is collected as mixed waste, except in a few cases so far, with varying degrees of success. The local authorities in possession of compost plants are keen on segregation of waste at the source to reduce labor intensive sorting activities and to improve the compost quality. Many attempts at implementing segregation at the source seem to have failed. Different local authorities have been using strategies to promote segregation. The most common successful strategies are (a) to refuse to collect mixed waste or (b) to introduce a fee to collect unsorted waste, while extending the free service for sorted waste.

Table 5.3: Average waste composition in Sri Lanka

Waste Component	Composition (%)
Glass	**2**
Wooden materials	**6**
Polythene and plastic	**6**
Paper	**7**
Biodegradable	**62**
Others	**1.7**

(Source: MENR 2007)

5.1.2 Regulatory Setting

Like in many countries, the governance and the administration structure in Sri Lanka has been decentralized and divided into three tiers: (a) local level, (b) provincial/regional level and (c) national level. In each of these three tiers the MSW service is delivered by (a) local authorities (b) provincial councils and (c) a host of government ministries, respectively. While exercising its powers to achieve a sustainable outcome in any sector coming under its purview, each authority should carry out their duties with a sense of responsibility to remain in a position to meet the needs of the future.

"Waste" had not been defined in legal terms in Sri Lanka until 1980. The then adopted definition can be identified as a significant step forward. Sri Lanka (1980), National Environmental Act No. 47 of 1980: Section 33, defines waste in a wider sense as follows: "waste includes any matter prescribed to be waste and any matter, whether liquid, solid, gaseous or radioactive, which is discharged, emitted, or deposited in the environment in such volume, constituency or manner as to cause an alteration of the environment." Clearly, this also includes MSW, and, hence, it seems that any legal provisions applied for waste (unless mentioned specifically) also applies for MSW.

National Level

The vision of the Government of Sri Lanka is to conserve the environment by applying the principle that "the abuser should pay for the abuse" (also known as "polluter pays"). Effective SWM has been identified as a priority area in the medium-term development plan of the government. To solve the urban waste problem, the Sri Lankan government's vision is to convert all the organic waste generated in the local authority areas and convert it into biogas and organic fertilizer while recovering the resources. Recycling of plastic and polythene is planned to increase from the existing 40% to 100% for the diminution of usage of the virgin plastic. This indicates that the government has a high interest in resource recovery and reuse as a solution to the final disposal of urban waste. The residues are intended to be dumped in sanitary landfills (Ministry of Finance and Planning 2010).

The major role of the Central Environmental Authority (CEA) is to act as the national regulatory body on the subject of the environment. Powers vested in the authority under Act No. 47 of 1980 are:

(a) to recommend to the minister a national environmental policy and criteria for the protection of any portion of the environment with respect to the uses and values, whether tangible or intangible, to be protected, the quality to be maintained**,** the extent to which the discharge of wastes may be permitted without detriment to the quality of the environment and long range development used and planning and any other factors relating to the protection and management of the environment; and

(b) to specify standards, norms and criteria for the protection of beneficial uses and for maintaining the quality of the environment.

Further, the Ministry of Environment, 2003 (National Environmental Policy, Section 2.2.8) states, "the impact on, and risks to, environmental quality and public health will be reduced to levels that are socially acceptable by managing waste streams."

The national policy on SWM (2007) states that "environmentally friendly disposal of waste with maximum opportunities for application of 3R concepts with special emphasis on prevention of waste generation has to be perceived, in order to exercise due care in disposing of all waste." Under the policy objectives (section 3.2), the importance to maximize the

resource recovery with a view to minimize the amount of waste for disposal has been highlighted. Section 5.1 and 5.2 of the policy emphasize that solid waste should be managed in accordance with the 3R principle and propose to limit landfills to receive only non-recyclable, non-compostable and inert material.

The National Sanitation policy (draft) demands resource recovery from septage (excreta or fecal sludge collected from on-site sanitation systems such as septic tanks and pit latrines) where feasible and appropriate as an alternative to disposal. This creates space for MSW and faecal sludge co-composting initiatives.

According to gazette notification number 1681/3 of November 22, 2010, the Ministry of Local Government and Provincial Councils is responsible for implementing the Municipal Council Ordinance, Urban Council Ordinance, Pradeshiya Sabhas Act and the Provincial Council Act. The local level waste management responsibilities are with the local authorities, but it is the ministry that is responsible for implementing the local authority's acts. Most of the provincial councils do not seem to be playing an active role in waste management at present, and it is the ministry that has been entrusted with the responsibility of implementing the Provincial Council Act at the national level. Additionally, the Ministry of Local Government and Provincial Councils has been instructed to formulate and implement national policies related to subjects of the provincial councils and local government.

Provincial Level

The provincial councils' direct responsibilities related to waste management are not yet defined, but it has indirect supervisory powers. However, under list 1 subject 4 of the constitution of the Democratic Socialist Republic of Sri Lanka[8], a provincial council has powers that include (a) supervision of the administration of local authorities established by law and (b) conferring additional powers on local authorities. Under subject 37, protection of the environment within the province (to the extent permitted by laws made by parliament) appears as part of the duties of the provincial councils (GoSL 2013). At present, the provincial government does not seem to be significantly involved in waste management. An excellent example to identify the kind of role that the provincial councils can play is to consider the role of the Waste Management Authority of the Western Provincial Council (only provincial level authority) in SWM (for more details, please refer to WPC 2013). At present, provincial level involvement in waste management in other provincial councils is rather low.

[8] Government of Sri Lanka Provincial Councils List. Available at http://www.priu.gov.lk/Cons/1978Constitution/Schedle_9_Amd.html [Accessed on 19.02.2015]

Local Level

Solid waste management has been mentioned as being the responsibility of the local authorities in the acts and ordinances given below:

1) Municipal Council Ordinance No. 16 of 1947 – Sections 129, 130 and 131
2) Urban Council Ordinance No. 61 of 1939 – Sections 118, 119 and 120
3) Pradeshiya Sabha Act No. 15 of 1987 – Sections 93, 94 and 95

The contents of all three local authorities legislations regarding waste management are almost identical (though the Pradeshiya Sabha Act is comparatively recent) and, as an example, the content of the Municipal Council Ordinance No. 16 of 1947 is stated in box 5**.**

Box 5: Municipal Council Ordinance No. 16 of 1947

129. It shall be the duty of the council, so far as is reasonably practicable, to take all necessary measures in every part of the Municipality: (a) for properly sweeping and cleansing the streets, including the footways, and for collection and removing all street refuse (b) for securing the due removal at proper periods of all house refuse, and the due cleansing and emptying at proper periods of all latrines and cesspits and (c) for the proper disposal of all street refuse, house refuse and night soil.

130. All street refuse, house refuse, night soil, or other similar matter, collected in any Municipality under the provisions of this Part shall be the property of the Council, and the Council shall have full power to sell or dispose of all such matter and the money arising therefrom shall be paid to the credit of the Municipal Fund.

131. The Council shall, from time to time, provide places convenient for the proper disposal of all street refuse, house refuse, night-soil, and similar matter removed in accordance with the provisions of this Part, and for keeping all vehicles, animals, implements, and other things required for that purpose or for any of the other purposes of this Ordinance, and shall take all such measures and precautions as may be necessary to ensure that no such refuse, night soil, or similar matter removed in accordance with the provisions of this Part is

The product certification scheme that is popularly known as the SLS Marks Scheme gives a third party guarantee on quality of a product. Sri Lanka Standards Institution Act No. 6 of 1984, and the regulations made thereunder, empowers the Sri Lanka Standards Institution to issue such permits to manufacturers (further information can be obtained from http://www.slsi.lk/web/index.php). In 2003, the Sri Lanka Standards Institute issued a compost quality standard (Standard number: SLS 1246:2003) for MSW compost and agricultural waste compost. The same institute has the authority to issue SLS certificates for products to comply with the standard. However, this standard is not legally binding and mandatory but could be considered as a complementary standard. In other words, there is no obligation to comply with SLS as per national legal standards, but doing so would increase the confidence in the product among users. The parameters and the requirements can be

found in table 5.4.

Table 5.4: Parameters and requirements, SLS Marks Scheme

Parameter	Requirement
Physical and other requirements	
Color	Brown/grey to dark black
Moisture	Less than 25% [dry mass basis]
Odor	No unpleasant odor
Particle size	98% less than 4 mm (i.e., pass through 4 mm sieve)
Sand content	Less than 10%
pH	6.5-8.5
Nutrient requirements	
Magnesium	More than 0.5% by mass
Potassium (K_2O)	More than 1.0% by mass
Phosphorous (P_2O_5)	More than 0.5% by mass
Nitrogen	More than 1.0% by mass
Organic Carbon	More than 20% by mass
Calcium	More than 0.7% by mass
C:N ratio	10 to 25
Biological and microbiological requirements	
Viable weed seeds	Less than 16 per 1 liter of compost
Fecal coliforms	Free
Salmonella	Free
Heavy metals	
Cd	10 ppm (max)
Zn	1,000 ppm (max)
Ni	100 ppm (max)
Hg	02 ppm (max)
Pb	250 ppm (max)
Cu	400 ppm (max)
Cr	1,000 ppm (max)

5.1.3 Opportunities and Challenges

Opportunities

Considering the local context, it is clear that there are many opportunities to promote composting in Sri Lanka:

- The high subsidies on chemical fertilizer have created environmental and health issues by encouraging excessive usage as shown in table 5.5. A chronic kidney disease of unknown etiology (CKDu) has become widespread among the farming

communities in the North Central Province of the country, and this is spreading to other farming provinces as well. The root cause for the CKDu is still unknown, but it is suspected to be caused by the excessive use of agro-chemicals and the resulting pollution of drinking water. A negative perception of agro-chemicals is growing at present. This can be converted to an opportunity.

- Agricultural soils in Sri Lanka have little organic matter. Organic matter content in most soils is between 1–2%, whereas the organic matter content in typical agricultural topsoil is expected to be around 5% (DoA 2014). In cases of low levels of organic matter, compost can play a vital role.
- Less than 3% of the country is covered by sewerage, while the rest of the country depends on on-site sanitation systems such as pit latrines and septic tanks. Septage has high nutrient value, and hence co-composting MSW with septage will produce a fertilizer high in nutrients, which is has high market demand.
- Organic farming is not widespread in Sri Lanka, although a growing interest for organic products exists in middle- and high-income societies.
- So far, most of the compost plants are established in rural or semi-urban areas. Hence, the farming industry is not far from the compost plant.
- Local rock phosphate is insoluble, but the composting process (using organic acid during the process) would be able to convert it to a soluble form of phosphate and produce phospho-compost.
- The plantation sector seems more concerned with protecting soil properties, and therefore it might be interested in organic fertilizer. The plantation sector has a high buying power and could afford additional contributions to improve soil properties. Present consumer segments can be found in table 5.6. Many target markets of the plantation farms are international rather than domestic, and demand for organic tea, coconut, vegetables, fruits and spices exists. However, this market still has to be explored. According to IFOAM & FiBL (2006), 15,215 hectares of land are under organic farming, representing 0.65% of total agricultural land and a presence of around 3,300 organic farms.

Table 5.5: Excess chemical fertilizer usage in the paddy sector in Sri Lanka as of 2011

Description	TSP		Urea		MOP	
	Yala	Maha	Yala	Maha	Yala	Maha
Recommended application (kg/ha)	35	35	138	138	49	49
Excess usage (kg/ha)	51	57	114	136	40	40
% of excess usage as a share of recommended dose	150 %	164%	82%	98%	80%	80%
Cost of the excess usage of chemical fertilizer (US$ million)	27.8		62.9		20.5	

(Source: DOA (2011); Central Bank of Sri Lanka (2013))

Challenges

Smallholder farmers seem interested in using chemical fertilizer to increase yield instead of increasing or protecting the soil properties for long-term sustainability. The MSW compost currently available is a soil conditioner and is low in nutrients. Nutrient values of the MSW compost are found to be around 0.9%, 0.4% and 0.8% for nitrogen (N), phosphorous (P) and potassium (K), respectively (Fernando et al. 2014a). This seems to be one of the main drawbacks in promoting MSW compost among farmers. In addition, no developed, local, organic food market exists in the country; instead, smallholder products are in demand. So far, no locally acceptable organic food certification system has been developed, and laboratory facilities lack food certification procedures.

There are many reasons for the low demand for compost among farmers globally (please refer to Hoornweg et al. 1999 for more details), and most of them are also applicable to the Sri Lankan context. As MSW compost acts as a soil conditioner instead of a fertilizer, the role of compost is to a large extent grossly misunderstood by farmers. Key relevant factors driving a low demand are listed below:

- lack of awareness and knowledge on how, how much and when to use compost
- misunderstandings of how compost works (i.e., expecting compost to perform the same way as a chemical fertilizer)
- concerns about the quality of compost made from MSW, which are sometimes based on negative experiences with waste in the past
- smallholder farmers' inclination to focus on optimizing yield within a short time and mostly target the current season
- competition with highly subsidized chemical fertilizers and low-cost biowaste, such as manure, septage, etc.
    - high transport costs relative to product value due to its bulky nature and difficulties in handling at the farm level
    - unbalanced regulations and policies (e.g., subsidies for chemical fertilizers) hamper the compost market
    - lack of opportunities for private sector participation
    - limited availability in the market and no quality control or reputed brand names like for chemical fertilizers

Table 5.6: Current market potential

Local government authority/ organization	Normal Price	Wholesale price	Customer Segment
	US$/kg	US$/kg	%
Nuwaragampalatha East PS	0.08		Entrepreneurs [eg: An entrepreneur attached to Sarubima supplies value added (by adding cow manure,

			gliricidia, etc.) compost to farmers in Nuwara-Eliya, Kalpitiya, Jaffna and Puttalam. A kg of compost is bought at LKR 4.00 and sold at LKR 12.00]
6th Bn Sri Lanka Army Camp Mahakanadarawa	-	-	The compost is used for vegetable farming within the premises. The only revenue generated is by selling vegetables to a shop at Mihintale.
Galgamuwa PS	0.08	0.06	75% of market segment is home gardeners* and farmers (flowers and vegetable). Balance is coconut, paddy cultivations and agricultural department (Medagama)
Bingiriya PS	0.06	0.06	75% of market segment is home gardeners and banana farmers. Balance is coconut, papaya and vegetables farmers
Wariyapola PS	0.05	0.05	Farmers (vegetables, water melon, papaya and coconut)
Weligama UC	0.08	0.07	Home gardening 60%, tea plantation 30%, balance used at the farm and in landscaping
Bandarawela MC	0.06	0.06	Tea plantations and farmers (vegetable, flower, potato, paddy)
Thanamalwila PS (Thanamalwila)		0.04	Government exhibitions (Deyata Kirula)
Kaduwela MC	0.07	0.07	Home gardening, Divi Neguma program, Divisional Secretariat office, garden designers, small-scale farmers
Attanagalla PS	0.12	0.08	Home gardening & vegetable, fruit farming within the premises
Kalutara UC - Pohorawatte	0.12	0.09	Tea/cinnamon (60%) & home gardening (40%)
Bulathsinghala PS	0.10	0.08	Home gardening & tea plantation
Niyagama PS	0.09	0.09	Tea plantation (60%), home gardening (30%), paddy (10%). Demand could not be met.
Mulatiyana PS	0.08	0.07	Tea plantation
Beliatta PS			Compost is used for mango, oranges, pomegranate, banana and papaya cultivations within the plant premises

(Source: IWMI, unpublished)

* Home gardening includes flower, vegetable, fruit, etc. are grown in the area of land around the family home mostly for own consumption.

