URBAN DEVELOPMENT SERIES
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Sustainable Financing and Policy Models for Municipal Composting

WORLD BANK GROUP

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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Produced by the World Bank's Social, Urban, Rural & Resilience Global Practice, the Urban Development Series discusses the challenge of urbanization and what it will mean for developing countries in the decades ahead. The Series aims to explore and delve more substantively into the core issues framed by the World Bank's 2009 Urban Strategy Systems of Cities: Harnessing Urbanization for Growth and Poverty Alleviation. Across the five domains of the Urban Strategy, the Series provides a focal point for publications that seek to foster a better understanding of (i) the core elements of the city system, (ii) pro-poor policies, (iii) city economies, (iv) urban land and housing markets, (v) sustainable urban environment, and other urban issues germane to the urban development agenda for sustainable cities and communities.

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Composting bin. Photo credit: © piotr_malczyk | Thinkstock.com

Foreword

Organic waste management is a growing global concern as cities experience increasing waste generation and the associated climate impact. Traditionally, municipal waste has been managed using a range of solutions, from advanced technologies, such as well-designed sanitary landfills in high capacity countries, to open dumping and burning in low-capacity countries. However, with rising consumption, scarce land, and escalating environmental impact, alternate waste treatment mechanisms are needed—ideally by "closing the loop" on the world's raw materials rather than allowing the negative impact of waste to compound.

Composting is a sustainable organics management solution that can potentially be low cost and require less technical capacity than alternative treatment methods. While the technical solutions available for municipal-level composting are well understood, the financing models and policy environments that create a conducive atmosphere are less so.

Since municipal solid waste generation is expected to continue rising, especially in low- and middle-income countries, along with the associated greenhouse gas emissions, this report attempts to understand how cities can more sustainably manage organic waste through composting. This research focuses on successful municipal-level composting models and the social, policy, and financial environments that enabled them. Starting with the pre-conditions needed in the initial planning phase to potential financing models and supportive policies that apply throughout, this report walks through the key factors a city must deliberate prior to pursuing composting as a waste management solution.

The anticipated audience for this work includes practitioners and policy makers. Readers are assumed to have basic technical knowledge related to composting but are not required to be experts in technology, policy, or financing matters. There is no single model that is applicable to all cities, rather, this report presents various financing and policy trends among successful operations in low- and middle-income countries. These common themes can serve as a starting point for building a composting sector, but the specific models appropriate for waste collection, composting operations, scale, production, and distribution will differ by city.

While many models of composting have been tested, the following qualities were consistent for the successful projects studied within the report. With regards to capital expenditures, all received external funding support to establish operations. However, all later became financially self-sufficient through a mix of operational revenues. While for a period of time carbon markets provided a financial incentive, the most salient revenue sources today are tipping fees, compost sales supplemented by sale of related services or goods, and importantly, avoided disposal costs. The compost produced in these cases targeted a specific customer segment and benefited from quality assurance measures that are standardized by policy.

This report, as well as a complementary report on Financing Landfill Gas Projects in Developing Coutries has been prepared in a collaboration with the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC). The CCAC is a global partnership of governments and organizations that works to reduce short-term climate pollutants in a number of sectors, including solid waste. The CCAC and the World Bank generously provided financing for the work conducted.

Information in the report is based on both primary sources, including field work, practitioner interviews and public records, and secondary source materials which are cited throughout.

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Acronyms

3R	Reduce, Reuse, Recycle
AD	anaerobic digestion
BOT	Build-Operate-Transfer
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide-equivalent
EU	European Union
GHG	greenhouse gas
LD	landfill directive
LFG	landfill gas
MBT	mechanical biological treatment
MSW	municipal solid waste
MT	metric tons
MTPD	metric tons per day
MTPY	metric tons per year
NGO	non-governmental organization
NQAS	national quality assurance system
PGS	Participatory Guarantee System
PPP	public-private partnership
QAS	quality assurance system
SLCP	short-lived climate pollutant
UN	United Nations
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
WMA	Waste Management Association

Executive Summary

Composting rates have been low in developing countries but are growing slowly at all scales. Composting is being adopted as an organic waste management strategy as well as a way to address climate change and agricultural needs. However, it is a solution that has been widely unsuccessful in low and middle income countries for a number of reasons including technical, financing and policy issues. This report focuses on the financing and policy environment that could lead to successful composting projects and the preconditions that must be in place before considering composting as an option.

Composting plants in developing countries operate in a fragile market. Consumers face competing products that can provide fast-acting results and are cheaper due to fertilizer subsidies. However, compost provides many advantages to the end user, varying from land restoration, moisture retention, and long-term crop nutrition. This paper discusses a number of operational strategies, reflecting on composting operations that have been succeeded and failed. These include designing an end product that fits a specific customer and end use, manufacturing high-quality compost from uncontaminated feedstock, utilizing quality assurance schemes and branding, and deploying business-savvy marketing and distribution schemes.

While all steps from determining a market to distributing compost products are important, a common failure seen globally is with regards to the feedstock utilized. A lesson learned repeatedly throughout the world is that pure organic materials will result in a higher quality compost product than contaminated organic materials. Agricultural waste and market waste tend to be the cleanest, most accessible inputs; however, some cities have experimented with mixed municipal solid waste (MSW) derived compost which quickly harms the reputation and development of the sector when not managed properly. There are opportunities to utilize source-separated MSW if strict quality enforcement exists.

Market considerations are only one piece of a complex puzzle. Other essential success factors for composting projects lie in the project's financial management and the policy environment of the locality. On the financial management side, experience has shown that while grants and loans are necessary for the initial buildout of the facility, operating costs must be financially self-sufficient. Aside from gate fees and sale of compost, projects have diversified their revenues through collection fees, sales of recyclables, consulting and educational services, and while markets were supportive, carbon credits. As evident within the upcoming narratives, financing strategies vary greatly by model and region.

Even if a composting project is soundly planned and financed, a plant cannot succeed without the support of an enabling policy environment. Policies that nurture the development of a composting sector include landfill taxes and organic waste disposal bans that channel feedstock to organic composting methods. In contrast, policies that stifle composting projects include those that create an uneven playing field between compost and fertilizers through subsidies and those that force organic waste treatment facilities to compete for feedstock. Ensuring that policies are aligned to support composters requires coordination between all stakeholders: national and municipal governments, NGOs, financiers, and the private sector. Beyond these policies, which help develop the composting sector, quality assurance of the product is a necessary mechanism to sustain operations.

While municipal-scale composting has traditionally been more successful in upper-middle and high-income countries than low-income countries, tried and true models are slowly paving a path for this cost-effective organics management technique around the world.

Report Approach and Structure

This report will provide an overview of optimal market conditions, common financing options, and enabling policy environments for composting projects globally. In order to understand the success factors of current composting practices, field research was commissioned in seven countries and one region: Austria, Bangladesh, Brazil, Ghana, India, Sri Lanka, Uganda, and Europe. Municipal-level composting is being undertaken nationally in these countries. However, each composting project occurs within differing circumstances and incentive structures. In practice, composting projects vary as much by national directions and practices as the social, policy, and economic environment of the city or locality—these case studies highlight the interplay between national and local conditions that enable the projects' success. This report is structured as follows:

- **Chapter 1** introduces background information on composting generally and discusses the opportunities and challenges faced in developing countries
- **Chapter 2** provides an overview of prevailing market conditions and strategies that would ideally lead to a sustainable composting sector
- **Chapter 3** details common financing mechanisms for composting projects that have been used for composting projects globally
- **Chapter 4** discusses the policy environments and incentives that promote composting production and market development

Chapters 5-10 offer the commissioned case studies that provide insights into national policies and enabling environments in different geographies. These allow for learning from tangible actions taken and associated outcomes. Shorter case studies or examples are provided throughout the report to illustrate other global scenarios.

- **Chapter 5** discusses Austria's decentralized, agricultural model of composting
- **Chapter 6** presents success factors behind Waste Concern, a private joint venture formed in Bangladesh
- **Chapter 7** features the organic farm model of composting in Brazil
- **Chapter 8** discusses a public and private composting operation in India
- **Chapter 9** describes a national grant program that powered municipal-scale composting in Sri Lanka
- **Chapter 10** highlights the history and development of organics recycling in Europe

A summary of the key lessons drawn from the global case studies is included in Table 1. For ease of reading, key messages and lessons are highlighted at the beginning of relevant chapters or sections throughout.

Table 1. Key Lessons from Global Case Studies

Market Conditions	Financing Mechanisms	Enabling Policies and Guidelines
Specific advantages of compost • Compost should **provide a clear value** to the local market • **Local needs differ**, and may include soil organic matter depletion, limited landfill capacity, water contamination from chemical fertilizers **A customer group must be targeted** • **Many potential customers** for compost exist (i.e., farmers, residents, landscapers, public works projects, nurseries, etc.) • **Customer identification** should employ a quantitative market assessment • Learn **whether a market exists** • Provide **consistent, quality product** to a *limited market* **Product quality a key determinant of success** • Compost is **reputation-sensitive** • **Quality standards** and branding can mitigate consumer fears • **Certification** can occur through a national accreditation body or peer evaluation • **Quality of inputs** determines quality of outputs **Marketing and distribution should be strategic** • Private firms can **expertly market and leverage existing distribution channels** • Products can be **used on-site**, sold on-site, or via secondary retailers • **Co-marketing** with fertilizers increases market access	**Common financing structures** • **Capital expenditures often require external financing** o Grants from national government or international organizations o Loans for larger or established organizations • Ongoing **operations and maintenance (O&M) should be financially self-sustaining** • Projects are typically financed through a **mix of sources** **Public sources** • **National governments** can spur activity through grants and subsidies • **Local governments** can levy taxes and fees, use reserve funds, issue bonds, or provide in-kind services • **User fees** for disposal influences public behavior while increasing revenue, but may be difficult to implement • **Carbon Emissions Credits** have funded projects but markets are weak **Private sources** • **Development banks** can provide low interest loans and grants • **Commercial and municipal banks** may provide loans and project financing • **Other institutions and investors** (e.g., NGOs) may provide loans or purchase equity • **Public-Private Partnerships** distribute risk to private operators and gain efficiency **Operational revenues** • Business revenues should support ongoing **O&M**, unless long-term subsidies are in place • **Compost sales** • **Gate fees** • Related businesses include: (a) Digestion for **liquid fertilizer and energy**; (b) **Recycling**; and (c) Other: waste **collection**, **education**, vocational **training**, **consulting**	**Compost guidelines and standards** • **National standards** on the production, composition, and marketing of compost • Mechanism of **enforcement** • **Coordination** between multiple stakeholders, including ministries of agriculture, environment, finance, and national and local governments • Implementation and enforcement by **local governments** **Diversion targets and disposal bans** • Waste recycling and **landfill diversion targets** • **Disposal bans** • **Source-separation requirements** • **Supporting infrastructure** and monitoring are needed **Competing policies** • **Uneven playing field for prices** o Subsidies for chemical fertilizers o Low gate fees for landfills for MBT • **Organic feedstock channeled to other uses** o Feed-in tariffs for renewable energy o Promotion of incinerators and alternative technologies **Incentivizing policies** • **Financial incentives include:** o Composting subsidies o In-kind support (i.e., land, labor) • **Market creation** can occur through mandatory co-marketing with other fertilizer and agricultural guidelines

Rows of mulch at a green waste recycling plant. Photo credit: © Photoroller | Dreamstime.com

1 Background for Sustainable Composting Project Models

Key Messages

Compost is an increasingly relevant mechanism for organic waste management in developing countries:

- Waste generation is estimated to reach 22 billion tons per year by 2025, driven by population, economic development, and increased consumption
- Waste in developing countries is primarily biodegradable: up to 65–75% in low income countries
- 45% of soils face nutrient depletion in certain areas, which is exacerbated by synthetic fertilizers
- Organic waste accounts for 2-4% of the world's greenhouse gas emissions

The advantages of compost are many:

- Cost: composting potentially reduces waste management costs by avoiding landfill fees, extending landfill life and reducing transportation costs
- Agriculture: when added to soil, compost replenishes nutrients and organic matter, sustains moisture and plant growth, increases plant uptake of fertilizers, prevents soil erosion and reduces irrigation requirements
- Environment: composting is a carbon neutral (and potentially even negative) natural degradation process. It reduces methane and toxic leachate generation from landfills as well as waste runoffs and algae blooms, which can disrupt the local ecosystem

Historically, compost projects in developing countries (particularly those dependent on municipal waste feedstocks) have struggled and have experienced high failure rates. Implementation has been limited, and best practice models are only developing. Only 8% of waste is composted globally, and as low as 1.5% in low income countries. Reasons include:

- Lack of coordinated policies, regulations, and enforcement that support composting across multiple sectors
- Lack of market demand, unreliable feedstock supply, and unfair competition (synthetic fertilizer subsidies)
- High operating costs due to unnecessarily complex technology poorly suited to local market conditions, often inadvertently encouraged by grants or subsidies that are provided up-front rather than based on outputs
- Poor management of solid waste operations
- Lack of tipping fees from the municipality and other feedstock suppliers
- Lack of compost standards, quality control and certification systems resulting in contaminated compost and a bad reputation with end users
- Reliance on revenues from carbon emissions credits as part of the Kyoto Protocol's Clean Development Mechanism, which contracted abruptly in 2012 with the expiration of the international agreements

continues

Key Messages (cont.)