Note: It was assumed 1USD=LKR 130 as of 2013 because the survey was conducted in 2013 (http://www.exchange-rates.org/history/LKR/USD/T)

5.2 Overview of the Composting Sector

The characteristics of MSW in Sri Lanka include a very high proportion of organic matter (60–85%), high moisture content (60–75%) and low calorific value (l000–1200 kcal per kg). (Bandara 2008). MSW incineration for energy is currently not viable because of the low

calorific value and high moisture content. On the other hand, high organic content and high moisture content offer great potential for composting.

Polythene and plastic recycling is one areas that has received national attention. A national project, called the National Post-Consumer Plastic Waste Management Project, provides capital grants for local authorities to establish plastic collection and recycling (pelletizing) centres. In addition, informal collectors of recyclables, who collect items like paper, plastic, metal and glass, can probably be found in each of the local authorities. However, the current recycling sector has been able to capture a significant percentage of recyclables found in waste, and the rest has been deposited in open dump sites.

Before 2008, international agencies (e.g., the Korean International Cooperation Agency, World Bank, ADB, the Japanese International Cooperation Agency, the United Nations Industrial Development Organization, International Labour Organization, the World Health Organization, GIZ, and the United Nations Environment Program) funded numerous composting projects. Provincial councils and the Ministry of Local Governments have also funded a limited amount of plants. In most cases, the capital investment was a grant, while operation and maintenance costs were subsidized for an agreed period. After the subsidized period, the local authorities had to keep the plant operational without any external funding. As a result of financial unsustainability, almost all of the plants were abandoned after the subsidized period expired.

In 2008, a national SWM project, named Pilisaru, worth US$40 million was initiated using public funds from the national treasury, and the promotion of composting was the main objective of the project. Looking at the current status in Sri Lanka in more detail, in 2013, 115 compost plants had been established under the government-funded Pilisaru project. The Government of Sri Lanka has already extended the Pilisaru project (phase 2 of the project has already been funded) for more than five years, until 2018, and many more plants are planned. The Pilisaru project provides the capital cost, as a grant, to the local authorities or public institutes, and the operation and maintenance cost should be borne by the relevant public institute. This capital grant includes buildings, access roads, services, equipment and, in addition, training of workers. Except for a few (approximately 10) public institutional plants, all other plants are owned by the local authorities because the grant is limited to public institutes. There are no extra subsidies for the composting industry in Sri Lanka, except for the capital grant already mentioned. However, cluster compost plants (i.e., large-scale compost plants serving more than one local authority) receive funds covering operations and maintenance costs for one year from the project's start, and after that period local authorities should cover the operations and maintenance. So far, only 12 cluster compost plants have been established.

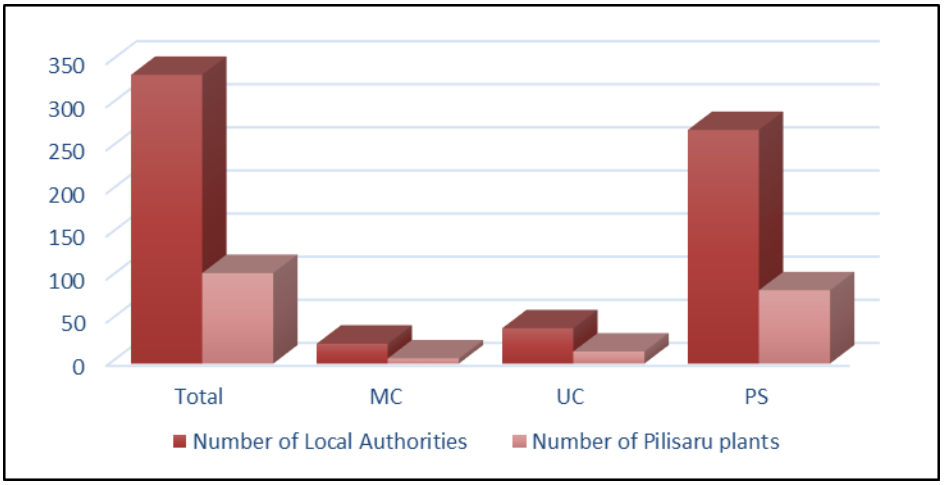
The local authorities have been subsidized by the central government, which have paid salaries for the approved cadre. (In Sri Lanka, most of the local authority workers' salaries

are paid by the central government. Each local authority has an approved number of workers, which get paid by the central government. This approved workforce is called the approved cadre This system also applies to the composting plants under local authorities' administration. In some cases, part of the compost plant workers were from the permanent cadre and received salaries from the central government (i.e., they were indirectly subsidized). But in some cases, all compost plant workers are still casual employees and are paid by the local authorities' funds.

Almost all of the compost plants that are operational in the country at the moment are funded by the Pilisaru project, except for a couple of plants in the east of the country that were funded by the United Nations Office for Project Services (UNOPS). The Pilisaru project's achievements in MSW composting appear to be significant in the area of the organic waste recycling process. There is potential (based on plant capacities) to treat 640 t of MSW (400 t of organic waste) per day, which is 10% of the total waste generated (i.e., 24% of the collected waste) in the country. An estimated daily production of 200 t of compost is possible with these facilities (while assuming biodegradable waste is reduced by 50% at the end of the composting process).

The compost plants are mainly established in rural or semi-urban areas at present. Nearly one third of all 335 local authorities in Sri Lanka have access to a compost plant (CEA 2013). Nearly 6%, 13% and 81% of these plants are accessed by municipal councils (cities or large townships), urban councils (medium and small towns) and Pradeshiya Sabhas (rural areas), respectively (figure 5.2). As can be expected, most of the plants are small scale (table 5.7).

Figure 5.2: Local authorities' access to compost plants



Note: MC is municipal councils, US is urban councils, PS is pradeshiya sabaha)

Table 5.7: Number of compost plants according to the scale

Scale in t/day	No. of plants	Percentage
0-1	29	25%
1-5	58	51%
More than 5	28	24%
Total	115	

Source: Pilisaru project data base as of 2013 (unpublished)

No private sector MSW compost plants were found to be operating in Sri Lanka during this investigation. Local authorities are the owners of the MSW (MSW is an asset of the local authority and will be discussed under legal aspects) according to the local authorities act, any private sector efforts to establish a MSW compost plant will probably not be possible. Additionally, government capital grants for compost plants are only available for public sector agencies, as already mentioned. Public-private partnerships are rare. During this study, two public-private partnerships were observed, one in Kurunagala and one in Balangoda, both of which were newly initiated. The Kurunagala partnership came to an end a few months after having been established. It was found that the public-private partnership only covered the compost plant. The low return on composting seems to be the reason. In the Balangoda case, the public-private partnership covers both the waste collection and compost plant. Thus, it will be interesting to observe performance and further development over time. If this partnership is successful, it may provide a suited model for replication.

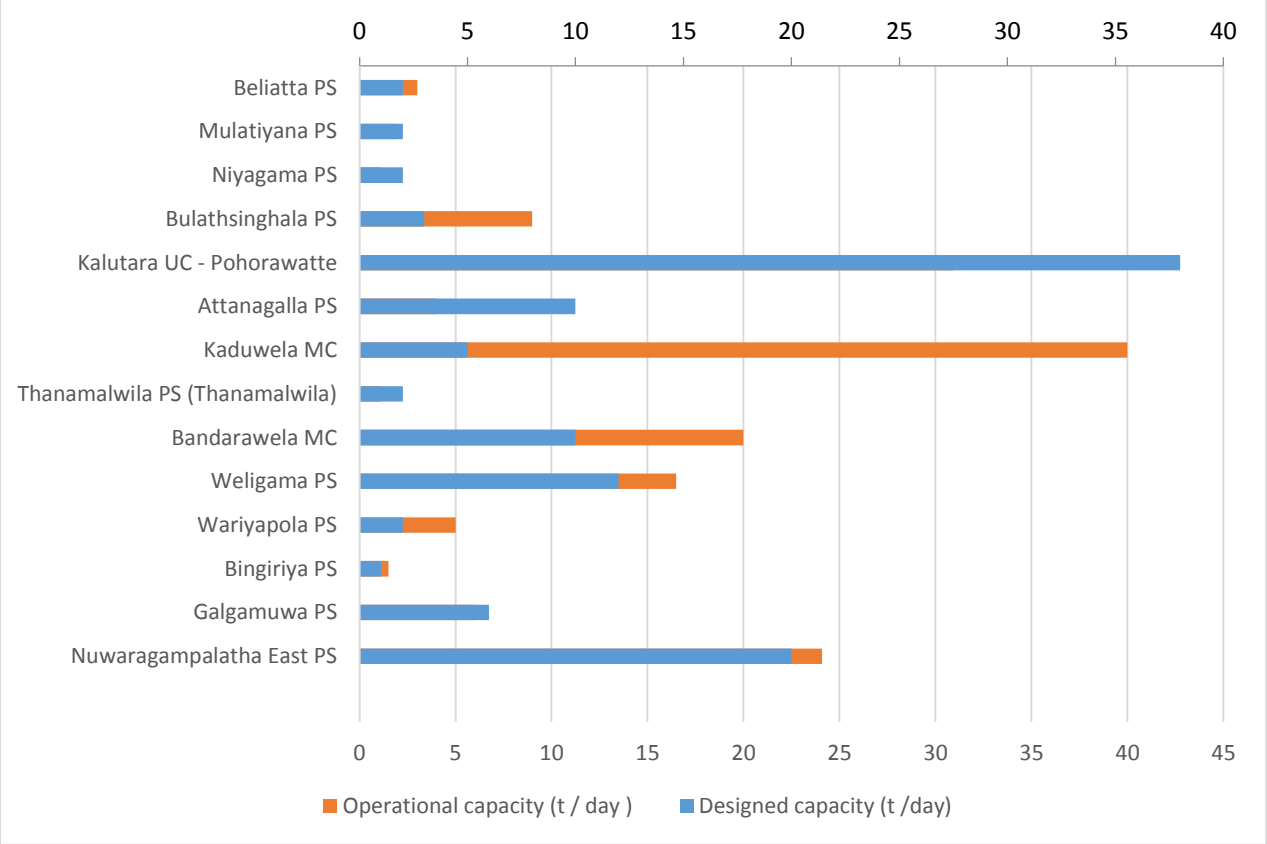
Though private sector participation is not visible in the composting sector, private sector participation in the solid waste collection sector is a success story in Sri Lanka. Many local authorities have contracted the solid waste collection service to the private sector. This is one of the areas that could be interesting to study for cross learning.

The current average cost recovery potential is as low as one-third of the operations and maintenance cost of the compost plant, with variances from 3% to 106%. It was evident that the capital cost cannot be recovered. The potential cost recovery will possibly reduce further if large-scale compost plants are introduced in cities, which use more mechanized composting plants that consume more energy. As a result of the low market demand for compost, the long-term financial sustainability of the industry seems to be the major challenge at the moment. The actual sales from compost production are in the range of 1% to 100%, with an average of 44% (Fernando et al. 2014b). The average price of 1 kg of compost ranges from US$0.06 to US$0.12, whereas the compost product is sold without any value being added. The bulk product is sold at US$0.05 to US$0.06 per kg. Further details can be found in table 5.6.

Figure 5.3 shows that the majority of compost plants in the country are operating close to their capacity or even above, where space allows. However, high levels of waste processing does not automatically translate into compost production. Initially, the compost production capacity was estimated to be 20% of the waste delivered (assuming roughly half of the waste is organic and of this more than half gets lost during the composting process); the percentages shown in figure 5.4 reflect the extent to which different plants are able to successful reach the target potential. The average efficiency is about 37%, or about one third of what has been expected. A key reason for this low production efficiency might be the lack of demand analyses and marketing of the product, which has resulted in poor sales.

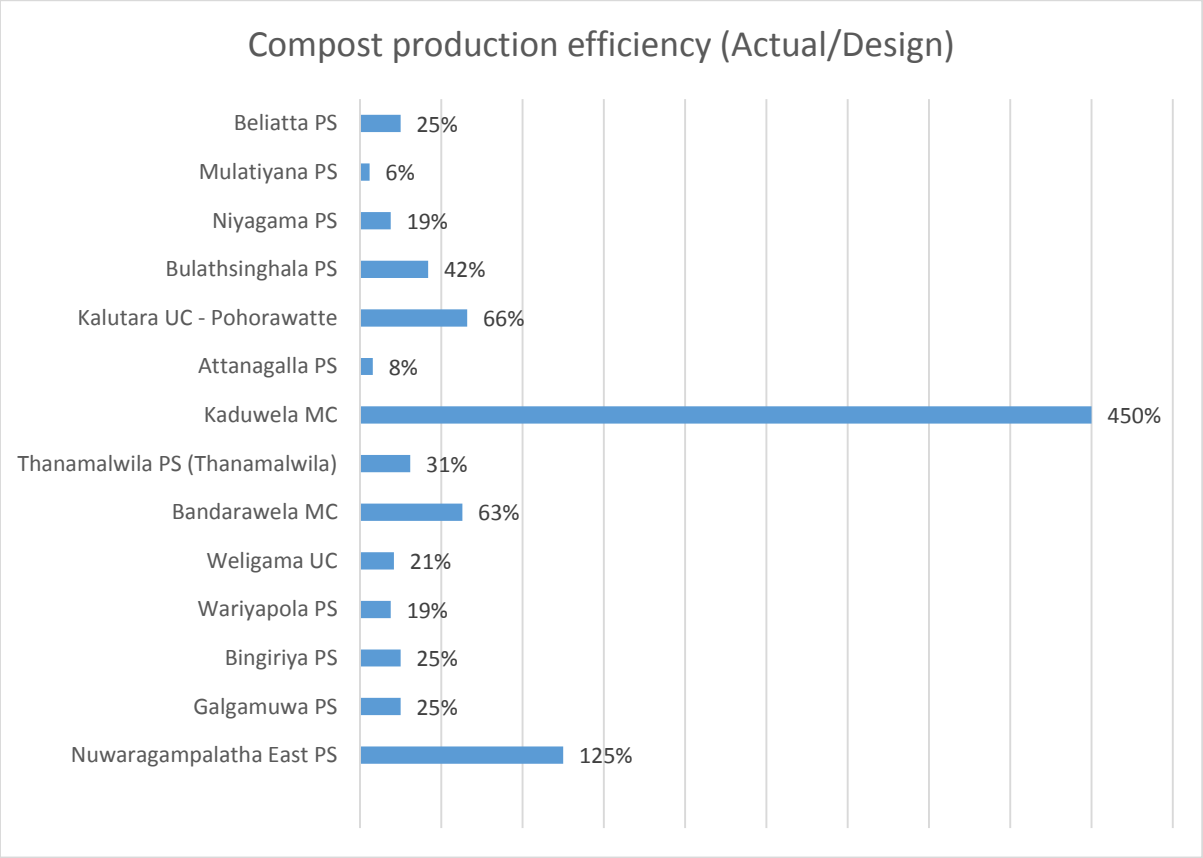
The limited nutrient value of compost makes it difficult to increase the product's brand value. Nutrient values for MSW compost were found to be rather low, 0.9% N, 0.4% P and 0.8% K, although comparable to MSW composts from other parts of the globe (Rostami et al. 2012).

Figure 5.3: Comparison of how much waste is treated in the plants compared to how much waste turnover was originally planned for



(Source: Fernando et al. 2014a)

Figure 5.4: Actual compost production efficiency compare to the designed target of 20% of waste input (set here as 100%)



(Source: Fernando et al. 2014a)[9]

According to the annual performance report of the Ministry of Agriculture (2012), the ministry had spent US$ 0.71 million (assuming US $ 1 = LKR 130) in promoting agro-waste compost production for utilization at farm scale. As a result, farmers have produced around 34,191 t of compost per year for their own use, using pile or windrow composting methods. The compost potential, based on the capacity of the compost plants currently established under the Pilisaru project's first phase and on waste collection, has been estimated to be 200 t per day (i.e., 73,000 t per year). However, the promotion by the Ministry of Agriculture so far has been limited to agro-waste compost. Although MSW composting has been promoted in the country, no specific mechanisms are in place to promote MSW compost use.

[9] For this calculation, Kadwela plant was disregarded because the main purpose of the plant seems to be volume and mass reduction through storage, not compost production.

Organic agriculture is still developing and is mainly focused on the export market. The total area under organic agriculture in Sri Lanka in 2006 was established to be 0.7% and this has further increased to 1.7% of total cultivated land in 2010. (IFOAM & FIBL statistics, 2008) and 2012)[10]. Sri Lanka is considered the pioneer in Asia for introducing organically certified tea and cinnamon to the world market. All major exporters do their own cultivation, and some exporters have arranged out-grower systems or community-based cultivation. The Sri Lanka Export Development Board (EDB, 2014) states that the value added by converting conventional products to organic products is more than 30%, depending on the product.

All regulations on organic agriculture are formulated based on guidelines or basic standards provided by the International Federation of Organic Agriculture Movements (IFOAM) and Codex Alimentarius. Presently, eight international certification agencies operate in the country as external inspectors, certification bodies, which are facilitated by the Sri Lanka Export Development Board, or both.

5.3 Compost Marketing

Composting can be perceived in two main ways:

- From a SWM perspective, wherein composting is a way of treating organic waste within the SWM system. Compost is seen as a by-product.
- From a marketing perspective, wherein composting is a way of producing a valuable product that can be sold. Compost is the core of all activities. Composting is driven more by customer demand than by material supply.

The Pilisaru project has adopted the first perspective, approaching composting as a SWM service. At the same time, compost does not enjoy a ready-made market in Sri Lanka, and MSW compost is a new addition to the fertilizer market. Therefore, it has to compete with cheap or free alternative biowaste, such as poultry manure, other animal manure types, agro-waste, raw organic waste and septage. For example, it was found that in 2013 18% of the total collected (by septic trucks) untreated septage was used in agriculture as a nutrient resource (Fernando et al. 2014a). However, the Ministry of Agriculture promotes the use of agro-waste compost, even though this sector has not yet been developed beyond the farm scale and does therefore not challenge the MSW composting sector, but it can be a challenge in the future. On top of all of these, the main competitor to organic fertilizer is synthetic fertilizer (e.g., Urea), which is subsidized with more than 90% for paddy farmers.
The fertilizer subsidies are not fixed for all farming sectors in the country. For example,

[10] http://orgprints.org/13123/4/world-of-organic-agriculture-2008.pdf
http://www.fibl.org/fileadmin/documents/shop/1581-organic-world-2012.pdf

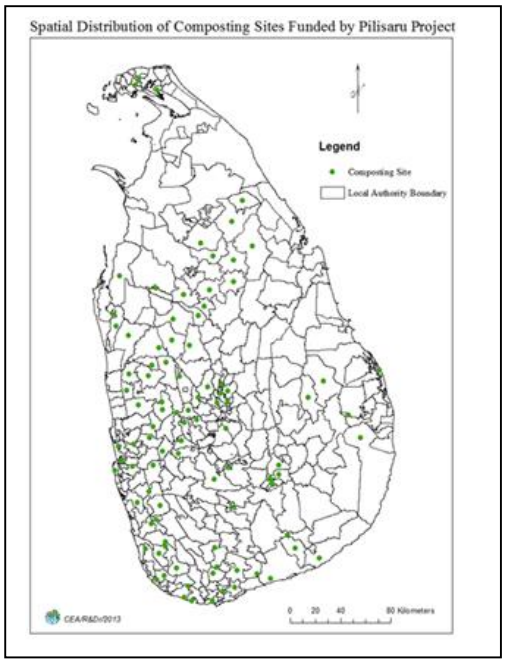
plantations, such as tea, coconut, rubber, vegetable and fruit plantations, receive lower levels of subsidies. As a result, organic fertilizer is more attractive for the farming sectors receive fewer subsidies.

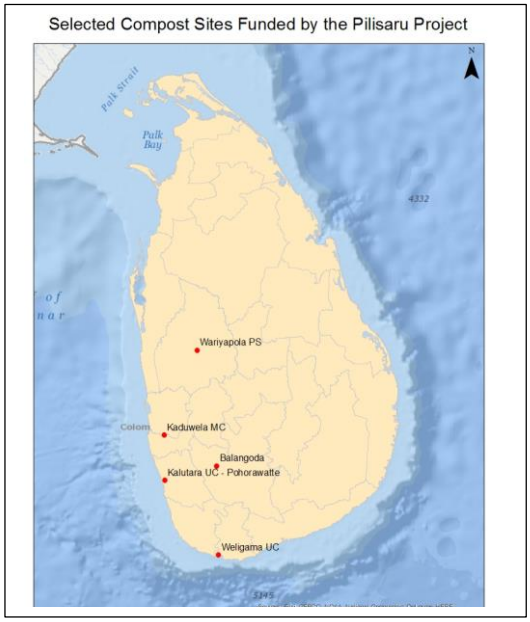
The potential consumer segments are detailed by compost plant in table 5.6. The main segments can be identified as

- The plantation sector (tea, rubber coconut, papaya and banana) offers a huge potential for compost.
- Landscapers. Low-quality compost can be used in landscaping projects and urban development activities. There is huge market potential in this area.
  Organic food farmers. A local organic food market is developing in the urban context. Having a growing market for organic food would reflect on a potential demand for organic fertilizer. The organic food export market is fairly established.
- Home gardeners and flower growers. Urban household use of compost in home gardening seems to be one of the promising consumer segments. .
- Government programmes. Government projects would offer excellent opportunities for compost producers because almost all compost plants in Sri Lanka are owned and operated by the public sector, and it would therefore be administratively less complex to establish agreements. Such projects include Divi Neaguma, a national project, which includes home gardening and which was established to raise the living standards of 1.8 million families and benefit five million persons, and Pura Neaguma, a national project to improve the infrastructure services in 108 selected local authorities in less developed areas of Sri Lanka.

5.4 Selected Compost Plants — Case Studies

Figure 5.5: Locations of Pilisaru compost plants and selected stratified random sample





Case 1: Balangoda Compost Plant

The Balangoda compost plant is owned by the Balangoda Urban Council and is situated in Sabaragamuwa province in Sri Lanka. The population of the urban council area is 23,220, and the total waste collection per day is estimated to be 20 t, with a 100% collection coverage. Out of the total 20 t, 4 t is recovered as recyclables and 2 t are put in open dump sites. The plant receives waste from various waste streams, namely MSW, fecal sludge, fish waste and slaughterhouse waste. As a result of blending and co-composting with high nutrient waste sources, the plant produces high nutrient compost. The compost plant capacity is 14 t per day, and the plant operates at full capacity. This compost plant recently began operating under a public-private-partnership arrangement.

Balangoda compost plant (Source: IWMI)

The integrated waste management system in Balangoda consists of a MSW compost plant, a

septage treatment plant, a plastic pelletizer and an open dump site. The Balangoda compost plant project started as more of a community service to provide a solution for the solid waste problem, but later on it was converted to a business. This project was started in 1999 and has undergone several types of ownership due to plant failures and management decisions—first from private to public ownership, and now it is a public private partnership. The Central Environmental Authority and the provincial council funded the compost plant's construction costs and the access roads, with later expansion under the Pilisaru project. The Land Reform Committee gave the land to the project at no cost.

Balangoda city is known nationwide for its success in composting. The urban council is a recipient of national level awards and has received the President's Award for SWM in 2008 and the Green Job Award in SWM (Waste Management & Pollution Control) in 2009 and 2010.

Technology & Performance

The turning windrow composting system is the technology in use. Hand-sorted MSW is heaped in piles with dimensions of 1.6 x 1.6 x 4 m. Every pile is turned using a mini front loader (also called bobcat) and moisture is added for 6 weeks during the composting period. A temperature of more than 60^{o}C is maintained inside the pile while confirming final product safety during the initial stage. After the composting period, the processed material is heaped and allowed to cure. The piles are left for maturation for a minimum of one to two weeks. In reality, compost is sieved when a purchase order is received, and the extended maturation period can be enjoyed in most cases. Then the compost is sieved through a 6 mm sieve to get the fine particles of compost. The moisture level in the final compost is maintained at 15%.

The treatment of night soil involves a cost-effective technology that does not consume much energy. The septage is unloaded into a settling tank, and that allows gravity thickening. The liquid portion (effluent) is treated using a wastewater treatment plant and passed through a charcoal filter to a constructed wetland for further treatment. The purified water is used in the compost plant, and unused shares are released to the environment. The sludge is sent to 2 drying beds and dried for 28 days. This dried fecal matter is mixed with compost to make high nutrient compost (called super compost).

To add value to the compost product, the following strategies are applied (a) Animal waste is buried in the middle of the pile, (b) half-burned rice husk is incorporated, (c) rock phosphate is added to increase the phosphorous content and (d) compost is blended with dried fecal sludge.

Social Aspects

Balangoda Urban Council (BUC) had faced numerous problems from the public due to the dumping of nearly 20 t of waste per day near the sports ground situated in the centre of the city. Today, the council is running a successful composting project under a public-private-partnership agreement while providing a sustainable solution for MSW. Since the present

composting site is situated just eight meters away from households, it is very important to maintain the aerobic conditions (in case anaerobic conditions arise, e.g., bad odour, fly nuisance, etc.). Therefore, strict process procedures need to be followed, e.g., compost piles are turned at appropriate intervals, thereby maintaining temperature and moisture; the site is kept clean; mixed waste is removed from site; etc. At present, citizens of the council are very much satisfied with these achievements. Due to the success of the venture, this service has been extended to neighboring authorities (i.e., BUC accepts waste from other local authorities for a nominal gate fee).

Seventeen workers from the locality are employed. These workers receive regular medical testing to ensure their health. Farmers benefit from the production of high-quality organic fertilizers. City dwellers benefit from the reduction of direct contact with untreated waste as well as from a city left clean and pleasant. The whole community benefits in numerous ways from this composting project.

A vocational training centre has been established at the same site to provide a diploma certificate in waste management and recycling; the course is called the SWM assistant course and has a low course fee. This diploma includes comprehensive exposure to field work in waste management and recycling. The course is conducted by the BUC in collaboration with the national vocational training authority and the Learn Asia organization. This diploma is equivalent to a national vocational qualification.

Economic Aspects

The Central Environmental Authority and the provincial council funded the construction of the compost plant and its access roads at a cost of US$300,000. The Land Reform Committee gave the land at no cost. Operation and maintenance costs are estimated at around US$1,340 per month. The council covered the initial operation costs until the project began making profit. Consumer segments are government projects, plantations, households and farmers, both locally and in the east of the country.

The Central Environmental Authority together with the urban council funded the construction of the night soil treatment plant and of collection centers for non-degradable waste (e.g., plastic, glass). Apart from the recovered resources from organic material, the municipality sells non-degradable materials to recyclers. Acting as the middlemen in the business, the urban council doubles the price paid for non-degradable products and earns 100% profit. The local authority sells MSW compost at US$0.08 per kg and 13% dry fecal sludge blended compost at US$0.11 per kg. In 2011, the council made a profit of $162. Data for 2012 and 2013 are not available.

Business Model

The plant operates under a public-private-partnership arrangement. The plant sells its products via sales outlets and agents, and the value proposition is high nutrient compost

instead a soil conditioner. The compost plant achieves breakeven from sale of the compost.