Municipal composting models are most common in upper-middle and high-income countries. However, while each project differs based on local circumstances, elements of successful projects have been:

- A coordinated policy environment specifically designed to encourage composting such as through organic waste diversion and regulations that encourage end-product use, coupled with strong enforcement
- Availability of external funding (e.g., grants and subsidies) to cover some or all of the capital investment
- Financial self-sufficiency across a mix of revenue streams (e.g., tipping fees, compost sales, sale of recyclables, sale of related services & goods, carbon credits) to cover operational expenditures
- Use of low-tech options for affordable upkeep, especially where labor and land are inexpensive
- A guaranteed stream of clean, quality feedstock, or, well-separated and processed municipal waste
- Production of a specialized product that meets the needs of a well-targeted market
- Existence of compost standards, quality control and certification systems that are trusted by consumers
- An integrated waste management approach that increases the efficiency and financial viability of composting by streamlining waste delivery and processing, and increasing revenue opportunities
- Engaging external parties, such as farmers, NGOs, and the private sector to improve efficiency and credibility

1.1 Introduction

With rapid urbanization and economic development, cities are producing more than 1.3 billion tons of municipal solid waste (MSW) annually and expected to generate approximately 2.2 billion tons by 2025 (Hoornweg, et al., 2013). Approximately half of the global waste generated consists of biodegradable organic materials, but this ratio is typically much higher in developing countries. This organic waste is primarily disposed of in open dumps and landfills and decomposes to produce 3-4 percent of the world's greenhouse gas (GHG) emissions (United Nations Environment Programme, 2012; Blanco et al. 2014). At present, only approximately 8% of municipal organic waste is being utilized productively through composting, a sustainable organics waste management solution (Hoornweg and Bhada-Tata, 2012).

In spite of the opportunities surrounding organic waste re-utilization, varying from simple composting to anaerobic digestion (AD), MSW management is a significant challenge facing municipal authorities across the world. Providing solid waste management services is costly. In developing countries, waste management services can account for 20-50% of a municipality's recurring budget, with 80-90% used for waste collection alone (Hoornweg and Bhada-Tata, 2012). Often times, only a fraction of MSW is formally collected and even less is sustainably processed or properly landfilled. As a result, a great deal of MSW is either disposed of in poorly managed dumpsites, burned, or indiscriminately discarded in streets and local waterways, endangering human health and the environment. Rapid population growth and economic development across low-income countries has led to increases in consumption and associated waste generation rates. While simultaneously faced with inadequate financial resources and institutional capacity constraints, governments are under significant pressure as they attempt to manage the environmental and financial impacts of increasing volumes of solid waste. Utilizing organic waste productively reduces waste volume and diverts waste from landfills, which not only prolongs landfill life and reduces costs but also typically improves the state of public health, waterways, and long-term land value.

Composting is the process of optimizing the natural decomposition of food, garden, and agricultural wastes into a fertilizer-like product. It is a relatively low-cost strategy for converting a portion of the municipal and agricultural waste stream into a valuable material that can enrich the soil on farms, public lands, and gardens. There exist a number of climate-friendly disposal strategies for organic waste, including biochar production via pyrolysis, liquid fertilizer and biogas production through anaerobic digestion, and direct conversion to animal feed, with each having its advantages. However, composting can entail relatively simple, scalable technology, and is therefore well-suited to lower capacity countries. Anaerobic digestion, for example, can be more expensive, typically requires greater technical capacity, and has not been as popular for municipal solid waste management as it has for animal waste and wastewater.

In response to the increasing demand on the global food supply caused by economic and population growth, intensive cultivation and inadequate soil management have resulted in soil depletion and low crop yields. Across Europe, approximately 45% of soils are severely endangered by nutrient depletion[i] (Van-Camp, et al., 2004). Commercial, synthetic fertilizers provide quick nutrient boosts but can be cost prohibitive, requiring government subsidies in many developing countries. At the same time, concerns are growing over the human health and environmental impacts of excessive fertilizer use. Groundwater pollution and the resulting explosive growth of algae in surface waters from the runoff of water-soluble elements are disruptive to ecosystems and drinking water supplies. Further, after repeated applications and crop harvests, synthetic fertilizer depletes and reduces land to sandy, inert materials. Compost, on the other hand, releases nutrients and organic matter into the soil over many years, improving quality over the long term. In Bangladesh, the use of compost has resulted in a 30% reduction in the use of chemical fertilizer and a 35% reduction in irrigation required (Rashid, 2011).

From a climate perspective, composting could prevent alternative waste management methods that result in emissions. Composting facilitates a "carbon neutral" degradation process in the presence of oxygen as occurs in nature, rather than a net methane-emitting process, as occurs in landfills.

Composting can be done at the household or community scale up to the municipal or even regional level. A comparison of different composting scales can be found in Appendix 1 and municipalities can employ a mix of composting strategies to achieve their goals and reduce costs. However, composting has repeatedly proven challenging to implement at larger scales and even more so in developing countries. Despite attempts of development organizations partnering with governments over the past twenty years to develop the composting sectors of low-income countries, success has been limited. On average, only 1.5% of MSW is composted in low and middle income countries (Hoornweg and Bhada-Tata, 2012). A study of composting facilities in the State of Pernambuco, Brazil in 2000 revealed that of 41 facilities constructed in the late 1980s and early 1990s, only one was still operational.

What is causing this shortfall? While cost is a primary factor, the drivers of failure are nuanced and vary from a lack of targeted marketing efforts to an uncoordinated policy environment. While past failed models expose points of learning, recent composting projects have exemplified success factors as well, many of which are discussed within this report. In reality, composting is far from impossible; rather, it is a relatively new waste management model at a municipal level, and best practice models are only emerging.

This report is focused on key financial and policy considerations for building a sustainable municipal-scale composting sector, specifically in low- and middle-income countries. Composting projects in cities have been failing globally, and while the technical failures are more readily understood, the financial and policy environments are less so. In the past, carbon markets helped monetarily incentivize development of the composting sector; however, as they have become less reliable, other financing models and enabling environments should be considered for sustainable composting projects. This report assumes that the government would have financial and technical resources available to conduct a feasibility assessment for selecting a locally appropriate composting technology.

1.2 Municipal-scale Technologies and Operator Models

Municipal-scale composting is most common in upper-middle and high-income countries where countries are seeking to improve waste management mainly for environmental and financial objectives.

Composting can be carried out with varying levels of mechanization ranging from low-tech manually turned piles, to high-tech forced aeration systems in fully enclosed buildings or technologies equipped with bio-filters. The advantageous choice is not necessarily high-tech; depending on land and labor availability, cities may prefer a lower cost, manual process of aerated windrow composting versus an automated in-vessel composter. The selection of technology will also depend on the feedstock of organic waste that will be processed. For example, when using MSW, unless a strict source separation policy is enforced or pure organic waste is used, in-vessel composting will not be as forgiving as aerated windrow composting. Table 2 shows five common types of composting that differ by scale.

Operators of municipal-scale composting vary across the globe and include farmers, non-governmental organizations, private companies, and municipalities themselves. Depending on a city's capacity and funding situation, they might choose to manage organics in-house, contract with a private operator, or partner with an NGO. The case studies chosen for this report show a range of examples of different models that can be considered with different operators for various services, as shown in Table 3. For example, Chapter 5 highlights an innovative model in Austria where municipalities contract with farmers to collect and co-process municipal organic waste with agricultural waste; Chapter 6 details a joint venture in Bangladesh between an NGO and international funding and technical advisory partner that has created a replicable composting model throughout the country; and Chapter 9 highlights a government driven national initiative in Sri Lanka which has incentivized development of municipal composting facilities.

Table 2. Types of Composting Technologies

Type of Composting	Scale	Concerns	Resources required
On-site Composting Composting on premises using either a bin or a pit in the soil	Small	Odor control and vermin	Either a pit or bin
Vermicomposting Composting in bins where worms process organic materials	Small	Sensitive to temperature changes	Worm bins, worms
Aerated Windrow Composting Composting outside with organic materials structured in rows and regularly turned/aerated	Large	Siting requirements, zoning, regulatory enforcement (i.e., contaminant runoff), odor	Land, equipment, continual supply of labor
Aerated Static Pile Composting Composting with static piles of organic materials that are aerated internally with blowers	Large	Siting requirements, zoning, regulatory enforcement (i.e., contaminant runoff), odor	Land, significant financial resources, equipment including blowers, pipes, sensors and fans
In-Vessel Composting Composting via a mechanized machine that processes organic materials and then requires compost to mature outside the machine for two weeks	Medium	Consistent power necessary, financially intensive, technical expertise necessary	Electricity, skilled labor, ongoing financial resources, small facility/land

Source: United States Environmental Protection Agency

Table 3. Operator Models for Municipal-Scale Composting[1]

Location	System	Operator Model: Collection	Operator Model: Production	Operator Model: Distribution
Austria	Distributed farm-based composting operations	• Regional organic waste collected by local authorities and dropped at either a central pre-treatment facility or farm for a fee • Farmers sometimes hired by municipality to collect organic waste	• Farmers produce compost on-site	• Majority of compost is used on-site at farms • Remainder sold on-site
Bangladesh	Small-scale pilot facilities	• Facility workers collect waste from households	• Workers sort and produce compost using low-cost technologies	• Partner companies purchase, enrich, and distribute compost through pre-existing agricultural network
	Large scale central composting facility (joint venture)	• Clean market feedstock historically picked up for free • Company negotiating for free delivery of waste from city	• Local NGO and international recycling company partner to produce compost from clean market waste	• Fertilizer company purchases and sells compost to farmers through existing distribution network
Brazil	Organic farming cooperative	• Cooperative members contribute agricultural waste • Non-members can drop off waste for a fee	• Farm cooperative produces compost alongside anaerobic digestion	• Compost is given for free to member farms • Remaining compost is largely sold in bulk to agricultural markets • Small bags sold on-site for household use
India	State composting facility	• Mixed municipal, household and agricultural, and manure waste dropped off for gate fee	• Compost plant produces three grades of compost based on feedstock source	• Facility sells both own source compost as well as compost from other producers mainly to farmers • Delivery cost included in price
	Private composting company	• Mixed municipal waste dropped off by the city	• Firm sorts out recyclables and produces compost from remaining organics	• Company sells compost through distributors • Compost sold under own name, and in re-branded forms
Sri Lanka	Distributed municipal composting facilities	• Door-to-door collection of mixed household municipal waste • Source separated biodegradable waste from commercial generators collected and charged if waste is not separated	• Facility sorts out recyclables and produces compost from remaining organics	• Sold to farmers in eastern Sri Lanka through sales outlets and agents

[1] While operator models are summarized by country, it is important to note that municipal-scale composting and related partnerships are most often led by a city or local government.

Box 1. Stree Mukti Sanghatana's Waste Management Services in Mumbai, India

Stree Mukti Sanghatana (SMS) is a non-governmental organization that has overseen waste management operations in Mumbai since 1998. With over 3,000 wastepickers collecting, treating and disposing of waste on behalf of the municipal government in over half of Mumbai's wards, SMS operates based on zero waste philosophies.

In terms of organic waste management, SMS requires households to separate their waste into dry and wet waste and then utilizes the wet waste for composting or biogas. Wet waste in most residential areas is composted in pits on-site by the wastepickers, which reduces transportation costs, decreases emissions, and saves properties money by using the compost on-site. While services are being performed at a municipal scale, community-level composting has been chosen as an appropriate solution for Mumbai.

Source: Stree Mukti Sanghatana

1.3 Composting Project Investments in Developing Country Contexts

Municipal solid waste in developing countries is well suited for composting given that it is mostly comprised of organic matter; however, significant challenges may arise when obtaining feedstock, managing the waste, financing operations, and creating a conducive environment. Municipal organic waste typically includes food scraps, wood and, in some cities, yard (leaves, brush and grass) waste streams. Additional compostable feedstocks, such as agricultural and animal wastes and sewage sludge, may be part of a jurisdiction's waste profile but are typically collected and managed separately from MSW. The most important factor influencing waste generation and composition is the level of economic development of the area. In low-income countries, 65-75% of the MSW generated is organic, compared with an average of 28% in high-income countries (Hoornweg and Bhada-Tata, 2012).

Despite the favorable waste composition, composting projects globally must consider a number of factors when operating in a developing country context:

- *Waste composition.* The composition of incoming organic materials must be appropriate to the composting process and desired end use. In order to optimize the composting process, the feedstock must have a certain makeup including a certain ratio of carbon to nitrogen and a moisture content of 50-55%, among other criteria. Broadly speaking, food waste, grass, manure and sludge are considered high nitrogen feedstocks and must be blended with much greater quantities of wood, leaves and branches, which are high in carbon, to create an optimal composting blend. Access to a carbon source may be a limiting factor when designing a composting facility, and in some cases, facility operators may be forced to purchase carbon feedstocks in the form of wood chips, straw or sawdust. When compost products fail to meet the nutrient requirements of the end market, operators may also be forced to augment their product with nitrogen, phosphorous or potassium additives, which may come at a cost.
- *Waste management practices.* Waste in low-income countries tends to have a high organic fraction which is favorable for composting practices; however, the challenge lies in the collection and quality of the feedstock available for composting or other organic waste management practices. Waste collection services greatly vary by city, and even municipalities with significant waste management budgets may yield a program that serves less than 50% of citizens (Henry, et al., 2006; Memon, 2010). The biggest hurdle for many composting projects is obtaining a large volume of purely organic feedstock. The availability of uncontaminated organic materials is a critical determinant in whether a composting project has the potential to succeed or not. *A city's ability to obtain a consistent supply of clean feedstock and enforce source segregation practices within its existing waste collection program and scope of control is paramount to whether a composting project can proceed.* It is closely linked with

poor public perception of compost derived from MSW and misalignment from what is demanded by end users. Some composting operations have integrated composting into their greater waste management systems, achieving economies of scale with feedstock delivery and a holistic public engagement campaign around source-separation and proper disposal practices.

- *Material and labor.* Many effective composting facilities rely on manual approaches that are not as technologically demanding. Since materials and labor in low-income countries tend to be comparatively inexpensive, low-tech composting is appealing as a cost-effective waste management technique as compared to landfilling, anaerobic digestion, or incineration among others. However, it would still be contingent on a number of factors including the operator's capabilities, ability to maintain the facilities, and accessibility of replacement parts.
- *Political, legal, and regulatory environment.* Lack of stakeholder coordination, policy alignment, and a supporting regulatory framework can derail composting efforts. Since composting is a multi-sectoral issue, the municipality's priority outcomes should be accounted for early in the dialogue and the related policies should be aligned appropriately. For example, agricultural policies promoting synthetic fertilizers would directly compete with development of a composting sector.

In terms of financing, compost projects are most easily funded in an effective, sectorally coordinated, and transparent regulatory environment that encourages the use and thus demand for compost. Markets should also allocate financing efficiently. Composting is not an industry strongly susceptible to political instability due to the need for low-cost infrastructure and high operational capacity. While there are many policies that could be beneficial to promoting the composting sector, in general, a predictable legal and regulatory framework around solid waste management and strong contract enforcement would help create a lower-risk environment for investment. Depending on the local circumstances and the government's service provision and enforcement capabilities, the city might consider partnering with operators that would not be considered as risky as private operators, such as NGOs or farmers.

- *Carbon finance and revenue streams.* While composting projects are not as popular as landfill gas projects with regards to carbon markets due to their smaller scale and the relative cost of registration and validation, some facilities in developing countries have supplemented revenue by selling carbon credits to wealthy countries through the Kyoto Protocol's Clean Development Mechanism (CDM). Compost projects obtain carbon credits through methane emissions that are avoided through aerobic decomposition. In contrast with landfill gas, composting can provide consistent emissions reductions over a longer period of time. The most famous example is that of Waste Concern in Bangladesh, which earned revenue from both the sale of compost and successful monitoring of emissions reductions. However, the majority of composting projects registered did not benefit greatly since carbon markets have proven less profitable than initially expected. The actual emissions reduction have tended to be significantly lower than anticipated levels for composting projects; composting projects within the CDM must overcome more barriers than regular landfill gas projects due to their relative to the resources regulated for compliance scale. While carbon finance provides an additional revenue stream, composting projects should not be dependent on this revenue source.

With this introduction to composting in developing countries, the following chapters will present more detailed information on factors that allow composting projects to succeed beyond the technical considerations. Chapter 2 provides an overview of market strategies that can be used in developing a financially sustainable composting sector. Chapter 3 describes potential sources of funding and financing for composting projects. Chapter 4 outlines policies that commonly affect the composting sector as well as how planning and institutional arrangements can affect the success of a project. Risk mitigation strategies are provided throughout the paper as relevant to each chapter. Lastly, Chapters 5-10 offer in-depth case studies to present trends and lessons from both developing and developed countries. The countries where detailed cases for municipalities are provided include Austria, Bangladesh, Brazil, India, and Sri Lanka. The last case study focuses on the history of composting in Europe and how the sector has evolved.

Covered windrows at a commercial composting facility in Ougadougou, Burkina Faso. Photo credit: Farouk Banna

2 Strategies for Navigating a Dynamic Composting Market

Key Messages

- A thorough and quantitative study of customer segments and external market factors is a critical first investment for a successful composting operation
- A consistent, high quality product is essential for customer trust and can be achieved by sourcing quality feedstock and participating in a reliable quality assurance system
- The end product should be designed to target a specific customer market. Quality, texture, and even "look and feel" must be strategically designed
- Distribution channels can be optimized to reach different markets and can occur on-site or through third parties. Promotion of the end product may be necessary to generate market demand

Central to a successful composting operation is a targeted strategy based on the local market environment in which it operates. While a poorly targeted marketing strategy will result in a product surplus and foregone revenues, a strong go-to-market strategy can secure profit for lasting operations. Similarly, a quality-oriented mentality is needed to secure consumer trust in the end-product. This chapter will discuss the key market factors that operators must consider in a municipal-level composting operation. These include:

- **Customer channels:** Different customers have different needs and willingness to pay. A compost producer must first understand and then design the end product to meet the requirements of specific market segments
- **Customer perception and quality assurance:** Successful composting operations need a clear value proposition over alternative soil enhancers and must achieve consumer confidence in the quality of their end product
- **Sources of feedstock:** A valuable end product requires quality inputs, which vary by cost, location, and nutritional quality
- **Product distribution:** Composters need to determine the method that allows their product to reach their consumers while minimizing cost and maximizing utilization
- **Cost-conscious operations:** The composting environment can be volatile and requires a risk-conscious mentality. Steps can be taken to promote success despite variations in demand and other external contingencies

Identifying the customer

Different potential customers of compost have different needs. The end compost product can take on many forms but must be designed to match the requirements of individual customer groups. For example, wealthy home gardeners may purchase low quantities of compost at high prices but require a fine grain and high nutrient content. Landscapers, on the other hand, may be more lenient in nutritional content, but require bulk loads of compost as a soil amendment.

Operators should identify and evaluate each potential local market opportunity. While many potential customers exist for compost operations, some channels are more suitable than others; compost grade and nutritional requirements vary as well.

There are many potential customers for compost. These include:

- **Conventional farmers**, who manage long-term land value and nutrient depletion in addition to using soil supplements for crop growth
- **Organic farmers**, who require a nutritional alternative to synthetic fertilizers
- **Residents**, who use compost for small-scale gardening and farming
- **Landscapers and developers**, who use compost to design, develop, and refurbish landscapes on properties
- **Public entities**, who use compost to filter storm runoffs, control erosion, and develop parks, roads, and public spaces
- **Plant nurseries**, who use compost to grow viable plant products that are sold to customers

Understanding the value that compost may provide to the local market should be a key first investment that any burgeoning compost operation makes. A thorough market analysis will consider both qualitative factors such as customer characteristics, as well as a quantified analysis of the market opportunity within each potential customer segment (Box 2). This includes characterizations of each segment's volume demand, purchasing patterns (e.g., timing, frequency), segment size, and willingness to pay. Estimating these factors requires a deep understanding of the use case and decision making process of each customer type. Will the customer use the product at a large or a small scale? Will the customers use compost for crop growth or for other restoration projects? What alternative products do the customers use and how likely are they to respond positively to a new product? At what times of the growing season might the customer purchase compost? It is generally advantageous for a new composting operation to develop products for a limited market, upon which it can later expand. Efforts should be strictly concentrated on satisfying customer needs with *consistency*. In fact, if there is no suitable market in which this can be achieved, it is better to understand sooner rather than later. Past experiences of successful or attempted efforts can shed much light.

As part of a market evaluation, composters should also consider external market factors. These include environmental and farming trends, the political environment such as agricultural subsidies and land reforms, social attitudes and taboos, and the general economic environment. These factors may influence the ultimate market segment and product choice. For example, in environments in which subsidies heavily favor chemical fertilizers, compost may not be easily sold due to its price disadvantage. In contrast, compost may be particularly suitable for countries prioritizing land and environmental reforms.

Finally, compost producers must understand patterns of seasonality in their locality and how that may affect demand from customers. Compost operations that process municipal waste, market waste, or other commercial feedstocks may be in operation throughout the year. However, many potential customers can only utilize compost during select times of the year. Compost operators must understand the needs and preferences of offtakers in their market and gain access to multiple offtakers in order to diversify risk. Many centralized compost facilities

Box 2. Market Opportunity Assessment for Single Customer Segment

The annual market opportunity for compost is dependent on the following four factors:

- **Number of customers:** size of industry, local economics, proximity to customers
- **Units per purchase:** number of units anticipated for use, area of land for application, sole use vs. alongside other fertilizers, or soil structural amendments (such as mulch)
- **Frequency of purchases:** customer type (farmer vs. nursery vs. household), seasonality, expected sales channel
- **Price per unit:** prevailing compost prices, alternative fertilizer prices, subsidies, customer willingness to pay

provide compost for local public works projects such as landscaping, erosion control, and storm water filtering, or, produce compost that is used as a daily cover for landfill. However, these use cases typically do not absorb all of the compost produced. Therefore, commercial buyers should not be neglected. Further, due to the seasonality of sales, storage facilities may be required and must be factored into cost considerations and revenue projections.

2.1 Understanding the Value of Compost

Users of compost, such as farmers, households, and landscapers have a number of alternative products available to them. These alternatives include chemical fertilizers, animal waste (e.g., chicken droppings, manure), mulch, and peat moss. The pull of many of these alternatives is their widespread availability and low cost, often due to the support of subsidies. Further, the nutrients of fertilizers can be quickly absorbed, resulting in an immediate boost in crop productivity while the nutrients in compost release over a longer period of time. However, any composter should identify the advantages of compost in the context of their local market. These may include:

- **Nutrient restoration:** Like chemical fertilizers, compost is rich in critical plant nutrients such as nitrogen, potassium, and phosphorus. However, these nutrients take longer to release than chemical fertilizers and remain longer in the soil, therefore being advantageous for long-term land maintenance.
- **Land conditioning:** The plant-based structure of compost effectively replenishes depleted soil reduced to inert materials such as rocks and sand. Depletion often follows repeated applications of chemical fertilizers and harvest cycles. Compost also supports root growth, soil aeration, and microorganism growth and balances soil acidity—purposes that are not achieved through chemical fertilizers (Perry, n.d.).
- **Moisture management:** Compost not only improves land drainage by allowing water to percolate from the surface, but it also distributes and retains moisture as a spongey soil cover.
- **Erosion control and re-vegetation:** As a dense and substantive material, compost blankets effectively replace soil lost to erosion through natural causes or construction and has proven effective in numerous urban settings (Classen, 2001). It prevents further erosion by absorbing water rather than allowing it to pool and flow. Finally, compost helps to replenish natural vegetation in damaged areas.
- **Filtration:** Compost, such as when applied as a lining, can filter pollutants such as heavy metals, grease, and fuel from storm water and improve the water quality of the resulting runoff (Tyler and Faucette, 2006).
- **Public health:** Chemical fertilizers can cause physical illness to people who are in constant contact, such as farmers, or leach into communal water supplies. Compost is non-threatening to human health when processed properly.
- **Waste mitigation and environmental benefits:** Composting diverts organic waste from landfill, reduces methane emissions, and contributes to urban cleanliness.