Highlights

- All the produced compost is sold and 100% cost recovery on operations and maintenance can be achieved with a tiny profit
- Farmers in the east of the country are a main consumer segment because soils in the east of the country are sandy and therefore synthetic fertilizer is not very effective.
- Frequent laboratory testing is conducted to confirm the quality of the product, while increasing confidence among farmers. A quality control protocol has been communicated to the customers.
- Interest of the political authority and the officer in charge is a highlighted fact.
- Sales outlets through agents are the channels of sale in far off locations.
- Multi-tasking workers (e.g., a supervisor who works as the bob cat driver) enhances efficiency.
- The council encourages segregation of waste at the source, and unsegregated waste is collected for a fee, while segregated waste is collected free of charge. This only governs the commercial area at the time of study and seems to be a success.
- Safety of the compost blending with dry fecal sludge is still to be determined.

Case 2: Kaduwela Compost Plant

Kaduwela is a rapidly urbanizing major town in Sri Lanka. In 2012, the population was about 250,668, and the daily waste generation in the area is 188 t. However, the total waste collection per day is 70–80 t (i.e., the collection coverage is 40%), and waste is being segregated at the source, and therefore 15 t of recyclable waste is collected per day. A total of 1,000 composting bins have been distributed to individuals as a promotion of home composting.

The Kaduwela compost plant is owned and operated by the Kaduwela Municipal Council, which was funded by the Western Province 2008. The plant's capacity is 5 t per day. The only input waste stream is MSW.

Kaduwela compost plant (Source: IWMI)

Kaduwela Municipal Council (KMC) is situated in Western Province. The KMC area has become a popular, urbanized and industrialized in the recent past, which has led to a dramatic increase of the amount of solid waste generated in the area. To solve the pressing SWM problem in the local authority, a composting plant has been introduced.

Another problem faced by the local authority is finding lands for final disposal of waste. Solid waste is dumped at a private ground in Bomiriya, Wattala, and KMC has to bear the disposal cost (at a per ton rate of solid waste disposed). Out of 75 t of total solid waste collected, 35 t is dumped at the land in Bopitiya, Wattala, where KMC has to bear an expenditure of US$ 1,115 per day, excluding transport cost.

Technology

Like most of the compost plants in Sri Lanka, KMC has also adopted the turning windrow composting technology. However, KMC does not properly practice the turning windrow composting process. Inadequate space for piling leads most piles to being combined. Due to inadequate space, larger piles have been constructed, which makes the turning process difficult. As a consequence of inadequate space, combined piles and various other factors, piles are not labeled, making it difficult identify the age of the compost.

Though KMC has conducted several awareness programs for the community, community participation is still just beginning. However, segregation of waste at the source started recently, and the quantity of segregated organic waste has increased from 5 t per day to 20–25 t per day. The plant's operational capacity is 40t per day. Unsorted waste is not collected by the council.

The plant is overloaded. To identify the scale of the issue, the plant is designed to have a capacity if 5 t per day, but the operational capacity is 25 t per day, which 500% over intended

capacity. Smooth operation is hindered by a poor location (e.g., it suffers from frequent flooding, which results in process failures) and by operating above capacity.

Most local authorities use their own land as dump sites, and therefore incur no extra charges on open dumping. Here the case is different: the local authority has to pay for the dump site because it is owned by a private owner. Therefore, the local authority tries to compost as much waste as possible without considering the effects on the quality of the final product.

Social Aspects

The most important social benefits from the project are

- 26 new employment opportunities (including workers, supervisors and security officers) and among them many permanent positions
- an annual medical clinic visit and regular health checks for workers
- 25% of the revenue from compost is allocated to workers.

On the other hand, the composting plant of KMC has issues, such as birds, flies and odor, because as the aerobic composting process carried out as intended. Due to lack of interest in producing compost, most of the degraded waste does not get screened and disposed.

Economic Aspects

The average price of 1 kg of compost without any value added ranges from US$0.06 to US$0.12. The bulk supply is sold at US$0.05 to US$0.06 per kg. The KMC is planning to sell the product through cooperative shops. Currently, the monthly demand for compost is 1,113 kg for the selling price of US$0.07 per kg. The income from recyclables can be estimated to be US$385 per month. Main customers are home gardeners, the Divi Neguma program of the Divisional Secretariat office, garden designers and small-scale farmers. The sold amount is calculated as 1% of the total production, which is 90,000 kg per month. Cost recovery remains as 3% of the operations and maintenance cost. The main purpose of the plant seems to be volume and mass reduction through storage to ease transport and to reduce disposal, not compost production for the market.

After introduction of the compost plant, the amount of solid waste directed to the landfills has reduced, which in turn enables KMC to reduce its expenditure on disposal substantially; it is now more than US$30.8 per ton. Daily savings can be calculated with US$770 (i.e., US$23.075 per month), excluding the transport cost to Wattala, which is about 18 km. If cost recovery is 0%, the local authority can still save US$19,250 (five times the operational cost) by diverting the waste from the dumping site to the compost plant.

Business Model

The Kaduwela compost plant is owned and operated by the local authority. The only input waste source is MSW. This plant does not concentrate on selling compost as a revenue

generation activity. It relies on saving landfill charges and transportation charges due to volume reduction.

Highlights

- 20% of the land in the area is agricultural land, which could represent a consumer segment.
- Educated and high-income households make it easier to introduce segregation of waste at the source, home composting, etc., and these households could be a potential consumer segment for compost.
- High land value, due to high demand, has made it difficult to find enough land for low-return projects such as composting.
- It seems that focused regulations can make segregation of waste at the source practical.
- From the local authority's perspective, composting may be profitable even without any cost recovery if waste disposal has a fee (i.e., where savings are attained from reduced waste disposal).

Case 3: Kalutara Compost Plant (Phorawatta Compost Plant)

The Kaluthara compost plant is situated in Western Province in Sri Lanka, and it has a capacity of 38 t per day. This is a cluster plant, and it serves three local authorities, namely Kalutara UC (urban council), Kalutara PS (Pradeshiva Sabaha) and Panadura PS. This plant is managed by the Waste Management Authority of Western Province, which is a provincial level authority.

Kalutara Compost Plant (Source: IWMI)

Kalutara Urban Council (KUC) is situated in the third largest city, after Colombo and Negombo, in Western Province. Due to a large residential and moving population, SWM is a huge responsibility vested in the KUC.

Prior to the composting project, all collected MSW was openly dumped on Dambuwa Watta land. The first attempt to compost was initiated in 1999 and was an inclined step grate plant, but this plant ceased its operation in December 2003. Under the Pilisaru project, relaunch of operations, using the turning windrow composting method, was recommenced in 2011. So far, a huge amount of mixed waste is directed to the compost plant, but no segregation of waste at the source is in place. Three conveyor belts are installed in the plant to aid hand sorting. Sorted organic waste is directed to the compost plant, while the recyclables are separated and sold.

Technology & Performance

Following the lead of most of the Pilisaru project plants, the technology used in this plant is the turning windrow composting method. Piles are kept in an open area for one month and transferred to a roofed area for two months for composting. After the composting period, compost is allowed to mature until orders are received. This technology works smoothly, and there no public complaints have concerned process-related issues. The quality of the compost is tested every three months and was found to be at a satisfactory level. However, there is no proper leachate disposal mechanism, and there are many complaints from the community about unsustainable leachate management. At the moment, leachate is diverted to the adjoining unutilized land without any treatment. There are plans to install a leachate treatment facility, but nothing has materialized yet.

A pilot project concerning waste segregation has already started in Kaluthara North. As a result, almost all the solid waste received from Panadura PS is segregated. Separate tractors are to collect degradable waste, and about 6,000 bins have been distributed so far.

Social Aspects

The compost plant has provided many social benefits, apart from the general environmental and health benefits of a composting operation. The site-specific benefits are

- 24 new direct employment opportunities (17 laborers, 1 manger, 1 management assistant, 1 supervisor, 2 security staff and 2 loader operators)
- medical insurance of US$ 1,538 for workers and regular medical check ups
- an annual bonus of one month's salary
- training for workers from new plants
- comprehensive training for all plant workers

Apart from the above stated benefits, the plant has been able to absorb some of the staff members from the failed large-scale compost plant (known as the burns compost plant, a private investment). In return, the plant benefitted from the technical expertise brought by the employees and the consumer network of the failed company.

Economic Aspects

The capital investment in the Kalutara compost plant is US$0.7 million. The monthly production of compost is 100 t, but so far it has only been able to sell 50% of the total compost produced.

The targeted consumer segment is the plantation sector, which has a high buying power, a high willingness to pay and large-scale consumers. The plantation sector is also very interested in soil conservation properties. As a result, compost is sold as a soil conditioner without any value additions. The plantation sector seeks to purchase bulk quantities of compost, and the compost is sold in areas like Galle and Mathugama. The rest of the compost is sold to domestic garden farmers directly from the outlet at the plant. There has not been any promotion to support marketing of the product, but if promotions were conducted they would likely increase the amount sold. To increase the confidence of the plantation sector, frequent quality monitoring mechanisms are in place. Kalutara compost plant strictly adheres to the required safety standards. The consumer segments are tea and cinnamon plantations (60%) and home gardeners (40%).

The current revenue generation is about US$3,450 per month from compost and US$385 from recyclables, and the recovery of operations and maintenance costs can be calculated to be 66%. This can be considered a remarkable achievement for a compost plant without any value addition strategies and a low percentage of sales. The present degree of cost recovery could be improved further by implementing appropriate strategies. This shows that high-quality soil conditioners can be marketed at higher prices if the correct consumer segment, with a real need and high purchasing power, is targeted.

Business Model

The Kaluthara compost plant is operated by a public provincial-level authority. The plant aims to produce a high-quality soil conditioner and has been able to attract consumer segments with high buying power, such as the plantation sector.

Highlights

- Well-trained staff**,** technical experts and the marketing expert have experience from a private sector compost plant.
- High quality soil conditioner has high value in selected markets.
- Strong quality control and monitoring mechanism strengthen the product.

The plant recovers 66% of the operations and maintenance costs.

Case 4: Wariyapola Compost Plant

The Wariyapola compost plant is owned and operated by Wariyapola Pradeshiya Sabaha, and it is situated in North Western Province. The population of the PS area is 120,000. The waste generation can be estimated to be 48 t per day, and the total waste collection is 5–10

t per day (i.e., the collection coverage is 20%). Of the collected waste, 2.5 t of organic waste is directed to the compost plant per day. The plant's capacity is 3 t per day, and it only receives MSW as input material.

Wariyapola Compost Plant (Source: IWMI)

Wariyapola Pradeshiya Sabha (WPS) is situated in the Kurunegala District of North Western Province. WPS has won first place in the managerial contest conducted among 33 local government authorities in the North Western Province. Though WPS had introduced a proper waste collection system, operating according to a timetable, no proper waste treatment mechanism, except for open dumping, existed until 2012. With the financial assistance of the Pilisaru project and the provincial council, WPS has started a composting project in an acre of land in Iswetiya Hena, Imbulanegama area.

From the beginning, WPS had a well-planned waste collection system. WPS collects organic waste from Monday to Saturday and inorganic waste on Monday, Tuesday and Friday. WPS has introduced its own bylaws for proper SWM. There is a fine for unsorted waste from shops and institutes and a charged waste tax for collection services from industries. An awareness program regarding waste segregation was done for commercial institutions, and separate containers for polythene, paper & plastics have been distributed. After the effort of doing several awareness programs, segregation is practiced by both domestic and commercial waste generators within the town limit. However, segregation of waste is still not practiced in the sub-town area.

Of the waste collected by WPS, 50% is turned into compost, and 10% of the solid waste is recycled. Hence, only 40% of the solid waste is currently being diverted to the open dump.

Technology

WPS also practices the turning windrow system like most other local authorities in Sri Lanka. Piles are constructed in an open area initially and then moved into a roofed area. However, pile sizes vary depending on the tractor loads received at the plant. Turning of the piles is done once per week for six weeks. Salvinia (*salvinia molesta*) and dried banana leaves are added to the top of the pile. Decomposed waste leftover after screening is directed back to the piles. After six turns, the piles are kept for maturation for two weeks prior to screening. Though there are no flies at the site, cranes are attracted to the site. Two cows were brought to the site to attract cranes for a biological control of larvas and eggs. However, inadequate capacity of the leachate collection systems has also caused disruption in the operation of the plant, but no process failures have been observed.

Social Aspects

The social benefits of the compost plant can be summarized as

- 11 new employment opportunities
- good gender balance in the labor force, including a female environmental officer
- an annual trip combined with a visit to another plant
- medical check-ups every three months
- a program for schoolchildren to collect recyclables
- free compost for schoolchildren
- technical training and capacity building for workers
- lakes and tanks are indirectly cleaned because water hyacinth is used as a raw material in the compost production

Economic Aspects

The capital cost for establishing the compost plant was US$ 38,076. Total operations and maintenance costs can be calculated to be US$1,190 per month. The composting plant produces 1,500 kg per month. The capacity is ten times lower than that of the Kalutara plant. The selling price is US$0.05 per kg. So far, only 1% of the produced compost is sold and the revenue from compost sale is US$21/month, and the revenue from recyclables can be estimated to be US$44/month. As a result, 5% of the plants' operations and maintenance cost is recovered. Present consumer segments are home gardeners and vegetable and fruit farmers. WPS is in the 'coconut triangle' with large coconut plantations. However, the plant has still not been able to capture this market because it is not able to provide quality assurance.

Further, WPS has provided compost and plants free of charge in order to promote home gardening, but the demand remains low. It seems that no adequate value additions are in place to increase the interest of the farming community.

Business Model

The plant is a publicly owned compost plant. The main targeted consumer segment is

smallholder farmers, and therefore nutrient enrichment is conducted by adding local high-nutrient waste to the compost to increase the value proposition of the final product.

Highlights

- Wariyapola is situated in middle of coconut plantations and vegetable farms. Without proper quality control and confirmation, it is difficult to access high-end markets such as plantation industries.
- Without proper nutrient enhancement it is hard to attract farmers.

Case 5: Weligama Compost Plant

The Weligama compost plant is situated in Southern Province in Sri Lanka. This plant is owned and operated by the Weligama urban council. The population of the urban council area is 130,000, and the total waste collected per day is 15–18 t. The waste collection coverage is 53%. Of the waste collected, 7–8 t of is sent for composting per day, and 750 kg of compost is sold per day at a rate of US$0.07–0.08 per kg.