The uses for compost and alternative products are also different. Chemical fertilizers are applied during plant growth for quick nutrient realization and must be re-applied whenever nutrients are required. Compost is generally applied to a soil bed before crops are planted. The early application gives time for nutrients to be released, but these nutrients are longer lasting (Rouse, Rothenberger, Zurbrugg, 2008). For land conditioning purposes, compost and alternatives such as peat moss and mulch differ in acidity, application method, and moisture retention; therefore, these products are not true replacements (Perry, n.d.). For example, peat moss, which is harvested from wetlands, increases the acidity of soils and is often applied with lime, whereas compost is slightly basic. Further, peat moss absorbs water more slowly than compost but has longer-lasting water retention qualities than compost. Mulch, on the other hand, is not typically mixed with soil as a conditioner, but rather applied as a protective cover to retain moisture and suppress weed growth (20 Minute Garden, 2011). Since it is not yet decomposed (e.g., shredded leaves and wood chips), the nutrients in mulch are not as readily available as that of compost.

Bark mulch (left) and blocks of dried peat (right). Photo credit: Thinkstock.com

Despite the differences in soil additives, an integrated plan nutrient management system is becoming increasingly common, and the use of multiple products in combination have proven to be more effective than a single product alone (Chen, 2006). Compost and fertilizers can complement each other: numerous studies have shown that when compost is applied together with fertilizers, plant nutrient uptake is far higher than when fertilizers are applied alone, leading to improved yields (Abedi, Alemzadeh, Kazemeni, 2010; Sikora and Azad 1993). When biofertilizers, or microorganisms that increase nutrient availability to plant roots, are added as well, nutrient uptake can be increased further (Chen, 2006). The co-beneficial effects of an integrated approach can result in financial savings for farmers by reducing the overall need for additives. It also significantly reduces nutrient runoffs and algae blooms, which sustains land quality and protects surrounding waters. In fact, the usage of compost is aligned with the needs of the agricultural community.

A useful way to understand the requirements and perceptions of the end market while educating people on the qualities of compost itself is to communicate directly with customer groups, such as through surveys, focus groups, and site visits. In fact, compost does not always have a preexisting market, one key reason being a lack of awareness and knowledge of the product. In a Tanzanian survey, 60% of farmers reported not knowing how to use the compost, and many did not know what quantity to use—a key barrier to purchasing (Rouse, Rothenberger, Zurbrugg, 2008). In this case, communicating the value of compost can even stimulate demand.

Despite its advantages and differences from alternatives, the value of compost must be made clear and compelling to potential consumers who face many options and who may not be familiar with compost at all. Promotion strategies for compost are discussed in the following sections.

2.2 Establishing Quality Standards

Compost is a particularly reputation-sensitive product due to a general lack of precedence. Therefore, it is critical to consistently deliver a quality product that mitigates consumer fears. Consumers must be confident that the product is free of undesired contaminants. Substances such as glass shards may be harmful to the customer and limit land use. Compost containing heavy metals or disease vectors (from hazardous, human waste, or even certain MSW waste) may contaminate groundwater and present a health hazard. Other risks include unviable plant growth conditions due to immature compost or improper acidity, weed growth from seeds, and a generally unpleasant smell and appearance. Reliable quality standards help to achieve consumer trust in the final product.[ii]

In established composting systems, quality standards are typically achieved through a trusted central accreditation body, which may exist as part of a country's national

Box 3. Survey of Common Perceptions of Compost and Reasons for Non-Use in Uganda

The composting sector in Uganda is still at an early stage. Compost production is suspected to be quite low although data on compost production and demand is not readily available. For reference, the nine municipalities participating in the Uganda Municipal Waste Compost Project through the World Bank Community Development Carbon Fund have a total installed composting capacity of 70 MTPD. In 2014, none of the plants were believed to be operating at full capacity yet.

While Uganda has one of the highest soil nutrient depletion rates in the world, farmers in Uganda use extremely small quantities of synthetic fertilizers (Majaliwa, 2012). On average, farmers use 1.8 kg of synthetic fertilizer per hectare per year while the average usage rate across Sub-Saharan Africa is 9 kg per hectare per year (Benson et. al., 2012). The low use is attributed to the high cost of synthetic fertilizers, a lack of knowledge, limited access and issues of poor perception. As an alternative to synthetic fertilizers, farmers use a variety of practices including: crop rotation, intercropping, green manureing, cover cropping with plants that are able to take nitrogen gas from the air and store it, and land fallowing, in place of using commercial soil amendments.

The World Bank commissioned a country report on Uganda in 2014, which included collection of primary data from three representative districts: Mukono for urban areas, Buikwe for semi-urban and Lira for rural. Data was obtained through interviews with 91 stakeholders including: 20 tree nursery operators, 18 potted flower nursery operators, 46 crop farmers and 7 government/NGO staff. User perspectives of compost (Table A) and the reasons for whether or not they purchase products (Table B) illuminate the challenges of developing a robust composting market.

Table A. User Perspectives of Compost

Crop Farmers	Tree Nursery Operators	Potted Flower Nursery Operators
• Compost remains in soil for longer, therefore smaller quantities are needed • Compost requires a labor-intensive production process (when produced on-site) • Compost is difficult to compare to other manures • Compost and other manures are no different	• Compost quality is variable which makes its performance variable • Many tree varieties can do without compost • Chicken manure is better than compost • There is competition with crop farmers for compost • Compost is expensive compared to forest soil • Compost does not produce desired results and works very slowly • Urea works better than compost in the short run	• Compost takes longer to produce desired results • Compost can only be used at certain stages of growing • Training is needed on how to use compost • Compost only applies to certain varieties of flowers • Artificial fertilizers work instantly • Sometimes compost burns and stunts seedlings when it is not properly stabilized

Table B. Reasons Cited for Non-Use by Survey Respondents

	Potted Flower Growers		Tree Growers	
Reasons for Non-Use	**Number of Survey Responses**	**Percent of Total**	**Number of Survey Responses**	**Percent of Total**
Lack of Access	5	28%	10	50%
Lack of Need	2	11%	7	35%
Other	11	61%	3	15%
Total Number of Survey Respondents	**18**	**100%**	**20**	**100%**

continues

Box 3. Survey of Common Perceptions of Compost and Reasons for Non-Use in Uganda (cont.)

Of the "other" reasons cited in Table B, most common responses included:

- Lack of knowledge about the benefits of using compost
- Lack of knowledge about the safety of MSW compost
- Lack of information about the quality and composition of MSW compost
- Lack of consistency across different compost batches
- Lack of awareness about potential sources of compost
- High transportation cost and poor road networks
- The weight of compost and its bulky presentation compared to synthetic fertilizers

Understanding market limitations offers valuable perspective on the barriers to compost sector development in Uganda. Survey results highlight the need for awareness building among end users to improve the perception of compost along with potential process improvements to increase compost quality and consistency.

Source: World Bank

regulatory framework or as an independent organization. This body publishes compost guidelines and standards that operations must adhere to in order to achieve certification. Accreditation bodies are typically public, but some are private, such as in Germany (Brinton, 2000). For example, in Austria, large scale and agricultural producers are monitored under two different government entities against the standards set by the Austrian Ministry of Environment. In addition to regular inspections, samples are laboratory tested for adherence. In a more demanding model in Bangladesh, the compost product must be proven effective over two growth cycles before it can be sold. In all cases, products that achieve certification may label their packaging with a standard symbol of quality assurance.

In countries with developing composting sectors, quality standards on an institutional basis may not yet exist. In an optimal case, officials may consider establishing a publically trusted certification body and benchmark the standards that guide similar regions. In this situation, it is important to ensure standards are appropriate based on desired end use in the local market, as standards in some developed countries may be inappropriate or too rigorous (Hoornweg, Thomas, Otten, 1999). Components of an advanced Quality Assurance System (QAS) from Europe are summarized in Box 4 and details can be obtained from the European Compost Network.

A less costly option is peer evaluation. For example, in Brazil, small scale organic farmers use peer evaluation through a Participatory Guarantee System (PGS) (Box 5) (International Fund for Agricultural Development, 2003). Farmers organize themselves in local groups that carry out inspections on member farms and ensure compliance with national standards. Representatives from each local segment form regional organizations that are accredited and audited by the national Ministry of Agriculture. Since these farmers use the compost for their own products, incentives are aligned to comply. This is an efficient yet cost-effective process that results in the official Brazilian organic seal.

Branding gives users the confidence that compost is at least as trustworthy as the alternative options they face. As in any industry, brands that customers know and trust have a higher likelihood of selling.

Where sufficient quality standards are not achieved, the compost product is sometimes used for lower-grade purposes such as landfill cover, mining site refurbishing, and land filler. However, these uses of compost should be deprioritized as they are less profitable (if at all), at times may need to be given away for free and, in a worst case scenario, may even incur disposal costs.

Box 4. Components of a Quality Assurance System in Europe

European quality assurance schemes are comprised of the following elements:

- Definition of feedstock type and quality
- Limits for contaminants (heavy metals, impurities, salt content)
- Hygiene requirements (time-temperature regime and testing of indicator pathogens)
- Quality criteria for nutrients and organic matter
- Third-party inspection and controlling of the product and the production (quality management)
- In-house control at the site for all batches (e.g., temperature, acidity, carbon dioxide levels)
- Quality label or product certificate
- Annual quality certificate for the site and its successful operations
- Product specifications for different application areas
- Recommendations for the proper use in different application areas
- Production control and process management guidelines
- Education and qualification requirements for facility operators
- Partnerships with accredited laboratories for product testing
- Process, product quality and end-use related research
- Promotion of quality standards, compost image and use
- Marketing tools

Box 5. An Example of a Community-level Product Certification System

In Brazil, small-scale peasant farmers follow an unconventional certification process known as the Participatory Guarantee System where peer farmers evaluate each other's products rather than a third party. It is based on mutual agreement and trust between producers, traders and consumers. Peasant farmers organize themselves into local groups and then form a commission to carry out inspections on each other's farms and verify product compliance with national standards. Within a region, all of the groups come together under an umbrella organization, which is accredited and audited by the Ministry of Agriculture. The umbrella organization is responsible for evaluating and verifying the results and issuing certification and the organic stamp to the peasant farmers. This process is less expensive than through national systems, aligns with the natural incentives of the compost producers, facilitates the efficient dissemination of information across farmer groups, and allows for a continuous certification process as farmers harvest different crops each season. Farmer participation in the program has increased from 138 families in 2009 when the participatory certification program was first implemented to 1,793 producers in 2014.

Source: World Bank

2.3 Selecting Feedstock

The quality of the inputs to a composting process is a key determinant to the quality of the outputs. A challenge to composters, especially in developing regions, is ensuring that the organic waste entering the composting process is free of major contaminants that devalue the end-product. Contaminants such as glass, plastics, heavy metals, and other hazardous chemicals cause the compost to contaminate and devalue the land that it is applied to. Other consequences include the inability to grow crops that meet quality standards,

Fruit and vegetable waste in a compost heap. Photo credit: maerzkind | Thinkstock.com

contamination of water streams, and restrained land use (e.g., park spaces that contain glass). The most efficient and cost-effective way to reduce contamination is at the source: by ensuring that the inputs are as pure as possible upon receipt, which limits intermediate separation steps needed to remove contaminants. There are a few common sources of feedstock for composting, including market waste, institutional food waste, commercial food waste, agricultural feedstock, landscaping waste, and municipal solid waste.

In developing country municipalities, ideal and accessible sources of pure feedstock are market waste, institutional food waste, and commercial (e.g., from large restaurants and hotels) food waste. Market waste includes spoiled produce and other organic remains from open food markets that can no longer be sold to customers. Market waste is typically uncontaminated and comprises a large deal of organic matter that would otherwise be left on the streets or become methane sources through disposal methods such as dumps or landfills. Food waste from institutions, large restaurants and hotels can also be substantial in quantity and easily source separated. The generating entities may ordinarily pay collection and disposal fees for landfill disposal whereas gate fees for composting are typically lower or negligible, and therefore advantageous.

If feedstock can be sourced from rural areas or if a decentralized composting operation is used, another ideal source of input is agricultural feedstock. Agricultural feedstock is waste sourced from farms, such as corn husks, wood, grass, vegetable remains, animal by-products, manures, and livestock bedding. Agricultural waste can be obtained in significant volume but would likely incur greater transportation costs. Where agricultural waste has been used, such as in the decentralized composting model of Austria detailed in Chapter 5, an effective system has been to establish partnerships with the agricultural community. In these systems, composting operations are managed by the farmers or cooperatives themselves. Not only do they process their own waste, but their income is supplemented by compost sales as well as gate fees for additional market or household waste brought in by the municipality. Seasonality is a strong factor for agricultural waste since feedstock streams ebb and flow based on the harvest schedule. As alternatives, forestry and landscaping waste are similarly as pure as agricultural waste, but they may be less bountiful and are sourced from public and private agencies rather than farmers.