Weligama compost plant (Source: IWMI)

Weligama Urban Council (WUC) used to dispose of MSW at an open dump site close to Colombo (Wellawaya (A2), main roadside land). After being garbage dump, these 7.3 hectares of land were covered with soil. Later, the dump was turned into a compost plant. Now the previous dump site has been converted into an integrated waste management and organic farming unit.

WUC became one of the significant waste management projects that attracted a large audience. This project is not another pilot project, but it is a success case. The local authority collects 68,000 households' worth of waste and covers 53% of the total population in the

area. WUC is the only local authority in Sri Lanka that makes a profit out of a composting project (the Balangoda compost plant is more of a breakeven). Today, WUC is not in position to satisfy the compost demand and hence expands its service and accepts additional waste from neighbouring towns (e.g., Imaduwa town).

Technology & Processes

The turning windrow composting system is used as the composting process. The piles are arranged in open areas initially or under roofing, depending on the weather condition. The additional advantage of constructing piles outside the plant during the dry season is that any larva (flies) are destroyed with the exposure to direct sunlight and the heat generated within the pile, thus avoiding fly nuisance. The piles are turned over every fortnight for aeration. The septage collected by WUC is stored in a tank located in the plant and used in piles in the early stages of composting to enhance the nutrient value. It takes eight to ten weeks to complete the decomposition process. When piles enter the maturation stage, the particle size is further reduced using a shredder/cutter. Then the compost is obtained by screening the material using a mechanical huller.

Social Aspects

Apart from the general social and environmental benefits from a compost plant, the following site-specific benefits can be listed:

- 25 new direct employment opportunities (23 laborers, 1 supervisor, 1 security staff)
- incentives, annual trips and medical schemes for laborers
- opportunities for women (females are employed for sorting waste)
- waste disposal is reduced by 70% due to composting and recycling of waste
- training centre for other local authorities and free training courses on composting

Economic Aspects

The Weligama compost plant is one of the best examples of how successful a composting project can be. The Weligama urban council's marketing success is based on 'word-of-mouth referrals' and the demonstration of farm plots situated next to the compost yard. All of the available compost is sold currently, for a price of US$0.07–0.08 per kg. Compost demand is 10,400 kg per month, and consumer segments are home gardeners (60%), tea plantations (30%) and farmers and landscapers (10%).

The operational and maintenance cost of the plant can be estimated to be US$12,750 per month, and the cost recovery is 106%, thus the plant is achieving a 6% profit, beyond covering operations and maintenance. Instead of relying only on income from compost sales, innovative high-value products are produced using compost. This is the key for high financial sustainability. The Weligama UC invested considerable efforts in 'greening' their composting plant with vegetables, fruits and flowers, and it also established a nursery that uses the compost for seedlings. The site, which is a practical demonstration of the use and

effectiveness of the compost, looks attractive to customers who park their vehicles to buy fresh fruits or to have a leisurely stopover. During their stopover, customers also buy compost and vegetables, fruits and flowers from the adjoining nursery. The Weligama sales outlet comprises a fruit juice stall, restaurant, seeds, seedlings, plant stalls and a livestock farm. The existing composting site is surrounded by banana, papaw trees and other vegetable patches, all of which are fed by compost manufactured at the plant. Livestock is fed with selected waste that is received from the compost plant. Recyclables, such as plastics, glass, cardboard, etc., are being sold to traders in the city creating additional income to the project.

Business Model

The Weligama compost plant is also owned and operated by the local authority. Instead of selling compost, the plant sells high-value products from compost, such as fruits, vegetables, fruit juice, seeds, etc. As a result of producing products with a high value proposition, the plant enjoys a tiny profit.

Highlights

- WUC's composting project is making profit by producing high-value proposition products instead of just compost.
- A demonstration farm acts as the indicator of compost quality while generating additional income for the project.
- A high level of political commitment is a key to success.
- Instead of soil conditioner, high nutrient compost is produced by co-composting with fecal sludge.
- High-value waste is used as animal feed instead of as raw material for compost.
- No segregation of waste at the source is practiced yet, but the project is still a success.

5.5 Conclusions

- Resource recovery from waste is one of the key priorities of the government of Sri Lanka, and public institutions seem to work hard to divert waste from open dumps.
- Under the government-funded Pilisaru project, many composting initiatives have been established and most of them are facing a lack of long-term financial sustainability. Besides, they face difficulties in the marketing of compost.
- The main competitor for compost seems to be synthetic fertilizer as a result of the high subsidies in place. Fertilizer for some of crops is less heavily subsidized than fertilizer for paddy crops. Crop types for which fertilizer is not subsidized can be potential consumer segments.
- The plantation sector has a high interest in compost due to attention in maintaining soil properties and due to high demand and high price for organic products in the international market.

- A proper organic product certification system is still to be developed. A local organic food market is not yet developed.
- Provincial councils can play a more active role in waste management than they currently are. The Western Provincial Council is a good example of the role that they can play.
- Political commitment is a key factor in a compost plant succeeding.
- The financial success of compost plants seems dependent on a few key facts:
    - Nutrient value: Nutrient enhancement of the product is necessary if the targeted consumer segment is farmers. Fecal sludge seems to be a great nutrient resource and can be co-composted with MSW.
    - Product quality: High-quality compost with quality confirmation is needed to promote compost in the plantation sector. In this case, nutrient enhancement may not be a need, and willingness to pay seems high.
    - High-value products: Instead of focusing only on compost, marketing of high-value products from compost (e.g., fruits, plants) is a successful strategy.
    - Cost of dumping: If waste a disposal tax or charge is in place, composting may prove to be a more cost-effective option than open dumping.

6. COMPOSTING IN DEVELOPING COUNTRIES: SYNTHESIS OF LESSONS LEARNED

For the four countries included in this research, relevant parameters that concern composting were assessed. Guiding questions were

- at what development stage are the countries when it comes to composting?
- what are the main drivers that enable composting, and what are barriers that could explain why intended developments and benefits could not be reached?
- what are the best suited business models for the various approaches and economies of scale?
- is there a market for composting products and if so, is the market good enough to support sustainable composting operations? And if not, what could be done to provide supporting mechanisms that could foster greater use of compost?
- what are the lessons learned from the evaluated countries and case studies?
- what are key learnings and enhancement measures that we should share with decision and policy makers?

6.1 Legal framework

The research findings from the analysis of policies on waste management, reuse and recycling from organic waste streams in Ghana, India, Bangladesh and Sri Lanka show similar trends. Sector laws that provide rules and regulations for roles, responsibilities, technology options, licensing, financing, incentives, penalties and more are available in general. For SWM, the responsibility for implementation is in all cases assigned to the local municipalities. Although regulations exist that allow private businesses to get involved in public waste management, so far only some municipalities are able to integrate private sector support in a sustainable manner. Many legal prescriptions appear conclusive at a first glance and mandate 'what has to be done'. However, detailed regulations or guidelines that could answer how a certain task should be done to be in line with best practices, sustainable and efficient are often lacking or incomplete. For example, although waste segregation is legally mandated in many of the legislations cited, input materials for composting projects still have to be gathered from collected mixed waste, and hence waste needs extra treatment for secondary material segregation. Many composting plants have to deal with comparatively high residual fractions of municipal waste, which affects business efficiency and requires extra efforts. Besides, regulations that support introduction and application of new technology options are mostly insufficient, and hence the needed innovations are delayed.

Many local waste management officers lack expertise and guidance and need to acquire know-how to implement innovations on their own. Very often, their focus is more to comply with legal mandates, while innovations and private business integration or support is given

lower priority. The latter may delay potential enhancements or hinder the business sector to partner with municipal waste management operations. Only some municipalities appreciate the benefits of informal sector involvement or private business efforts for resource recovery and recycling. Although the public sector indirectly saves money on avoiding waste collection and disposal, many municipalities fail to allocate the saved funds to support and upscale beneficial informal sector or private sector business projects that enhance municipal waste management. Although recycling is envisioned, and law demands reduction of waste disposal, clear mandates for recycling quotas or waste disposal reduction with time targets are missing. Nevertheless, reducing the amount waste disposed remains a relevant driver for composting and recycling activities because land for waste disposal is scarce and local resistance prevents establishment of new disposal sites.

An additional barrier that may hinder the private sector's strong support of waste management is the disintegration of laws that concern waste management, resource management, agriculture, sanitation, renewable energy use from waste, and more. Potential materials that could substitute primary resources could be gained from the waste stream, but their recovery is not explicitly demanded or rewarded through national waste management legislation. Resource recovery is only considered 'optional', which may be insufficient to overcome various barriers that hinder establishment of innovative technologies. The fragmentation of sector laws requires extra efforts by the private sector, and often keeps businesses from proposing or defending potential investments and from establishing technologies that could enhance value added, product variety and quality.

Most composting operations analyzed within this research are not optimized yet. Several gaps need to be addressed and barriers overcome in order to provide conditions that could put composting on a more sustainable pathway. Waste recycling demands joint efforts of various disciplines and sectors. An integrated multi-sectorial approach, including participation of all concerned sectors and harmonization of sector policies, is needed. Relevant stakeholders should be engaged in the formulation and implementation of policies and development of projects that could serve as role models in composting. This would likewise enhance collaboration between the various governmental agencies concerned (environment, agriculture, sanitation and renewable energy) to better drive composting agendas in the countries.

In Ghana and Sri Lanka, efforts were made to enhance environmental sanitation policies that enable recovery of additional input materials for co-composting as part of new waste management strategies. In India, a new legal prescription now requires chemical fertilizer to be sold in combination with compost or organic fertilizer in order to increase organic matter in soils (Fertiliser Control Amendment of India, 2013). This law amendment had a significant positive effect, mobilizing both the private sector and fertilizer trading companies, and may be a good example of policy support to enhance compost application in low-income countries. Although this approach was followed in Bangladesh, composting business

development there is much too low to show positive effects on the market. However, the cited examples and approaches are trendsetting and need to be scaled up to gradually enhance business models and the economic viability of compost operations in other countries. Increasing application of organic fertilizer would contribute to enhancing farming and soil conditions, in addition to providing other benefits for communities and the environment.

To secure better policy support, it is recommended to request national governments to strengthen their regulatory framework by implementing policies and programs that increase waste recycling into agriculture and alternative energy. Such efforts would also serve other global concerns, such as mitigation of climate impacts and enhancement of ecosystem services. Presently, the agriculture and energy sectors are the main contributing sectors of GHG emissions in most low-income countries, based on many GHG inventories reported to the Intergovernmental Panel on Climate Change.

6.2 Institutional arrangements

Regardless of whether composting or other recovery and recycling technologies for organic waste are applied, operators depend on functioning arrangements with involved governments, authorities and relevant stakeholders to sustain operations. Such well-functioning relationships positively influence the availability and quality of input materials (i.e., the supply criteria) and ensure sufficient and reliable product sales to customers (i.e., demand criteria).

In order to promote compost and resource recovery from organic waste, many national and municipal governments provide support programs that offer subsidies for composting projects. In this research, the countrywide composting program initiated by the national government in Sri Lanka (the Pilisaru project) is a good example that demonstrates how institutional arrangements can motivate composting development and assist in overcoming development barriers (see page 110). A similar trend is emerging in Ghana, with public-private-partnership initiatives springing up across the country. Although such arrangements are very important to increase motivation and to extend magnitude and coverage area of composting, further support mechanisms are needed to secure sustainable operations. Compost producers have to compete with business models that offer much stronger economic incentives (e.g., chemical fertilizer) or with low-cost organic fertilizers such as manures. In many cases, compost producers need to undergo lengthy and costly licensing procedures for plant operation, product application and marketing, but they are hardly supported by involved governmental agencies or with incentives such as tax deductions or support mechanisms that could enhance organization of input materials and product marketing.

In some cases, agreements concerning composting made between private business entities and municipal authorities were not fulfilled by the public sector, as in the case of Zoomlion

(in Accra, Ghana, see page 45) where the local government failed to pay the agreed share for provided services over a long time, resulting in a debt of approximately US$5,263,158 as of August 2014. In India, the government had mobilized composting with the set up of 60 composting plants nationwide in the 1990s. Only around 10% of the composting plants established under this initiative are still operating. A renewed trend with set up of 270 new composting plants was started in 2005, and it will be interesting to monitor and evaluate if framework conditions for composting are now more favorable in India. The reported experiences show that instead of being supportive, complex institutional and municipal processes can themselves become an additional barrier during operation. Therefore, institutional arrangements should be given high priority and be clarified at an early stage of project development, preferably in a legally binding manner with the concerned municipalities if a private business development is intended. It may be supportive to involve other relevant stakeholders or to form a special 'composting business forum'.

6.3 Business models

In composting, one can distinguish between two basic business incentives:

a) business models that primarily aim to support municipal waste management and hence mainly rely on cost recovery from tipping and processing fees, whereas compost and other products of material recovery add to increased revenue
b) composting business that aim to serve farmers and agri-businesses and therefore focus on sourcing suitable input materials and on producing quality products, whereas organic waste from municipal waste management is less relevant for the success of business operations

Experiences from the countries included in this research show a wide variation, from small to large scale, with business operations being conducted by local governments, at the community level, with NGO support, as public-private partnerships or as independent, private business.

Ghana: Compared to the other countries analyzed in this study, Ghana's municipal waste composting business is very limited. For ages, farmers have been using different types and forms of compost for agriculture. In the northern rural areas, it is not uncommon to find household pits composed of food waste and animal manure. This type of composting is usually practiced in very small scale for vegetable gardening around the homestead. Toward the southern part, poultry manure composting has been carried out for many years. With the rising cost of inorganic fertilizer (subsidized only from 2008-2013) and concerns over its environmental impacts, farmers and other stakeholders are encouraging the development of a more sustainable source of soil amendments, such as compost and its derivatives. Currently, municipal waste composting mainly takes place in the large urban areas. The biggest composting plant, the Accra Composting and Recycling Plant of Zoomlion, has the capacity to process up to 600 t of waste per day and is founded a on public-private-

partnership arrangement with the district assemblies. DeCo!, another composting plant, is run as a social enterprise composting initiative in Tamale, in the northern part of the country, while Jekora composting plant is a private enterprise in Accra, in the southern part. Apart from these, several other composting initiatives are ongoing, and many more are in the pipeline, especially initiatives for co-composting MSW with fecal sludge.