Municipal solid waste is a readily available input source for composting; however, the risk of contamination and producing non-marketable compost is significant.

Compost produced from municipal solid waste is often not well-received by the public; therefore, when municipal solid waste is used, the objective of composting may be geared toward waste volume reduction rather than soil conditioning. Because developing countries' waste often exceeds 50% organic matter in composition (United Nations Environment Programme, 2015), composting urban waste is an effective way to divert organic matter from landfills while reducing the amount of methane that results from the degradation of these compounds. However, to produce a viable compost product from municipal waste sources, contamination must be avoided. This entails the implementation of source separation of organics, separate collection of organics, public education, and diligent quality control—all of which may be costly.

Municipal solid waste is plentiful but the most challenging to process. Mixed municipal waste can be obtained as part of a pre-existing door-to-door collection system or from aggregation facilities, such as community waste bins and transfer stations. Since this system relies on the participation of many individuals and entities, an ideal strategy is to employ source segregation, in which different waste types are separated at the household or organizational level. One form of source separation common in developing countries is a wet/dry separation program, in which compostable, "wet" waste comprised of food and other organics, is collected separately from non-compostable, "dry" waste comprised of recyclables and other refuse. Source separation has been successful in some areas but is difficult to implement where collection systems are still nascent, where enforcement power is lacking, and where local waste culture has not yet set a precedent for community engagement. If municipal solid waste is used, further separation steps are often required both for the raw materials and in later processing steps, for which costs in labor, equipment, and time must be accounted for. Compost produced chiefly from municipal solid waste is easily fit for landscaping and urban design uses. To produce a more marketable product, organic municipal solid waste can be mixed with other waste streams or nutrient supplements. Enrichment using fecal sludge, manure, and chemical fertilizers is a common way to boost nutritional content.

The choice of feedstock should also be based on what is socially acceptable by the target customer group. In many areas, urban waste and fecal sludge are stigmatized. For example, in Arab countries, farmers are typically unwilling to use compost derived from sewage or fecal sludge (Rouse, Rothenberger, Zurbrugg, 2008). In cases like this, it is both important to select an acceptable source of organic matter and ensure that contents are well known to consumers.

2.4 Distributing Products Effectively

In a municipal composting system, products can reach customers in a variety of ways depending on the market systems and location, and even the economic priorities of the municipality. On-site usage is most cost-effective in terms of transportation. For a centralized urban composting facility, compost may be used for local public works projects such as landscaping, erosion control, and storm water filtering. Positive externalities of this approach include reducing the landfill waste stream, pollution, water, and health risks while improving the city's infrastructure. If composting operations are distributed across rural sites, the end product may be directly used by farms and cooperatives and their local counterparts.

With regards to where compost is sold, it can either be distributed at the site or through secondary channels such as local retailers and bulk wholesalers. On-site buyers may include local farmers, nursery operators, or home gardeners that pay more per unit for small amounts. This method of sale is advantageous as it reduces transportation costs of the final product. Compost may also be sold for redistribution by local retailers. This enables composters to reach a larger portion of the market through the existing relationships between retailers and their customers. Further, retailers can support the co-distribution model by selling and marketing compost alongside chemical fertilizers. Co-distribution puts the two competing products on par, especially when they are similarly branded. For example, in India, a recent policy requires that fertilizer companies market urban compost alongside chemical fertilizers (India Press Information Bureau, 2016). Finally, local retailers may provide access to customers who must buy on credit, such as local

Box 6. Producing Compost from Municipal Solid Waste in Rio de Janeiro

Waste management in Rio de Janeiro is provided by the municipal public company COMLURB (Companhia Municipal de Limpeza Urbana), an organization with a budget of $500 million per year, 21,000 employees, and around 1000 pieces of equipment (e.g., collecting trucks, front loaders, dumpster trucks, bulldozers, sweepers). Currently the majority of the 10,000 tons per day of municipal waste generated in the city is disposed in landfills. By the end of 2016, 70 tons each day (half of which is organic matter) will be directed to a new biomethanization plant. This plant will produce 10 tons of compost per day. Approximately 9.5 tons will be used for the municipal forestation projects and the remaining 5 will be sold to farmers. Currently, COMLURB is producing about 5 tons of compost per day through an aerobic system, where the organic fraction of the MSW is decomposed in open windrows followed by a screening in a rotary trommel.

The sale of compost to farms has been consistently and remarkably successful, unlike most municipal waste compost projects around the world. A driver of this success is an on-site research center at which compost is tested for quality, heavy metal composition, and adherence with national standards. While farmers were initially skeptical of compost produced from municipal waste, marketing and promotion by the city enticed farmers to conduct tests and trials. Demand increased when quality results were achieved. The compost was formerly used for growing citrus and coffee and is now mainly used for growing vegetables.

The biomethanization plant will use 8 automated methanization tunnels to produce biogas and compost. The technology is simple and unsophisticated, has few moving parts, and requires minimal maintenance. Inputs are initially hand sorted before entering the tunnels for an anaerobic decomposition phase. Outputs include biogas (about 60% methane content) that will be used either for energy generation or for vehicle fuel (after purification), and the remaining organic matter will be shifted to a windrow system for curing and finally screened to the final product.

The final compost product is sold at a low price to farmers (~$8/ton), of which transportation costs are a large component. Today, 100% of the compost produced is sold.

Finished compost (left). Seedlings are grown for city's reforestation program using compost outputs (right). Photo credit: Jose Henrique Penido

Source: Jose Henrique Penido, 2016

farmers whose need for upfront materials is not synced with their revenue flows.

Composters may also sell products in bulk to wholesalers at lower per unit prices. Wholesalers may further enrich the compost, process it to different forms (e.g., pellets, powder), and transport it to distant points of sale. While wholesalers pay a lower price for compost per unit, and sometimes even on credit, they can help composters reach markets beyond the operation's own capacity. A successful wholesale model has been that of Bangladesh, in which compost produced by Waste Concern, a social business, is distributed through the largest synthetic fertilizer distributor in the country, Advanced Chemical Industries.

There are also more unique and creative ways to distribute compost. If feedstock providers are also consumers of compost (e.g., farmers), compost may be purchased in bulk at the same time feedstock is delivered, saving a trip. Retailers, such as vegetable markets, may also purchase compost for resale when feedstock is delivered. Deliveries may also be coordinated by a single point of contact to distant communities.

Generating compost sales almost always requires promotion in the form of government policies or simple marketing. Distribution opportunities may be weak due to lack of awareness of the benefits of compost and messages working against compost that are disseminated by competitors. Consumers can become more informed through community education programs, demonstrations, and endorsements by organizations, such as trade groups, universities, and businesses. Operators may also consider providing samples and efficacy guarantees.

Relatedly, composters should ensure that the look and feel of the compost product is best positioned for sales. Packaging should be informative to the customer, display a reliable brand and quality guarantee, and look at least as compelling as that of competing soil amendments. The product itself should also be appealing in physical appearance. For example, pellets and powder may work best in communities traditionally accustomed to processed fertilizers, which are sold in those forms. Ultimately, successful products need a distinctive reputation amongst customers along some dimension, whether that be contents, quantity, or quality.

2.5 Operating Cost Sustainability

While cost management is typically an operational concern, decisions must be made judiciously in light of the fact that composting markets can exhibit volatility and fluctuate. Poorly managed costs are where most composting operations fail; profits generated from product sales and gate fees may not be sufficient to sustain an operation that is not cost-efficient.

The major costs in composting are in sourcing feedstock (collection and transport), operations and maintenance, and end-product transportation. Plants should aim to source the purest possible waste streams, such as agricultural waste, since the additional sorting and processing are expensive. With regard to siting, composting close to the feedstock source is most transportation efficient, since input volumes are higher than output volumes. Composters may even seek to source feedstock, such as municipal market or landscaping waste, free of cost.

In terms of infrastructure, developing communities generally should opt for low-tech, labor-intensive processes rather than high-tech, mechanized solutions. For example, an open windrow system may be advantageous to a complex in-vessel system assuming that land can be readily accessed. Labor can be less costly than acquiring and maintaining complex infrastructure. In many cases where capital was granted to plants that started up with complex machinery, plants closed following the completion of the grant as infrastructure repairs and other technical requirements surpassed their financial capacity (Hoornweg, Thomas, Otten, 1999). In 1979, the Accra Waste Management Department constructed the Teshie Compost Plant with financing from the Swiss Government. The capital-intensive, European system was designed with a processing capacity of 38,000 TPY, but due to inadequate electricity, water supply, spare parts, and proper maintenance, the plant never reached full capacity before being fully decommissioned in 2009.

It is essential to plan sales according to customer demands and purchasing patterns. This avoids unnecessary transportation and excess stock. Speaking with retailers themselves can be effective as they are in tune with the needs and trends of their customer market. Customers themselves are a rich source of insight as well.

Finally, following core principles of financial management, composters should conduct rigorous financial forecasts and especially maintain a strong capital buffer to protect against variations in demand. For risky operations from non-profits to banks, an adequate capital buffer is recommended and even legally required at times (Dailey, n.d.; US Federal Reserve Board, 2016). Composting can be similarly volatile and operate at the margin, and a "rainy day fund" can help operations in slow seasons and support eclectic business needs, such as extending sales on credit. In terms of revenue, compost prices should be set to provide a satisfactory margin over costs while considering customer willingness to pay, the competition, and the product type. Prices should be high enough to allow for growth but not be so low that they generate doubt (Rouse, Rothenberger, Zurbrugg, 2008).

While managing costs, ambitions should be balanced with realities. It is also important to keep in mind that many of the benefits of composting are difficult to price—such as improved crop quality, reduced erosion, and better air and health.

2.6 Market Risks

Inherent in any infrastructure project are risks. In particular, for composting, significant risks are borne through the market environment, whether relating to customer demand, feedstock supply, or competition. This section will serve as a brief overview of the top risks encountered in composting markets and recommended mitigation measures.

Risk	Description	Mitigation techniques
Lack of market demand	Product sales and customer demand do not generate enough revenue to sustain operations	• Conduct an extensive market feasibility study: though an upfront expense, invest in thoroughly and preemptively understanding market conditions, including customer types, potential end uses, forecasted sales volumes, and competition. Quantify expectations. Speak to target customers to confirm hypotheses. Gather data. Study past or attempted operations • Market products: Sometimes, demand can be created. Experiment with novel marketing methods, such as through focus groups, pamphlets, on-site demonstrations, and media advertisements to raise community awareness • Adjust the product: Products may not appeal to customers for specific reasons. Changing the nutritional contents or simply the "look and feel", such as texture (e.g., pellets) or packaging, may have a significant effect • Start small: Begin by developing a high quality product at low volumes for a limited target market, then scale up. Avoid producing a low quality product that is difficult to sell and that leads to compounding losses • Establish quality assurance systems: Avoid poor product quality or contamination issues by obtaining facility and product certifications and developing product quality control and testing programs • Set enabling policies: Ensure that policies encourage compost demand, such as through subsidies, agricultural guidelines and organics disposal bans
Unreliable feedstock supply	Quality feedstock supply is limited or cut off, which stresses operations and affects product quality	• Use contracts: Negotiate binding contracts with the agricultural, hospitality, or market sectors for a guaranteed amount of high-quality feedstock. In return, offer favorable rates on compost products • Diversify feedstock sources: Avoid reliance on a single source of supply, while minimizing transportation costs • Understand the sources: Map and prioritize all local sources of feedstock, potential quantity, and key contract information to quickly reference when needed. This may be useful even in simple scenarios, such as a poor growth cycle • Set enabling policies: Ensure that municipal policies, such as landfill diversion targets and taxes, direct waste streams to composting rather than landfills and dumps (discussed in Chapter 4)
Competition is strong	Competitors to compost, including other compost plants, synthetic fertilizers, and alternative products dominate the market	• Market: Launch a targeted marketing campaign (see above) • Focus on the advantages: In marketing and publicity efforts, make clear the advantages of compost over alternative products, including health and environmental impacts • Target priority customers: Reach out to customers most likely to purchase compost, including those with depleted land and long-term land owners • Adjust prices: If there is room in the profit margin, use promotions and competitive pricing to gain customers • Lobby for favorable policies: If government subsidies favor competitive products, form interest groups and coalitions to develop more favorable conditions for compost. Emphasize environmental and health benefits

Farmer raking soil and dry leaves to produce nutrient-balanced organic compost in Thailand.
Photo credit: © Bidouze Stéphane | Dreamstime.com

3 Sources of Funding and Financing for Composting Projects

Key Messages

- Capital costs are often accounted for by a large upfront investment by an external organization, including grants from national governments and from development agencies
- Operational costs should be self-sustained through operational revenues, namely gate fees and compost sales, and may be supplemented by subsidies and tax agreements
- The private sector can be involved in any phase of composting and provides financing and risk mitigation in exchange for opportunities to earn a return
- Developmental assistance and national funding are often included in a compost project's funding scheme
- There is no magic bullet for financing; most composting projects in developing countries are financed by 2-4 sources in combination

Unlike traditional waste disposal methods, composting produces a commercial product for revenue. The production process involves a variety of costs, which can be roughly split into capital expenditures, or upfront costs, and operational expenditures, or recurring costs.