India: Composting is the preferred municipal waste processing option in India. Most composting projects integrate MSW into their business models and are operated by the public, public-private partnerships, private sector actors or private partnerships with fertilizer companies. The majority of the MSW processing facilities in India are either aerobic composting plants or vermicomposting facilities. Vermicomposting is mostly practiced on a small scale, with up to 10 t per day, more in rural areas. More relevant for composting are large-scale composting plants in cities that mostly apply windrow composting, often the Indore method. Typical sizes range from 200–400 t per day processing capacity; some larger composting plants are designed to have capacity to process up to 1,000 t per day. Product enhancement for final products is mostly done by sieving. In the 1990s, the main business model was for municipal compost plants to receive municipal waste and to process all fractions of materials that had been delivered, including by compost production, recovery of non-organic recyclables and, often, landfilling operations. One of the few business models from this development period that still exists is the Karnataka Compost Development Corporation in Bangalore (page 71)..

The latest trend shifts business models more toward private operations. Many local governments now start to outsource waste processing facilities to the private sector through public-private partnerships. Two trends are observed: a) investment and set up of the facility is done by the municipality, and operations are later handed over to a private operator (for example, Terra Firma Biotechnologies in Bangalore, page 73 73); b) a private operator is invited to set up the facilities itself and to cover its own expenses through operation revenues (for example, A2Z Infrastructure Private Limited Ludhiana, page 75). For the private operators, the business model is to generate revenues via compost production, sales of alternative fuels, sales of recyclable materials and tipping fees from the served municipality and from private users. Lately, plants started to explore options to get additional revenues through clean development mechanism (for example, IL&FS Environment Infrastructure & Services Ltd, page 76).

Bangladesh: Compared to the other Asian countries analyzed in this study, Bangladesh is still in its infant stages when it comes to composting, although various national policies that promote composting are in place. At present, only around 2% of organic waste is recovered from municipal waste streams that contain 70-80% organic waste in average (BMDF 2012). Segregation of waste at the source is hardly practiced, and most of the waste is collected by smaller vehicles at the community level. Recovery of sellable materials is mainly conducted by the informal sector. Composting is promoted by various sector laws, but so far the

majority of ongoing composting projects are initiated and funded by foreign development support (e.g., ADB, EU, Swiss government, GIZ, UNICEF, see page 110). Hence, most composting projects are owned by municipalities, but they are run by NGOs at smaller scales with 1–5 t per day capacities, often serving as demonstration and learning facilities (Waste Concern, Dakar and PRISM, Khulna City). Only one larger composting plant exists in Dakha, and it is operated by the NGOs World-Wide-Recycling and Waste Concern (see page 89).

One private initiative was reported for Khulna City where RUSTIC, a private company, operates a compost plant that is owned by Khulna City Corporation. The plant receives about 65 t MSW per day and outputs 25–30 t of compost daily. This compost product was certified under the brand name RUSTIC Compost Jaiba Sar by the Ministry of Agriculture in 2012 (see page 95). This case could be used for scaling up and initiating similar projects in other locations. However, business models for private composting operations are new for Bangladesh, and significant barriers, such as chemical fertilizer substitution, lack of markets, low awareness of farmers and more, need to be addressed first to verify viable business models in the Bangladeshi context.

Sri Lanka: Due to the country being an island and the fact that only some (30) municipalities out of 331 produce more than 50 t solid waste per day, private sector development in composting remains low in Sri Lanka so far. National laws that promote composting are established, and awareness to better reuse organic matter from waste streams is increasing. The Sri Lanka national government set up a countrywide composting development initiative called the Pilisaru project. This project offers local governments a grant to finance investments needed to establish a composting plant, whereas its operation has to be refinanced by user fees, revenues from compost sales and municipal subsidies. At present, 115 composting plants are operated by local governments and have been established in Sri Lanka under this program. Most of these municipal compost operations report ongoing compost production, but cost recovery remains below 30% of operation cost. Further options on how to enhance the revenue situation or to establish public-private partnerships have to be explored.

6.4 Market conditions

The findings of this study confirm that large-scale composting could be economically feasible under certain premises (Ghana and India), but it is often unsustainable due to poor quality of input materials, and hence low compost quality, unstable markets or failure to understand the market and to create sufficient demand for compost. To streamline compost quality, a technical standard that addresses waste management and compost processing concerns under specific country conditions is needed. Although compost quality standards are available in most countries included in this research, it is questionable if the provided regulations sufficiently guide compost producers and give them incentive to establish mechanisms and technologies that produce quality products that satisfy farmer needs. In Ghana, this aspect was followed up, and it was proposed to establish a stakeholder platform

that includes all compost producers and involved relevant institutions such as the Environmental Protection Agency, the Ghana Standards Board, concerned ministries and others to guide quality control and use of compost products. This platform also aims to prepare guidance papers in a participatory manner, while relevant aspects, such as a framework for product and quality declarations, selling procedures, pricing and quality control of the compost, could also be streamlined to provide fair and balanced market conditions for all concerned private business operators.

Furthermore, it may be useful to drive the development of markets for organic produce, e.g., through an organized system of labeling and through quality control, so that demand for organic products and organic fertilizer gradually increases. This trend could be enhanced if innovative farming segments that target cash crops, e.g., vegetable or fruit production, can be developed.

The market conditions in India are very challenging. Two types of markets can be distinguished between: a) urban markets where the compost is purchased for gardening, landscaping and kitchen gardens and b) rural markets where the compost is sold to the farmers for food and plantation crops. The demand in urban areas is marginal but consistent, with around 5%, whereas most of the compost needs to be sold to distant farming markets. Business viability is threatened by large transport distances and seasonality. Many composting plants have huge compost stocks that do not meet farmers demand, and sometimes compost is given away for free or even sent to landfills in order to proceed with operations. These findings imply that thorough assessments of supply and demand are a relevant precondition for designing plants, ensuring that the size of the plant correlates with market demand prior to launching operations.

6.5 Funding

The development of composting projects is often hindered by lack or uncertainty of funding. Some projects are run as municipal activities and depend on restricted public budgets, or projects are delayed because of intra-municipal competition for funds, or funding requests from private operators are denied because the business is considered to be 'uncertain' or 'risky'. The experience from the Pilisaru project in Sri Lanka shows that national governments can play a decisive role in driving municipal development priorities. Funding the recovery of operational budgets is another challenge for the public sector. As learned from several cases from India, development of larger compost projects as private businesses depends foremost on the municipality securing supply of input materials and on subsidies via tipping or processing fees. Although private funding of investments is an option, project development appears easier and more sustainable if the public sector develops a composting project, including the initial investment and plant construction. Operations can be handed over to a private partner later. This may assist in speeding up development processes (e.g., licensing) and in reducing the capital cost for loans that would decrease the cash flow needed to sustain operations. Projects that aim to include input materials from municipal waste

streams should in any case include a partial subsidy from the served municipality as a mechanism to stabilize the funding of maintenance and operations cost.

For private business operations, funding is the main force driving ventures into composting. Hence, funding needs to be given proper attention when planning to replicate composting programs. Project-based finance will always end, and hence there is need for business models that allow any reuse initiative to sustain itself. Besides tipping or processing fees and revenues from product sales, other funding sources can be relevant, for example government exemptions on imported machinery, tax deductions or government incentives to support loan packages. Experiences from many developing countries have shown that composting projects that were funded and operated by the public sector are less sustainable or need higher subsidies than privately operated projects. If the state creates a congenial atmosphere, the private sector can explore a cost recovery model for compost production that satisfies common and competitive business standards. In any case, private operators are in a better position to operate freely and to partner with various other businesses, customers and stakeholders as needs arise, whereas municipal enterprises foremost have to fulfill their public mandates.

Awards for innovative projects could also be another funding source, as can be seen in the case of DeCo! in Ghana. DeCo! received the honored SEED Initiative Awards in 2010. It was one of 30 winners (out of 428 projects), exemplifying their innovative strategy. The SEED Awards for Entrepreneurs in Sustainable Development is an annual award program that searches for the most promising, innovative and locally led social and environmental startup entrepreneurs in countries with developing and emerging economies. The SEED initiative website[11] explains the process of selection by an international jury of experts, who choose businesses that have the potential to make real improvements in poverty eradication and environmental sustainability while contributing to a greener economy. The SEED award is not solely a funding mechanism. SEED winners receive technical support and training from a team of experts, offering the businesses access to knowledge, expertise and networks to strengthen and grow their strategies.

The case of Waste Concern in Bangladesh is an example of drawing funding from different sources. The initial design was a community-based composting model that values public and private partnerships to recycle organic waste and improve interrelated aspects of social, economic and ecological concerns. It was an approach that exemplified not-for-profit efforts and viable solutions for social integrity. Waste Concern initially depended on donations and personal finances, but when it demonstrated success in its pilots, the project attracted the

[11] http://www.seed.uno/

interest of donors and other stakeholders, including the Bangladeshi Ministry of Environment and Forests, the United Nations Development Program, UNICEF, etc. Financial incentives are critical components to a program's success.

To enable successful private sector involvement, the state must provide the needed policy framework to safeguard economic framework conditions, to guide quality concerns and to promote compost usage by farmers in order to enhance marketability of products. In addition, proving the economic return from composting through proper research, training and awareness building campaigns will further secure governments' support of private-sector driven composting initiatives.

6.7 Use of local input materials and appropriate technology

To allow set up of a year-round composting operation, availability and quality of input materials are relevant aspects. Arrangements have to made to provide suited input materials that are a) sufficient in quantity at all times of operation and b) are suited to produce quality compost. Whereas organic waste content is relatively high in all municipal waste streams in developing countries in general, suited raw materials that allow for producing quality compost, and especially that guarantee high NPK content, are more difficult to provide because access to such materials depend on very good segregation prior to composting. Moreover, desired additives to enhance NPK values, such as chicken manure, mineral fertilizer or cow dung, may be costly (also due to transport logistics) or are competing products since they are much cheaper for farmers. Organic input materials from municipal waste streams are in general of lower quality.

Results of this research confirm that the identification of input materials depends largely on regional conditions, especially land use, socio-economic conditions, geographical setting, agriculture development, etc. It is therefore mandatory to conduct a specific survey that clarifies sources, availability, quality, cost and logistics of composting feedstock for the specific business case. Such studies should include assessments of any future expected development and changes, whether related to agriculture, size of populations, seasonality or economies that may influence waste generation.

Having appropriate technology and technical competence in place is very important for any composting initiative. Otherwise it will fail, as in the case of the Teshi compost plant in Accra, which was too sophisticated to be maintained in a sustainable manner.

6.8 Perception and Behavioral Changes

It is important to understand both what kind of perceptions and whose perceptions are relevant and need to be addressed in setting up a composting initiative. For example, it might be necessary to support every composting project with an environmental awareness program or promotions affairs and demonstration projects for farmers. Relevant processes,

related to developing, licensing and operating composting projects and marketing of products, have to consider perceptions, positions, behavior and feedback of the main stakeholders and clients. In fact, the perception regarding a business activity and its products are a result of all efforts and creativity provided, also of shortcomings and failures that may have affected clients' 'likes and dislikes' over a longer period of time. In most businesses, dealing with client-related perception is the main task of marketing experts, who try to influence clients' views and who often aim to gradually change perceptions and behavior of customers in order to enhance consumption patterns. One of the main barriers in the composting business is the link to waste management because 'waste' for many people usually corresponds to 'low value' or 'dirtiness'. Compost may still have a negative image due to the input materials used, such as MSW or sludges, which could potentially result in bad quality. End users and farmers often lack knowledge about compost and its benefits. Misconceptions may be confirmed if the nutrient value of compost is compared with that of chemical fertilizers and consideration of the long-term effects is neglected.

Composting products are hardly attractive since they appear as bulky goods loaded on trucks, sometimes enhanced through packing in a white or colored sacks that contains a brand name and some information. But farmers, the main customers for compost products, make decisions on compost acquisition based on the information available to them. Findings of this research confirm a need for improved access to information on the value chain of compost production and the benefits of compost application for farmers.
However, marketing information and packaging have to be made available to farmers in forms that they can understand and adequately apply. Often, information is disseminated to farmers through various channels, such as agricultural extension officers, farmer-based organizations, NGOs and demonstrations on individual farms. Farmers prefer information and recommendations provided people they already know, ideally recommendations from other farmers. One approach to strengthen the communication channels between compost producers and farmers is by leveraging the agricultural extension officers and representatives of NGOs that already support farmers in compost application, capacity building and knowledge sharing. Activities that provide platforms to strengthen knowledge sharing on a farm-to-farm level can also be effective. This was found to be effective in the case of Deco! in Ghana.

6.9 The Way Forward: Lessons to Be Learned

Innovative ways of using and adding value to the organic components in waste streams, along with new business opportunities, are emerging in both developed and developing countries. In developed countries, the main drivers of this development are increasing environmental awareness, technology changes, banning of waste disposal and growing demand for alternative raw materials, e.g., for renewable energy. Increasing use of alternative raw materials also strengthens resilience, lessens dependency on and costs of raw material imports and meets carbon market incentives. The carbon market has become a significant factor since many developed countries agreed to comply with GHG emission

reduction targets, as per the Kyoto Protocol.

In developing countries, agricultural needs prevail. For example, low cost fertilizers, such as manures from livestock or byproducts of agro-industries (organic sludge, mud press from sugar production, etc) are already being reused. While vast resources, in the forms of MSW and sludge from sanitation, could still be tapped as additional input materials, especially in urban settings, the biggest challenge to scaling up is financing the capital for investments. Other challenges include consumer and community acceptance, market demand and transport costs. Wider adoption at scale could take place if compost, for example, is fortified with a mineral fertilizer to meet agricultural needs of diverse farmers.

New approaches show that organic waste recovery can be enhanced, for example by using combined technologies that treat waste with anaerobic technologies to produce biogas and generates byproducts such as biomass that can be used as alternative solid fuel and compost for agriculture. Often, further value adding takes place, e.g., production of fertilizer, feeds, energy pellets and heat and/or electricity. These technologies seem to be 'low hanging fruits' to be tested in developing countries. Future research and interventions on composting of municipal waste in developing countries should focus on enhancing technology and product quality together with policy frameworks, market conditions and environmental awareness to overcome barriers as discussed in prior chapters.