Capital costs account for the land on which the facility is located, construction of the facility, and equipment. Other costs that must be paid upfront include planning and feasibility studies, which improve the likelihood of success of the project, as well as permitting and market research activities. Operational expenditures are associated with the operations and maintenance of a facility. These include labor, utilities, ongoing facility costs, transportation, business development, marketing, and equipment repairs and upgrades.

Financing mechanisms vary, and a typical composting project is financed through a combination of two to four sources. Examples of hybrid financing schemes are detailed in boxes throughout this chapter, and summarized in Appendix 2 and Appendix 3.

A large upfront investment is required to finance initial capital expenditures. This is typically achieved through a development agency or a central government transfer or grant. Facilities that have financial stability through association with a larger private organization or municipality may have access to loans. Smaller facilities are more reliant on grants and transfers since their profits can be uncertain and slow to achieve.

Operational expenditures, on the other hand, must be financially self-sustaining. Countless failed composting projects began with tremendous amounts of grant funding but ultimately collapsed due to inability to support their operational costs. Often, this results when the selection of technology is too complex and repairs and maintenance costs become unmanageable. Operational expenditures can be managed through traditional methods of improving businesses' processes and maximizing revenue streams, including gate fees and compost sales. These costs can be alleviated through long-term government support, such as through per-unit subsidies on compost sales, as used in India (Box 16), or tax benefits.

Before seeking funding, it is crucial for composting operations to accurately estimate their upfront and operational and maintenance costs. Many composting projects fail due to poorly estimated operational expenditures that are too optimistic. Further, while composting projects may operate as a business, they also serve as a basic municipal waste management service which is traditionally costly. Therefore, composting can be beneficial even if it is not independently profitable, as it may reduce municipal service costs as a whole.

When a municipal composting operation divides assets and operational ownership across multiple stakeholders, such as with privately contracted or distributed systems, costs and revenues may be borne by multiple entities. While finances must be sustainable for each entity, this chapter discusses general means of financial sustainability for the holistic composting operation, not focusing on any one party.

Cities commonly fund composting through three main sources, or a combination thereof: private corporations, public donors, and the composting plant's own operations.

3.1 Private Funding

The private sector is a useful source of funding as it can have more capacity to invest than the public sector. Private entities tend to make efficient use of time and resources. The most common way the private sector plays a role in composting projects in developing countries is in operations through a public-private partnership (PPP); most composting projects have some form of private organization involvement. However, private organizations may also provide loans, grants, equity, and venture capital. The private sector is incentivized to invest in composting when there is a clear mechanism to recoup costs and earn a return. There are steps both municipal and national governments can take to encourage private sector participation—these are discussed further in this section.

Banks and financial institutions

The simplest form of funding from the private sector is through debt—simply borrowing money from a bank or other financial institution. An advantage of debt financing is that it does not relinquish control of the operations and strategy to the lender as occurs when a facility is financed through equity. However, not all composting operations have ready access to loans, which requires a strict repayment schedule often on a short- or medium-term basis, interest payments, as well as a steady revenue stream. This is challenging for small organizations that have unpredictable cash flows, require time to become profitable, and need to invest their profits in the operation itself. Established private organizations or municipalities that conduct composting alongside larger waste operations have increased access to loans and ability to repay them in a timely manner.

Further, lenders seek counterparties that are creditworthy. In countries without developed credit rating systems, a mechanism to garner trust is through providing key documents such as a comprehensive business plan with detailed assumptions, market and feasibility studies, feedstock supply agreements, product offtake agreements, and financial forecasts.

A soft loan is a form of debt that is particularly appropriate to composters (Hoornweg, Thomas, Otten, 1999). These loans are offered below the market rate of interest and often provide other benefits such as long payback periods, grace periods in which only interest or service fees are due, and interest holidays. To improve debt availability, smaller facilities may also seek a syndicated loan—a loan issued by multiple financial institutions for a single project using identical terms. Here, the risk of each participating lender is reduced. Banks may also provide project financing, in which the terms of a loan are contingent on project revenues, and general obligation financing, in which the creditworthiness of the local or central government secures the loan.

Private sector participation

Another way to finance a project is by including the private sector. Private organizations can participate in a variety of capacities, from concept and design, to construction, operations and maintenance. They can also provide financing to a greater capacity than the public sector and relieve governments of borrowing constraints.

Private organizations can provide an advantage to municipal projects by reducing the time to completion of projects, offering specialized skills, and utilizing their established business networks and resources. However, by assuming financial risk in the composting project, the private sector requires confidence in an expected return.

Box 7. Debt Financing for a Private Sector Composting Project in Massachusetts

In the late 1990s, KeyBank, a US commercial bank, debt financed two privately owned and operated composting facilities in Nantucket and Marlborough, Massachusetts. KeyBank evaluated the projects across the following basic criteria:

- Was the composting technology well established and currently operating at other facilities?
- Was the investment adequate in size to be attractive to KeyBank (minimum $5 million investment required)?
- Was the team comprised of strong and reputable team members?
- Had permits been approved or were they forthcoming?
- Did owner equity reach 20-30% of the total project cost?
- Was the projected annual operating cash flow at least 1.5 times the amount of the loan?
- Based on an independent valuation of the project's income, was the loan amount less than or equal to 75% of the total project cost?

In order to evaluate these criteria, KeyBank required the loan applicants to submit a loan package comprised of a **business plan** including construction plans, budget, company history, the qualifications of top management professionals, and a **pro-forma financial analysis**. The financial projections were expected to reflect existing supply and offtake agreements (including minimum tipping fees, minimum and maximum monthly feedstock quantities, feedstock quality requirements) and local market factors, along with detailed, well-justified assumptions. An **independent engineer** was required to review and verify all plans, at a cost incurred by the applicant. **Construction bonds, construction advances and performance bonds** were also required of the applicant to ensure that the plant was built according to the construction plans and to cover any additional costs to modify the plant post-construction in order to comply with output requirements. The financed composting facilities in Nantucket and Marlborough are still in operation today.

Source: Graydon, 1999

The private sector typically partners in the municipal composting process in two ways—a traditional PPP, in which a private company conducts some combination of the designing, building, financing, maintenance, or operation of the facility on an extended basis, or engagement in a short-term or limited capacity. The municipality may also build an ecosystem that nurtures the growth of fully private composting operations, where the public sector does not claim any ownership, such as in Austria.

In a traditional PPP model, a significant portion of the development project is owned by the private sector for an extended period of time. The relationship can take on many forms, which are detailed in Box 8. Even if a private company is deeply involved in the operation of a facility's assets, the public company retains oversight throughout the process and may contribute to the project's success. For example, Waste Concern's privately-owned compost plant in Bangladesh benefits from a pure market waste stream guaranteed by the municipality. This contributes to their compost quality. Further, a privately-owned compost operation can be transferred back to public ownership, or vice versa. For example, the Temesi Recycling Center that composts organic waste in Bali was established as a pilot in 2004 by the local Rotary club. However, the ownership was eventually transferred to a municipal foundation, Yayasan Pemilahan Sampah Temesi, after which expansion efforts increased the processing capacity by 15 times (École Polytechnique Fédérale de Lausanne, 2016). Another Build-Operate-Transfer example in Pakistan is detailed in Box 9. Increasing integration with a private operator can realize more cost savings through continuity and efficiencies (National Council for Public and Private Partnerships, n.d.). For example, assigning one company to both constructing and operating a compost plant can be more efficient than conducting this process through two separate entities, and often, the private sector will participate in the design, build, and operation of the facility. However, municipalities should be cautious since the more the private sector is involved, the less control the public entity retains over the project.

Box 8. Public Private Partnership Models in Composting

Traditional public-private partnership structures vary in degree of ownership, from nearly full ownership on the part of the municipality to full operation on the part of the counterparty.

Short term service models include:

- **Contract:** Through a competitive procurement process, a private firm is hired to deliver composting services for a finite period of time. The government pays this entity, rather than sharing revenue. An example of this service is a site study or a source-separated organics collection program.
- **Concession:** The government grants a private firm the opportunity to invest in and provide services for a period of time, in exchange for rights to profit.
- **Lease:** A private operator pays the municipality for the use of composting assets. Profits, such as through compost sales, tax benefits, or carbon credits, can be shared between the government and the private operator. The private operator is responsible for maintenance and repair, while the municipality is responsible for upgrades and investments.
- **Management:** The government hires a private operator to manage a facility, sell a product and collect revenues, but pays the operator a fee. This is a less common model for composting.

Longer term service contracts include:

- **Design-Build-Operate:** Private operator will design, build, and operate a facility and is sometimes responsible for maintenance. These include feasibility and market assessments, systems design, construction, and project management. Funding can be supplemented, and operations should be financially self-sustaining.
- **Design-Build-Finance-Operate:** This form of contracting requires the private operator to take responsibility over financing the project from design to operation. Since the private operator is required to source funding, the municipality may need to offer risk mitigating measures such as credit guarantees. The municipality can further reduce risk by providing a feedstock supply and offtake agreements.
- **Build-Operate-Transfer:** A private operator takes either full or partial responsibility over financing the construction, operations, and maintenance of a facility, and therefore owns rights to outputs and revenues through which they are compensated for their investment. The operation will eventually be returned to public control at which point the municipality is responsible for operations and maintenance and long-term financing. These contracts are risky, as control over the success of the operation is in the hands of the contractor for an extended period of time. Further the condition of the operation at the time of transfer must be carefully monitored and enforced.
- **Build-Own-Operate:** In this structure, the private sector is responsible for an operation end-to-end, and there is no obligation to transfer to the private sector. Many composting operations are privately owned but may receive external funding.

Sources: United States General Accounting Office, 1999; UNEP, 2005

Many models of composting engage the private sector at discrete phases of the project. This might be in collection of waste, marketing and branding, or distribution. For example, Waste Concern's pilot and joint venture facilities in Bangladesh have utilized private distributors, Map Agro and Advanced Chemical Industries, to market and sell their compost, respectively. These companies provide expertise in branding and marketing compost and are able to leverage their existing distribution network. Additionally, cities may use their existing private waste hauler to collect organic waste or engage them in waste separation and processing. For example, in Kampot, Cambodia, a local NGO operates an integrated resource recovery center that processes compost. However, source-separated waste is delivered by a private corporation, Global Action for Environment Awareness, which is contracted by the municipality (United Nations Economic and Social Commission for Asia and the Pacific, 2015).

Box 9. Example of a Build-Operate-Transfer PPP in Lahore, Pakistan

In 2003, the Solid Waste Management Department of the City District Government of Lahore (CDGL), Pakistan issued a public tender for a private sector company to design, built, operate, and transfer a 1,000 MTPD composting facility at the Mehmood Booti Landfill. The Safi Group, a leading industrial corporation in Pakistan was awarded the tender and established the Lahore Compost Ltd. to undertake the work. Under the contract, the CDGL provided land at no cost and guaranteed the delivery of waste from residential areas and fruit and vegetable markets. The facility became operational in 2006 with a processing capacity of 300 MTPD and was gradually scaled up to 1,000 MTPD by 2009. The total project cost was estimated at $5.52 million with an initial investment of $3.11 million, which was financed through a combination of long-term debt from the parent company ($2.87 million) and equity ($2.65 million). Revenues from carbon credit sales as part of the United Nations Clean Development Mechanism were expected to cover annual operating costs, while compost sales were to cover debt service. The project will be transferred back to the CDGL after a period of 25 years.

Source: Energy Sector Management Assistance Program, 2010

Finally, a municipality may engage the private sector by facilitating an entrepreneurially friendly economic environment by providing compelling incentives and support. For example, private for-profit agricultural composting plants in Brazil have taken off in the wake of a national solid waste policy to divert organics from landfill, which guarantees a feedstock stream, as well as favorable tax and financial incentives from local governments. A municipality may set up an agreement to deliver feedstock from the city to farm-composters, such as in Austria, and encourage farmers to use compost on site, thereby saving fertilizer costs. It may also provide financial incentives in the form of tax breaks and holidays. For example, Bangladesh has issued a 5-10/year tax holiday on waste plants in addition to reduced import taxes and no value added tax or sales tax. With the right incentives from local and national governments, an independent composting sector can bloom.

Municipalities should be deliberate in encouraging private sector involvement if it is desired, and there are multiple ways to achieve this. They may provide a capital grant for initial fixed costs to operators engaged in extended ownership and construction, such as for feasibility studies and plant property and equipment. They may also offer tax abatements, land provisions, guaranteed tipping fees, and product offtake agreements. Finally, municipalities can encourage private sector investment by providing financial guarantees to the private investors such as on product demand (as a percentage of forecasted revenue) or costs (by providing feedstock) (World Bank, Asian Development Bank, Inter-American Development Bank, 2014). Investors that face fewer risks are more willing to assume responsibility and provide capital in exchange for a likely profit. Municipalities that issue investment guarantees should be careful to accurately estimate their financial exposure and diversify their risks by implementing a comprehensive investment strategy. Strategies to attract the private sector are further outlined in Box 10.

When a private organization is delegated by a municipality, one way to ensure success is through performance bonds. Performance bonds are an insurance system in which a contracted entity issues bonds that are turned over to the municipality in order to guarantee financial and operational success of the project. The bonds, which are commonly mandated at 1-3% of the contract value, are paid out if a contractor does not deliver on the contract to the quality and criteria outlined within (JW Surety Bonds, n.d.). This was used in Prince William County, Virginia, USA when a private composting operator issued performance bonds to ensure compliance with the contract, prevent site abandonment and cover any site restoration costs (Prince William County, 2005). This system delegates some financial risk and responsibility to the operator and helps to ensure that the project will be completed within budget.

Engaging private operating models requires solid contract structures in which the key roles and responsibilities of the contractor and the municipality are clearly outlined. Example provisions are detailed within Appendix 4.

Box 10. Strategies for Attracting Private Sector Participation in Composting

Market and demand

- Lack or limits on **subsidies** for chemical fertilizers, or equivalent benefits for compost
- Requirement for **fertilizer companies** to sell or market compost
- Strong **incentives for farmers** to use compost
- A robust **organics market**, along with organics labeling / certification, that drives organic compost demand
- **Subsidies for the compost product** and promotion by the government
- Clear **value-add of compost** to improve competition with chemical fertilizers

Policies and regulatory environment

- **Presence of supporting policies**, such as organic waste diversion, soil requirements, co-marketing requirements and source separation programs
- Controls on organic waste disposal from **commercial entities** (e.g., restaurants, stores, hotels)
- **Publically accepted standards and guidelines** that establishes compost quality standards (grades) and appropriate use cases for each quality grade
- **Certification** system for the compost product as well as the operator
- **Product testing** requirements by either the compost facility or third party
- Strong **enforcement mechanisms** of all policies

Financing and cost recovery

- Indicators of **financial recovery** for the private operator, including clear revenue opportunities, and investment guarantees
- **Financial support** by the government or banks and intuitions to cover initial capital costs and output-based support for operational costs
- **Government guarantees** on minimum compost offtake amounts, product pricing, or feedstock pricing
- Multiple **product offtake agreements** for the final compost product at an acceptable price, preferably from creditworthy entities
- Diverse **supply of feedstock** associated with a tipping fee or high quality feedstocks (e.g., market waste, agricultural waste, manure) that can be obtained at little or no cost. Agreements with municipalities and other entities for long-term supply at established prices are ideal
- Favorable **tax incentives**, including on value add, import, sales, and favorable utility rates

Operations

- **In-kind support**, such as provision of land for facility building and of quality feedstock
- **Capacity building** to increase the technical capabilities that enable success
- Adequate **baseline information on organic waste** in the city, which helps operators understand the market readiness for compost

Source: Hasnat and Sinha, 2012; Michelsen, 2016

Philanthropic institutions

While less common, municipal compost plants may seek funding from private or institutional donors, who contribute funding on a philanthropic basis. These organizations—such as high net worth individuals, companies, and NGOs, typically invest in projects aligned with their goals or beliefs. For example, in Quy Nhon, Vietnam in 2007, the UN funded an integrated resource recovery center in partnership with the NGO, Environment and Development Action in the Third World (ENDA), which also provided local technical assistance and promoted source separation (Storey, et al., 2013). Donor entities may be involved in the operation of the company, offer skills and information, or provide assistance in-kind, such as in the form of consulting services and equipment. However, this assistance may come with terms and provisions that limit the control of the municipality over outcomes.

Other forms of private funding

Additional sources of private funding include equity issuance, such as through a private equity investment, venture capital, angel investments, sale of company, and financial partnerships or joint ventures (Kessler and Seltzer, 2009). These forms of financing are advantageous in that repayments depend on the success of the project. However, these forms of financing also typically require the project owner to officially relinquish partial or full control over the strategy and earnings. These methods of financing are traditionally used in high-income settings where financial markets are mature and developed. For smaller-scale composting projects in low- and middle-income countries, these methods may be less feasible and therefore they are not discussed in depth.

The private sector may not only participate as operators and funders but also as buyers of the product. A partnership arrangement with the private sector for the purchase of compost not only ensures that consistent quality compost is produced but also that a ready market exists for the product. Offtake agreements with companies do not only secure a revenue source for the compost project but makes the project more appealing to external sources of funding. Companies that may purchase compost for their business operations include land developers, mall owners, power plant owners and operators, plantation owners, and other businesses involved in activities related to land such as reforestation, municipal infrastructure and construction, and agricultural livelihood support (Tuyor, 2016).

Finally, compost projects that take place in cities with a developed private sector may be sponsored by private companies as part of their Corporate Social Responsibility commitments. Companies are increasingly taking action to achieve social and environmental good by making expenditures outside of their normal lines of business or to offset negative impacts their business may have on the community. These vary from sponsoring programs that benefit the poor to environmental cleanup efforts. Outside of donating to compost operations, companies may purchase compost for their corporate social responsibility work. If companies require soil amendments for their day-to-day operations, they may commit to purchasing recycled organics rather than virgin fertilizers. Finally, companies may donate skills or materials in kind. Donations from the private sector were a significant success factor for the Integrated Solid Waste Management Facility in Teresa, Philippines (Growth Revolution Magazine, 2009). The project's social awareness campaign was supported with fliers and bins donated by a marble company, the building received donated bamboo fencing from farms, and each week, the facility receives 20 bags of cement from a cement firm as an ingredient for their hollow brick product, in which recyclables are repurposed as a structural filler.

3.2 Public Funding

Public funding is a universal source of funding for compost plants. It is also a relatively inexpensive source of capital for a municipally-managed project that does not delegate ownership to private operators and investors. Almost all municipally-run compost systems have benefitted from international, national, state, or local funding to some degree, from the most developed models in high-income countries to burgeoning and innovative models in low-income countries. Grants from international development agencies are extremely common as one component of funding. While public funding can be limited due to local resource constraints, having some public backing can result in compounding benefits since it serves as a signal of confidence to potential external investors.

Public funding may originate from the national government, local government, or international development agencies.

Development organizations

Developmental assistance is an extremely common source of funding for finance and infrastructure demanding projects. International development agencies and NGOs commonly fund environmentally-oriented projects in the form of Official Developmental Assistance or generic grants. Performance-based transfers have also become increasingly common, where aid is given based on the results achieved through the program. These agencies commonly issue a grant or low- interest loan that funds capital costs and occasionally operational and maintenance costs in a limited capacity. For example, the UN Economic and Social Commission for Asia and the Pacific has funded numerous projects in the Asia-Pacific region, supplementing funding from NGOs and even national grants (Storey, et al., 2013).

Since development funding will inevitably terminate, it is critical to ensure that the selection of technology and methodology is fitting for long-term sustainability based on local constraints. For example, before 2008, many composting projects in Sri Lanka were funded by a team of development organizations, but when grants dried up, most plants closed because they were not financially viable. Therefore, it is necessary to accurately forecast financials in a realistic manner and plan for long-term operations beyond the funding period. Finally, to maximize the likelihood of success, recipients should seek technical capacity building from development agencies in addition to capital.

National government

Funding from the national government typically occurs in the form of grants and subsidies. Governments may provide cash transfers to local governments, direct investments in compost projects, or offer low-interest loans. National funding is most viable in countries committed to sustainable methods of waste processing, for which composting of organic wastes plays a role. That is, it is easier to obtain funding when composting is aligned with national agendas for environment and urban sustainability. A successful example is in Sri Lanka, where a 2008 $40 million government grant promoting urban waste management reform led to the construction of 115 locally-administered compost facilities. Similarly, funding may be more accessible if sought as part of a larger city planning project or if a case is made to achieve larger end goals such as improved community health, urban safety, or air and water sanitation. In some areas, interest groups and coalitions have been formed to make these cases clear.

Increasingly, operational and fiscal responsibility for public programs have been widely pushed from the national to the sub-sovereign level, creating a strain on local budgets. For a sector such as composting with little precedence and knowledge base in developing countries, the project may fall lower in priority in local budgets than traditional services, and the need for national investments is great. This is particularly relevant in low-income countries with significant local resource constraints.

Local government

Local governments, tasked with providing a variety of services to the urban population ranging from public transportation to sewage treatment and basic waste management, often have limited resources to support composting. However, there are a variety of financing sources that a municipal government can access. These channels include taxes and fees directly charged from users, a revenue source, as well as bond issuance, a debt source. Cities may also provide favorable tax incentives to composting operations, such as through California's Pollution Control Tax Exempt Bond Financing Program detailed in Box 11, or subsidize compost, whether inputs or the end-product. Finally, local governments can supplement financial incentives with in-kind provisions, such as land, feedstock, and equipment. Below, direct charging of user fees as well as bond issuance are elaborated in further detail.

Direct charging

Taxes and fees from households are a form of municipal own-source revenue that follow the producer or polluter pays principle. This is achieved by charging variable rate fees to households or institutions based on their organic

Box 11. California's Tax Exempt Bond Financing Program

California's Pollution Control Tax-Exempt Bond Financing Program (CPCFA) provides California businesses with a lower-interest alternative to conventional debt financing. The program serves as an intermediary to issue bonds as a creditworthy institution and provides this financing to eligible projects. Businesses may use the funds for the acquisition, construction, or installation of equipment, land, cost of bond issuance, soft costs (engineers, attorneys and permits), and buildings associated with waste disposal and recovery facilities. Prospective borrowers submit an application to the California Debt Limit Allocation Committee. If approved, a detailed review of the project's technical and financial plans and obtainment of all necessary certificates ensues. Successful borrowers may then request an "allocation." Once a project receives an allocation, the State Treasurer sells the bonds and disperses payment. Restrictions include the following:

- 95% of proceeds must be used for the defined project
- 2% of bond proceeds can be used for costs of issuance
- 25% of bond proceeds can be used for land costs in certain cases
- The average life of the bond issue cannot exceed 120% of the weighted average of the estimated useful life of the assets being financed

In November 2013, Zero Waste Energy Development Company LLC, a company formed in 2011 by GreenWaste Recovery Inc. and Zanker Road Resource Management, Ltd., commenced operations at the world's largest dry anaerobic digestion facility in San Jose, CA. The company obtained $103 million of bond financing through the CPCFA to finance site improvements, additional equipment, and vehicles and to repay bonds that were previously issued. The organics management system is currently comprised of 16 dry digestion tunnels and 4 in-vessel composting units, which can process 90,000 tons per year. The complete project is expected to include three times this capacity. Among seven applicants, Zero Waste Energy Development Company LLC was the only CPCFA bond recipient in 2013.

Sources: California State Treasurer Website, 2016; California Pollution Control Financing Authority, 2014; United States Environmental Protection Agency, 2014

waste production, implementing fees and fines in excess of a threshold, or through a flat fee that is jointly billed with utilities. In 2010, Korea implemented a volume-based waste fee that now diverts 95% of household waste to animal feed, biofuels, and composting, leading to both saved disposal costs and additional revenues (Innovation Seeds, 2012). In Maputo, Mozambique, the World Bank and GIZ helped the city initiate a joint billing structure that combined solid waste fees with a household's electricity bill. This program increased waste collection rates from 250 TPD to 600 TPD and cost recovery from less than 40% to 62% between 2004 and 2010 (GIZ, 2012). While effective for cost recovery, these fees may be challenging to implement in low-income countries where waste fees are already uncommon, disposal services are inadequate, and where communities are especially resistant to additional public utility fees (Ren and Hu, 2014). For example, in Kon Tum, Vietnam, operation and collection costs have been unsustainable due to the low fee charged to households—$1 a month at a 50% collection rate—which is the lowest in the country (United Nations ESCAP, 2015).