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7. CONCLUSIONS AND RECOMMENDATIONS

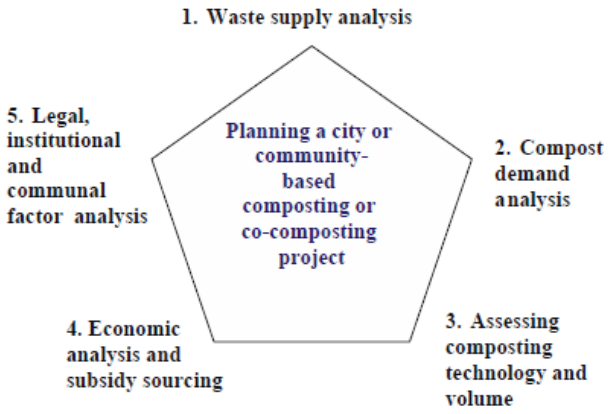
In low-income countries, composting has clear advantages for municipalities and farmers, but it may not automatically offer mutual win-win options for both parties, except when it is properly planned and well-coordinated. Municipal waste management departments are mostly aware of the advantages they can gain from composting, especially concerning reducing cost and efforts for waste collection, transport and final disposal. Ideally, composting should take place close to the source of waste generation to increase savings as much as possible. With this intention, compost sale is not the main target but a necessary condition.

Revenues from compost sales are mostly much lower than savings from reduced collection and disposal efforts. Farmers, on the other hand, would be interested to benefit from compost. However, farmers' willingness and ability to pay is often lower than the cost of compost production in general. This aspect has to be considered for compost pricing in order to sustain product application and marketability. But demand and price dimensions depend also on the type of farming system and the income level of farmers. Furthermore, farmers need compost close to the point of application. They are usually hesitant to search for fertilizer in distant markets, and they prefer to deal with local providers. The challenge is to balance demand and supply of waste input as well as to harmonize economic, technical and institutional issues to make composting a sustainable venture.

This study reconfirmed findings and recommendations made in prior research in many aspects, and it especially highlights the need for thorough analysis of the established five key aspects of composting, which allows for selecting an appropriate recycling technology at the appropriate scale of intervention (see figure 7.1) (Drechsel et al. 2004; Cofie et al. 2006; Cofie et al. 2008). The main factors for this analysis are

- waste generation (quantitative and qualitative waste supply analysis)
- compost demand by potential users (market analysis, willingness and ability to pay)
- waste processing and scales (technical options considering supply vs. demand)
- economic analysis (competing products, collection and processing costs, best locations, economies of scale and subsidy sourcing)
- options and constraints related to legal, institutional and local communal settings

Figure 7.1: Waste recycling framework



(Source: Cofie et al. 2008)

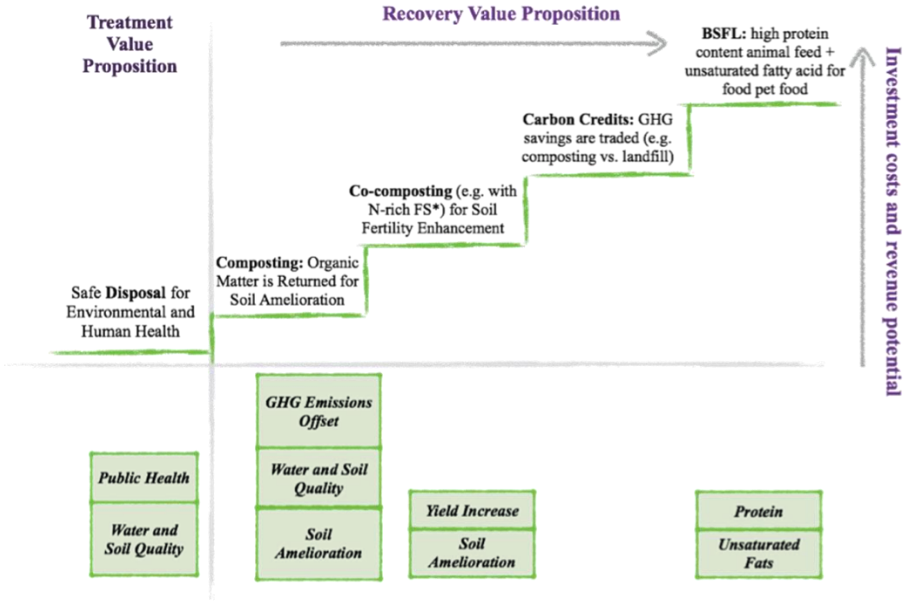
Composting is costly if done at any significant and commercial scale. However, unlike in the developed world, it is more difficult to establish composting as a profitable endeavor. Whereas business operators in developed countries can rely on comparably high subsidies, which are guaranteed by stable waste collection fees from municipal waste management systems, composting businesses in low-income countries face harder constraints, especially with regard to receiving subsidies from public funds or fees from users. Collecting waste management fees in low-income countries—where the majority of users live below poverty line—is a challenge. In many cases, cost recovery for provided municipal waste services stays far below 20%, e.g., 15% on average in the case of Ghana.

However, subsidies are needed to stabilize compost operations. Although the public sector indirectly saves money on avoided waste collection and disposal, municipalities mostly fail to allocate saved funds to support and scale up beneficial private sector business projects that enhance municipal waste management. Hence, planners for private composting operations have to keep in mind that subsidies for composting might be limited (in volume or in time). Therefore, operational expenditures must be kept as low as possible. This means that low-technology options may best serve to avoid large investments and related accumulating debts and that all options for cost recovery through compost sales should be explored to reduce dependency on the permanently constrained public budgets. Compost prices, however, have to be reasonable in order to be competitive with other organic soil enhancers, such as manures, to match farmers' willingness to pay.

Compost quality is an important prerequisite in the sustainable use of compost. As MSW is generally of low quality, especially in terms of nutrient content, which is the most immediate need of farmers, it is important to add value to MSW compost, as was addressed in the case of Waste Concern, Bangladesh and in the case of Fortifer development in Ghana. The greater the added value, the more investment cost and revenue potential increase as a result (compare trends in figure 7.2) Therefore, the scaling up of operations has to be approached

carefully and needs to be matched with farmers capability or willingness to pay and market changes prior to starting production.

Figure 7.2: Ladder of value proposition: From safe disposal to composting, co-composting and enrichment. As investment costs increase, the value also increases.



(Source: Otoo and Drechsel, forthcoming)

The findings of this research indicate that technology innovations and economical enhancements are desirable to enhance business models. Options in reach are to better combine and integrate municipal waste management, agriculture and renewable energy production. It is foreseen that technical options for composting and treatment of organic waste must be upgraded in order to make business models more viable, attractive and environmentally safe. Further research may assist to clarify options and conditions that would allow adaption of innovative technologies that are already used in industrialized countries. Select technology adaptations could increase the market value, including via complementary benefits such as climate mitigation and renewable energy from biomass. However, related research must also address that socio-economic, cultural and natural conditions in developing countries vary considerably. Thorough adjustments may be needed to adjust to specific country conditions, whereas the latter need to be clarified within a participatory approach to integrate all relevant stakeholders in the development process.

8. REFERENCES

Abraham, E.M. 2011. *Improving urban water quality for livelihoods enhancement in the Odaw-Korle River Catchment of Accra, Ghana*. PhD Dissertation. University of Greenwich, UK.

Adamtey, N.; Cofie, O.; Ofosu-Budu, K.G.; Danso, S.K.; Forster, D. 2009. Production and storage of N-enriched co-compost. *Waste Management* 29(9): 2429-2436.

ADB (Asian Development Bank). 2011. *Towards Sustainable Municipal Organic Waste Management in South Asia. A Guidebook for Policy Makers and Practitioners*. Mandaluyong City, Manila, Philippines: Austrian Government Aid Program..

Ali, S.M. (ed.). 2004. *Sustainable Composting: Case Studies and Guidelines for Developing Countries*. Loughborough University, UK: WEDC.

Ankrah, D.A.; Owusu, E.S. 2012. *A market survey for scaling-up fortified excreta pellets for market use in Ghana*. (Unpublished report submitted to the International Water Management Institute).

Bandara, N.J.G.J. 2008. Municipal Solid Waste Management. *Proceedings of the Sri Lankan Case Conference on Developments in Forestry and Environment Management. Colombo, Sri Lanka*. Pp. 20–5.

Banegas, V.; Moreno, J.L.; Moreno, J.I.; Garcia, C.; Leon, G.; Hernandez, T. 2007. Composting anaerobic and aerobic sewage sludges using two proportions of sawdust. *Waste Management*. 27(10): 1317-1327.

Birley, M.H.; Lock, K. 1999. *The Health Impacts of Peri-urban Natural Resource Development*. Liverpool, UK: Liverpool School of Tropical Medicine.

BMDF (Bangladesh Municipal Development Fund). 2012. *Study on Municipal Solid Waste Management – Final Report*. Chittagong City Corporation, Rajshahi City Corporation, Rangpur Municipality and Patuakhali Municipality. Bangladesh.

Bogdan, L. 2010. *ECO Labels 101: Green Certifications Explained*. Available at http://www.inhabitat.com/demystifying-eco-labels/ (accessed on October 25, 2014).

CCAP (Center for Clean Air Policy). 2013. *Tackling Waste through Community-Based Composting: Bangladesh*. Washington DC, USA: Center for Clean Air Policy.

CEA (Central Environmental Authority: Pilisaru Project). 2013. *Compost plant database*. Colombo, Sri Lanka: Central Environmental Authority.

Central Bank of Sri Lanka. 2013. *Annual Report of the Central Bank of Sri Lanka 2013*. Colombo, Sri Lanka: Central Bank.

CHF International. 2012. *Value Chain case study. Developing a value chain for a new product: Compost in Accra, Ghana*. Accra, Ghana: CHF International.

CIA (Central Intelligence Agency). 2014. *The World Fact Book*. Available at https://www.cia.gov/library/publications/the-world-factbook/fields/2048.html (accessed on October 25, 2014).

Cofie, O.; Nikiema, J.; Adamtey, N.; Impraim, R.; Rao, K.C.; Fernando, S. Forthcoming. *Recycling of nutrients and organic matter through co-Composting of faecal sludge and municipal solid waste*. Colombo, Sri Lanka: International Water Management Institute.

(CGIAR Research Program on Water, Land and Ecosystems. Resource Recovery and Reuse Series 3).
Cofie, O.; Van Rooijen, D.; Nikiema, J. 2014. Challenges and opportunities for recycling excreta for peri-urban agriculture in urbanising countries. *Water Science and Technology Library* 71: 301-310.
Cofie, O.; Kone, D.; Rothenberger, S.; Moser, D.; Zubruegg, C. 2009. Co-composting of faecal sludge and organic solid waste for agriculture: Process dynamics. *Water Research* 43(18): 4665-4675.
Cofie, O.; Danso, G.; Larbi, T.; Kufogbe, S.K.; Obiri-Opareh, N.; Abraham, E.; Schuetz, T.; Forkuor, G. 2008. *Livelihood Support Potentials and Policy Issues for Urban Agriculture in Accra, Ghana*. Available at http://ruaf.iwmi.org/Data/Sites/4/PDFs/Accra%20UPA%20paper%20-%200309.pdf (accessed on November 8, 2014).
Cofie, O.; Bradford, A.; Drechsel, P. 2006. Recycling of Urban Organic Waste for Urban Agriculture. In: *Cities Farming for the Future; Urban Agriculture for Green and Productive Cities*, (ed.), Veenhuizen, R. Philippines: RUAF Foundation, IDRC and IIRR.
CPCB (Central Pollution Control Board). 2013. Status report on municipal solid waste management. Ministry of Environment & Forests, New Delhi, India
Danso, G.; Drechsel, P.; Cofie, O. 2008. Large-scale urban waste composting for urban and peri-urban agriculture in West Africa: An integrated approach to provide decision support to municipal authorities. In: *Agricultures et développement urbain en Afrique subsaharienne : environnement et enjeux sanitaires* (eds.), Parrot, L. et al. France, Paris: L'Harmattan (Ethique économique).
Danso, G.; Drechsel, P.; Fialor, S.; Giordano, M. 2006. Estimating the demand for municipal waste compost via farmers willingness-to-pay in Ghana. *Waste Management* 26(12): 1400-9.
DoA (Department of Agriculture). 2011. *Agricultural Statistical Hand Book*, Colombo, Sri Lanka: Department of Agriculture.
DoA (Department of Agriculture). 2014. Integrated plant nutrient systems – IPNS. Available at http://www.agridept.gov.lk/images/stories/site/Institute/Publication/ipns.pdf (accessed on August 20, 2014).
Drechsel, P.B.; Keraita, O.; Cofie, O.; Nikiema, J. Forthcoming. Productive and safe use of urban organic wastes and wastewater in urban food production systems in low-income countries. Book Chapter
Drechsel, P.; Cofie, O.; Danso, G. 2010. Closing the rural-urban food and nutrient loops in West Africa: A reality check. *Urban Agriculture Magazine* 23: 8–10.
Drechsel, P.; Cofie, O.; Fink, M.; Danso, G.; Zakari, F.; Vasquez, R. 2004. *Closing the rural-urban nutrient cycle. Options for municipal waste composting in Ghana*. (Final Scientific Report on IDRC project 100376. Unpublished).
Durand, C. 2013. *Sustainable Waste Management Challenges in Developing Countries*. Ideas for Development Blog coordinated by the Agence Française de Développement. Available at http://ideas4development.org/en/sustainable-waste-management-challenges-in-

developing-countries-charlotte-durand (accessed on July 24, 2014).
EDB (Export Development Board, Sri Lanka). 2014. *Organic products.* Available at http://www.srilankabusiness.com/organic/ (accessed on August 8, 2014).
Etuah-Jackson, I.; Klaassen, W.P.; Awuye, J.A. 2001. Turning municipal waste into compost: The case of Accra. In: *Waste composting for urban and peri-urban agriculture: Closing the rural-urban nutrient cycle in sub-Saharan Africa,* (eds.), Drechsel, P.; Kunze, D. Wallingford, UK: CABI Publishers.
Fernando, S.; Drechsel, P.; Amirova, I.; Jayathilake, N.; Semasinghe, C. 2014a. Solid waste and septage co-composting as a pathway to cost and resource recovery in Sri Lanka. *Proceedings of the 1st Specialist Conference on Municipal Water Management and Sanitation in Developing Countries, Bangkok, Thailand, 2-4 December 2014.*
Fernando, S.; Drechsel, P.; Jayathilake, N.; Semasinghe, C. 2014b. Performance and potential of the public sector municipal solid waste compost plants in Sri Lanka. *Proceedings of the SLCARP International Agricultural Research Symposium, Colombo, Sri Lanka, 11-12 August 2014*.
Ghana Standards Authority. 2011. *Good Agricultural Practices for Ghana (GHANAGAP): Part 1-Code of Practices for Crop Production*. Ghana Standard: GS 949-1:2011. Accra, Ghana: Ghana Standards Authority.
GoG (Government of Ghana). 2013a. *National Fertilizer Policy*. Accra, Ghana: Ministry of Food and Agriculture.
GoG (Government of Ghana). 2013b. Fertilizer and Seed Subsidy Programme Implementation. Accra, Ghana: Government of Ghana.
GoG (Government of Ghana). 2012. *National Urban Policy Framework*. Accra, Ghana: Ministry of Local Government and Rural Development.
GoG (Government of Ghana). 2010a. *Environmental Sanitation Policy*. Accra, Ghana: Ministry of Local Government and Rural Development.
GoG (Government of Ghana). 2010b. *Plants and Fertilizer Act 2010, Act 803*. Accra, Ghana: Government of Ghana.
GoG (Government of Ghana). 2007a. *National Water Policy*.. Accra, Ghana: Ministry of Water Resources Works and Housing.
GoG (Government of Ghana). 2007b. *Food and Agriculture Sector Development Policy (FASDEPII)*. Accra, Ghana: Ministry of Food and Agriculture.
GoG (Government of Ghana). 1997. *Public Utilities Regulatory Commission 1997, Act 538*. Accra, Ghana: Government of Ghana.
GoG (Government of Ghana). 1994. *Environmental Protection Agency Act 1994, Act 490*. Accra, Ghana: Government of Ghana.
GoG (Government of Ghana. 1993. *Local Government Act 1993, Act 462*. Accra, Ghana: Government of Ghana.
GoG (Government of Ghana). 1992. *The Constitution of the Republic of Ghana*. Accra, Ghana: Government of Ghana.
GOSL (Government of Sri Lanka). 2013. *Provincial Councils*. Available at http://www.priu.gov.lk/ProvCouncils/ProvicialCouncils.html#A6 (accessed on October

22. 2013).
GSS (Ghana Statistical Service). 2010. *Population and Housing Census*. National Analytical Report. Accra, Ghana: Ghana Statistical Service.
GTZ-GFA. 1999. *Utilization of organic waste in peri-urban centers. The decision makers' guide to compost production (with financial analysis tool)*. Hamburg, Germany: GFA. (Software tool, economic model, v. 0.9 E).
Gu, W.J.; Zhang, F.B.; Xu, P.Z.; Tang, S.H.; Xie, K.Z.; Huang, X.; Huang, Q.Y. 2011. Effects of sulphur and Thiobacillus thioparus on cow manure aerobic composting. *Bioresource Technology* 102(11): 6529-35.
Hargreaves, J.; Adl, M.S.; Warman, P.R.; Rupasinghe, H.P.V. 2008. The effects of organic amendments on mineral element uptake and fruit quality of raspberries. *Plant Soil* 308(1): 213-226.
Hoornweg, D.; Bhada-Tata, P. 2012. *What a Waste: A Global Review of Solid Waste Management*. Washington D.C., US: Urban Development & Local Government Unit, World Bank.
Hoornweg, D.; Thomas, L.; Otten, L. 1999. *Composting and its applicability in developing countries*. Washington D.C., US: World Bank. (Urban waste management working paper series 8).
IDCOL (Infrastructure Development Company Limited). 2014. *Towards a greener future. 2013-2014 annual report*. Dhaka, Bangladesh: Infrastructure Development Company Limited, Government of Bangladesh.
IFOAM & FiBL. 2014. *The World of Organic Agriculture. Statistics and Emerging Trends 2014*. Bonn, Germany: International Federation of Organic Agriculture Movements (IFOAM) & Frick, Switzerland: Research Institute of Organic Agriculture (FiBL).
IFOAM & FiBL. 2006. *The World of Organic Agriculture. Statistics and Emerging Trends 2006*. Bonn, Germany: International Federation of Organic Agriculture Movements (IFOAM) & Frick, Switzerland: Research Institute of Organic Agriculture (FiBL).
Idrissu, S.N. 2012. *Feasibility of incorporating composting into faecal sludge treatment plant and agriculture in the western region of Ghana*. An M.Sc. Thesis submitted to the Department of Agricultural Economics and Agribusiness, College of Agriculture and Consumer Sciences, University of Ghana, July 2012.
Katalyst 2009. Licensing Issues and Reforms in Bangladesh Organic Fertilizer Market; available online at: http://www.katalyst.com.bd/docs/tpieces/tpieces01.pdf
Keraita B; Amoah P; Drechsel P; Akple M. 2014. Enhancing adoption of food safety measures in urban vegetable production and marketing systems. *Proceedings of the International Symposium on Urban and Peri-Urban Horticulture in the Century of Cities: Lessons, Challenges, Opportunities. Dakar, Senegal, 6 December 2010. Vol 1,* (eds.), Nono-Womdim, R.; Mendez, D.; Gutierrez; Sy Gaye, A. Leuven, Belgium: International Society for Horticultural Science.
MENR (Ministry of Environment and Natural Resources). 2007. *National policy on solid waste management*. Colombo, Sri Lanka: Ministry of Environment and Natural Resources.
MENR (Ministry of Environment and Natural Resources). 2005. *Database of municipal solid*

waste in Sri Lanka. Colombo, Sri Lanka: Ministry of Environment and Natural Resources.
Ministry of Finance and Planning. 2010. *Sri Lanka the emerging wonder of Asia: Mahinda chintana vision for the future: The development policy framework*. Colombo, Sri Lanka: Government of Sri Lanka.
MOA (Ministry of Agriculture). 2013. *Fertiliser Control (Amendment) Order, 2013*. Government of India. Available at http://agricoop.nic.in/imagedefault/inm/Amendment2682013.pdf (accessed on October 4, 2014).
MOA (Ministry of Agriculture). 2003. *Fertiliser Control (Amendment) Order, (1985)*. Government of India. Available at http://agricoop.nic.in/actsrules.html (accessed on October 4, 2014).
MOEF (Ministry of Environment and Forestry). 2000. *Municipal Solid Waste (Management & Handling) Rules, 1999*. Government of India. Available at http://envfor.nic.in/legis/hsm/mswmhr.html (accessed on December 15, 2013).
MOUD (Ministry of Urban Development). 2000. *Manual on Municipal Solid Waste*. Central Public Health & Environmental Engineering Organisation (CPHEEO), Government of India.
Nikiema, J.; Cofie, O.; Impraim, R. 2014. Technological options for safe resource recovery from fecal sludge. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 47p. (Resource Recovery and Reuse Series 2).
Ofori, R.A. 2013. *Integrated Waste Management. Source Separation and Composting of household waste in Ayuom farming community in Bosomtwe District of Ashanti Region.* MSc. Dissertation. KNUST University, Kumasi, Ghana.
Osei-Asare, Y.B. 2009. *Status of Organic Agriculture in Ghana: A Survey of Consumers, Producers, and Marketers*. Available at http://www.ifoam.bio/sites/default/files/page/files/status_of_organic_agriculture_in_ghana-_a_survey_of_consumers_producers_and_marketers_.pdf (accessed on July 24, 2014).
Osei-Bonsu, P.; Adjaottor, A.A.; Owusu-Boateng, G. 2014. Characterisation of solid waste in the Atwima-Nwabiagya district of the Ashanti Region, Kumasi-Ghana. *International Journal of Waste Management and Technology* 2(1).
Otoo, M.; Drechsel, P. (eds.). Forthcoming. *Resource recovery from waste: Business models for energy, nutrient and water reuse.* Routledge and IWMI.
Owusu-Sekyere, E.; Osumanu, I.K.; Yaro, J.A. 2013. Dompoase Landfill in the Kumasi Metropolitan Area of Ghana: A 'Blessing' or a Curse'? *International Journal of Current Trends in Research* 2(1).
PROSHIKA. 2004. *Ecological Agriculture Program. Provincial Council Act - Democratic Socialist Republic of Sri Lanka*. Provincial Council Act (1987) (No. 42). Sri Jayawardenapura, Sri Lanka: Parliament of Sri Lanka. (Available at www.proshika.org/ar_2003_04).
Rashid, Z.S. 2011.. Composting and Use of Compost for Organic Agriculture in Bangladesh. *Proceedings of the 4th International Conference for the Development of Integrated Pest*

Management in Asia and Africa held on 20-22 Jan 2011, Dhaka, Bangladesh.
Rostami, S.V.; Pirdashti, H.; Bahmanyar, M.A.; Motaghian, A. 2012. Response of soybean (Glycine max L.) yield and nutrient uptake to three consecutive years application of municipal solid waste compost. *International Journal of Agriculture and Crop Sciences* 4(8).
Sharholy M S, K Ahmad, G Mahmood, RC Trivedi.. 2008. Municipal solid waste management in Indian cities–A review. *Waste Management* 28(2): 459–467.
Singh, S.; Singh, B.; Mishra, B. 2012. Microorganisms in Sustainable Agriculture and Biotechnology. Springer Netherlands.
Uddin, N.M.; Ahmed, S.; Halim, G.M.A. 2010. Status of Organic Farming in Bangladesh, Country Paper. *Presented in the Regional Workshop on ANSOFT of AFACI-PAN-ASAIN project held on 29-30 Nov. 2010 RDA, Suwon, Korea*.
Vázquez, R., Cofie, O.O., Drechsel, P. and I.F. Mensa-Bonsu, 2002. Linking urban agriculture with urban management: A challenge for policy makers and planners. In: C.A. Brebbia et al. (eds.): The Sustainable City II. Urban Regeneration and Sustainability, WIT Press, 925-934 Wolkowski, R.P. 2003. Nitrogen management considerations for land spreading municipal solid waste compost. *Journal of Environmental Quality* 32(5): 1844-50.
WPC (Western Provincial Council). 2013. *Waste Management Authority*. Available at http://www.wpc.gov.lk/chief-ministry-waste-01.htm#Aims%20and%20Objectives%A0 (accessed on October 4, 2013).
Yousuf, T.B. 2005. *Sustainability and Replication of Community-Based Composting–A Case Study of Bangladesh*. PhD thesis. Department of Civil and Building Engineering, Loughborough University, UK.
Yousuf, T.B.; Rahman, M.M.; Huda, K.M. 2010. Municipal solid waste management in Bangladesh. In: *Municipal Solid Waste Management in Asia and the Pacific Islands*, (eds.), Agamuthu, P.; Tanaka, M. Society of Solid Waste Management Experts in Asia and Pacific islands.
Zurbrugg, C. 2003. Markets for Compost – A key factor for success for urban composting schemes in Developing Countries. *City Matters Magazine – Urbanicity, For Local Government and Urban Development*. www.urbancity.org.
Zurbrugg, C.; Drescher, S. 2002. Solid Waste Management – Biological treatment of municipal solid waste. *SANDEC News No. 5*. Duebendorf, Switzerland

Annex 1: Framework for case study analysis

Activity	Questions
Overview of the composting sector (solid waste) and its core particularities	• What is the size of the composting sector in the country? • Who are the main players of the composting sector (public, private, etc.)? And how is it organized (big versus community plants)? • Are there any regulations on solid waste recycling and how do they affect/support composting? • How is waste collection organized in the country or in specific cities? (any separation at the source or pre-sorting)? How does it affect the quality of compost? • What are the sources, volume and composition of waste generated (households, markets, etc.)? And how is it collected? • How is waste collection covered, recycled and disposed? • Is there a quality compliance system for compost? • What health considerations are covered during composting? • Are there any financial or fiscal incentives that promote or impede the development of biowaste or composting? What pays for composting (gate fee, compost sales, etc.)? • What mechanisms are in place to promote composting in the countries? • Is composting in competition with any other biowaste technology? • Is composting being developed in combination with other products (anaerobic digestion or manure) in order to improve its potential market or profitability?
Overview of the compost market and its core particularities	• What are the different market segments for the use of compost? What has been the recent evolution of the compost market? • What is the level of awareness of compost and its benefits for agriculture or other markets? Are farmers well educated on such products and their economic benefits? Does any compost marketing strategy exist and how effective is it? • What are the major reasons why farmers claim they don't use compost (e.g., quality, price, no need)?

	• What is the estimated market size and the different market segments for the use of compost? What has been the recent evolution of the compost market? • What is the level of development of organic agriculture? • Is compost a product allowed in labeling of organic foods? • What is the price of compost (for some localities for examples)? And can the cost be paid off by agriculture revenues? • What are the possible competing products used in agriculture, and which ones are more competitive and why? • Is organic agriculture well developed, and is compost a product allowed in the labeling of organic foods? • Are there some untapped opportunities for composting in organic agriculture? • What are the constraints/challenges facing the sector? • Is there geographically a good match between the composting plants and the compost market?
For a few composting plants (selected with the World Bank team*), detailed review of the operations * The selection shall consider criteria such as ownership type, capacity, and technology.	• What is the business model of the composting plants (centralized, decentralized, community, farmer-owned, market-based, etc.)? What is its designed capacity? And who owns the plant? • What is the history of establishment of those operations (trigger, initial interest, etc.)? • What is the performance level of the plant (how much waste treated compared to its designed capacity)? • What is the source of waste (households, market, etc.)? And how is it collected (municipality, private, etc.)? • How much compost is being sold or given away for free? And who are the users? • How do they sell their products (wholesale or retailers, bulk or small bags)? Is compost transport/delivery covered by the plant or the user? • What are the big budget lines of the plant (revenues and expenditures)? What is the sell price of compost and what is the part of transport in the price (if any)? • What are the sources of financing (capital and operation)? • What is the level of success of the operations over time? Profitability, cost recovery, etc.? • Are there end markets nearby? Are those food crops or non–food based?

	• What is the effect of legislation and other regulatory mechanisms on the operations? • What challenges do the operations face across the value chain? How can the entire value chain be improved in these operations? • What are the benefits of the operations to the local communities and the general public?
Conclusion	• Identify the strengths and weaknesses of the legislations and regulatory mechanisms, on both waste management and agriculture. • Identify other key constraints/obstacles. • Propose recommendations to promote composting as a solid waste treatment alternative; enhance the use of compost in agriculture and sustainable land management; and sustain the financial performance of composting.