Other common models of financing include landfill taxes that are used to finance waste diversions to alternative treatment sources, increasing landfill tipping fees, and charging fees for different volumes of household and institutional organic waste. It is becoming more common for municipalities to charge for waste destined for landfills but waive the fee on source-separated organics disposal. This secures revenues from non-compliant behavior while increasing the organics waste stream. A relevant example is in Ghana, where Jekora Ventures offers a 20% service fee discount to large commercial generators who separate their organic wastes. Municipal own-source financing may also come from traditional sources of local revenue, such as land taxes, property taxes, and public fines; however, these funds must be re-allocated from existing budget priorities. Where municipalities are able to fund their own composting operations, they gain the benefit of greater control over the operations and timeline while reducing the need for debt.

Bonds

Where municipalities are unable to fully fund their own operations, they may also seek to raise money by issuing bonds. Municipal bonds are debt obligations issued by a public entity to fund public facilities and infrastructure. In structure, bonds are similar to traditional loans but diversify risk to multiple stakeholders, the purchasers of the bond. Bonds typically follow a structured interest repayment schedule and may allow for more favorable interest rates than a common bank loan. Advantages of public bonds include favorable rates or exemption from national taxes, a longer maturity time period, and lower interest rate. Disadvantages include the transaction costs, administrative hassles associated with issuance, and a need for proven creditworthiness to potential buyers. To achieve efficiency and scale, bonds for composting projects may be issued as part of a larger public financing project, of which composting is one component.

One example of a bond-financed composting project is a new composting facility to be constructed in Hilo County, Hawaii, USA through a $10.6 million bond (Lauer, 2016). A private contractor, Hawaiian Earth Recycling, will collect and process green waste and in turn determine the price at which to sell compost to the public. Mulch, which is also produced, will be given away for free to residents. The facility is anticipated to increase landfill diversion by one-third and the composting project will be aided by a ban on polystyrene food containers which requires substitution with compostable or recyclable containers.

An emerging form of bond financing is the "green bond". While identical to traditional bonds in structure, they are committed to financing environmental or climate-friendly projects and appeal to institutional investors that prefer to move their funds toward green projects, all else equal. Green bonds have been used to address a variety of projects in developing countries, from building infrastructure to divert methane emissions from a pig farm in Mexico to increasing irrigation efficiency in Indonesia (World Bank, 2013, 2015). Since mid-2015, the World Bank has applied green bonds toward 77 projects globally.

Public banks

Public banks are another source of publically-owned funding that may be accessible to composting projects. Public banks are owned by a government entity, can exist from the local to international level, and are focused on serving the growth of the local economy. Funding from public banks is typically cheaper than from private banks because revenues are directed back toward public projects rather than private shareholder profits. Public banks provide a variety of product services served by traditional private banks, such as loans, advisory services, bond issuance, and equity underwriting. To access this funding, municipalities may acquire direct loans or pool multiple composting or other urban development projects to diversify their risk and increase access to capital. Small- and medium-sized municipalities may even look to pool resources with other cities and governments.

Carbon markets

Lastly, carbon markets have historically been a supplementary source of income for projects that reduce greenhouse gas emissions through carbon credits, taking off in the 1990s and early 2000s. Carbon markets generate funding through sales of carbon offsets or credits (e.g., tons of CO_2 reductions) in open markets. Through composting, carbon is offset by diverting organic waste from landfills, where it would otherwise produce methane resulting from anaerobic digestion. Composting is considered carbon neutral, and even carbon negative. At downstream stages of the compost lifespan, carbon is sequestered in soil as organic solids rather than released into the atmosphere, and the associated reduction in related land inputs, such as fertilizer, herbicides, and water irrigation, also reduces carbon emissions (Lal, 2004; Ozores-Hampton, 1998). However, obtaining carbon credits is time and resource intensive. Not only is it costly to register within the carbon market, but the process of calculating and validating greenhouse gas emissions reductions requires consultation and validation with a third party. Therefore, using the carbon markets to fund composting projects may only be feasible when done on a large scale and may generally be more appropriate for middle-income countries than in low-income countries.

As of 2012, only 46 composting projects had received carbon emissions reduction credits as part of the

Clean Development Mechanism (CDM), the largest international compliance market operating under the United Nations Framework Convention on Climate Change (UNFCCC) (UNEP, 2016). Further, carbon markets fluctuate: while they may be effective in one time period, they may be less effective during others. The efficacy of carbon markets has waned over the years, with prices peaking at €30 per ton in 2006 and 2008, but dramatically lowering to less than €10 per ton since then (Benthem and Martin; 2015). In 2016, prices have been significantly less than even half of that.

Composting projects that have received funding through the CDM include Waste Concern in Bangladesh, earning $1.5 million in carbon credits, and the Temesi integrated resource recovery center in Bali. For the latter, while a $1.5 million revenue in credit sales was expected, $70,000 was invested in fees for quantification, certification, and registration in the CDM program (Mitchell and Kusumowati, 2013).

In response to the weakening carbon credit market, the World Bank developed an innovative climate finance model called the Pilot Methane Auction Facility. The facility is a payment mechanism that sets a floor price on the future price of carbon through a public auction. The agreement is facilitated through a tradeable put option, which provides buyers the right, but not obligation, to sell carbon at the agreed-upon price at a future date. The auction encourages private sector investment in methane reduction projects while efficiently disbursing limited public funds. In the first round of the auction in July 2015, 8.7 million tons of carbon dioxide were sold at $2.40 per credit. Fund are distributed on a results basis when final results are proven (World Bank, 2015).

3.3 Operational Revenues and Avoided Costs

Operational revenues must sustain every composting plant. In fact, ongoing operations and maintenance costs should be fully supported by revenues earned through the composting business; many models have failed when they relied too heavily on grants and loans. Revenues are generally comprised of gate fees and compost sales. In some instances, governments can supplement basic revenues with long-term policies and support, such as tax abatements and subsidies on product sales.

Operational revenues

Operational revenues occur as a product of the composting operation. Direct revenues from the sale of compost is a primary source of revenue for most operations. However, operators may need to hedge their risks associated with compost sales, such as fluctuating prices driven by production costs, prices of competing products, seasonality, and policies around subsidies. Revenues can be maximized by generating demand through strong marketing initiatives.

Another form of operational revenues is tipping fees paid by entities disposing of waste, which is often the municipality itself. Organics tipping fees are most effective in middle-income countries where landfill tipping fees not only exist but are typically lower for compost facilities than for landfills, making composting a more cost effective way to dispose of organic waste. In low-income countries, tipping fees may not be effective, especially where open dumps are common and the general waste disposal budget is limited. As a rule of thumb, tipping fees should be high enough to help sustain operations but lower than competing disposal options. If a city is establishing a system for organics waste tipping, it will save time and money by accepting only source separated waste (as opposed to mixed municipal waste requiring further segregation and processing).

Reallocated costs

While there are many opportunities for a composting project to be profitable, composting should be viewed not only as a business, but as a form of waste disposal and a municipal service. Alternative methods of waste disposal most often do not fully achieve cost recovery but result in large expenditures by the government. In comparison to these traditional methods, composting can be a relatively cheaper way to dispose of organic waste and can result in significant long-term financial savings in the form of avoided costs. The money saved by reducing waste treatment through costly activities can then be reallocated to composting. Therefore, a composting operation that requires sustained government support may still be

The Integrated Solid Waste Management Facility in Teresa, Philippines operates a Learning Resource Center where waste management training is offered to local government units and interested parties for a fee. Photo credit: Teresa Municipal Environment and Natural Resources Office

worthwhile if the expenditures for composting are less than how waste would otherwise be disposed.

As shown in Appendix 5, composting is generally significantly cheaper as a disposal method than alternatives, including landfilling and waste-to-energy. With the potential to divert half of the municipal waste stream to organics recycling in low- and middle-income countries, significant savings are possible. Composting also tends to lead to other financial savings through bypassing private landfill tipping fees, avoiding costly technology buildout and maintenance, achieving deferred capital expenditures from extended landfill life, and potentially shortening delivery routes if composting facilities are closer to the waste generation source than are alternatives. It also helps reduce landfill operation costs, such as the one associated with leachate management by removing organics which have a high water or moisture content. Unlike many waste treatment facilities that require large areas of land, create odor issues, and generate public fear of environmental toxins, composting can feasibly be operated locally. In Ghana, Jekora Ventures saved between $0.21-0.31 per ton per km by delivering organic waste to a nearby composting plant rather than a more distant landfill.

While composting has the potential to reduce costs in the long term, there may be additional costs in the short- and medium-term related to the establishment of the composting sector. For example, adopting source separation, establishing separate collection, and building a single-source or integrated facility to separate comingled waste and finally process compost all require upfront investment. There are a number of conditions that increase the potential for cost savings by composting. These include (Michelsen, 2016):

- Willingness of customers to pay an attractive price for compost, which reduces the capital and operational expenditure burden of the municipality
- Regulations and enforcement that exist to either limit through policies or discourage through taxes, the disposal of organic waste in landfills, which results in a high tipping fee for compost facilities
- High land costs which makes landfilling an expensive alternative
- Siting a new landfill which is difficult, impossible, or expensive due to cost or social limitations
- Transportation to transfer or end-disposal sites that is not economical
- A life-cycle assessment, where the future cost of manufacturing, processing and disposal of materials will be high, rendering composting a worthwhile investment in the present
- Local conditions and unique circumstances that lend themselves to composting, such as on-farm composting, a strong organics market, and community participation

Related business models

Finally, composting plants may operate other revenue-generating functions alongside organics waste management, thereby diversifying the revenue streams for the operation. In fact, composting is often conducted alongside other waste management operations that process recyclables and other residuals in an integrated approach. To a large extent, the viability of a compost operation can depend on how the operator manages these other opportunities. A major revenue source lies in the sale of dry recyclables that are collected or dropped off alongside organics. For example, in Sri Lanka, the Balangoda Urban Council's compost project collects, sorts, and sells recyclables at a profit in order to supplement revenues from compost sales and tipping fees. When composting is operated as part of a comprehensive waste management program, it may be most cost efficient to deliver mixed waste to materials recovery facility, where organics, dry recyclables, and other residuals can be separated. When this is the case, there are many other marketable products that can be derived from waste. For example, the Integrated Solid Waste Management Facility in Teresa, Philippines, detailed in Box 12, not only sells compost but has diversified its revenues by selling nets made of coco husk, paving blocks, and hollow blocks made by reinforcing concrete with shredded recyclables, pillows made from recycled plastics, and charcoal from recycled paper and cardboard (Buena, 2008; Santos, 2014; Tuyor, 2016). Other general revenue opportunities include operating a landfill at the compost site, conducting municipal waste collection services, and offering the facility as a learning or training center for a fee. These activities are all exemplified within the case studies further in this report.

Box 12. An Integrated Waste Management Approach in Teresa, Philippines

Teresa is a municipality in the Philippines located 50 km from Manila in the province of Rizal. It is one of 61 municipalities located in the Laguna Lake watershed, which feeds the largest lake in the Philippines and the second largest freshwater lake in Southeast Asia. Waste in Teresa has traditionally been managed haphazardly through open dumps and open burning. In 2000, the Ecological Solid Waste Management Act in the Philippines mandated the closure of dumpsites. In 2006, a major 2,000 square foot dumpsite in Teresa was closed.

In 2007, an Integrated Solid Waste Management Facility was built where the dump once lay. The Laguna Lake Development Authority (a quasi-governmental entity that promotes sustainable development) had begun a project called Laguna de Bay Institutional Strengthening and Community Participation Project (LISCOP). This project was funded by the World Bank and the Netherlands Ministry of Development and targeted environmental renewal projects within the Laguna Bay Watershed, which had been suffering from the impacts of increased human impact. The materials recovery facility in Teresa was one such component of LISCOP.

The LISCOP project received a $5 million loan from the World Bank and another $5 million through a grant. The facility in Teresa was funded through a PHP 8.2 million total (PHP 3.27 million grant, PHP 3.68 million loan, and a 15% equity split between the Laguna Lake Development Authority and the Local Government Unit). Further, the World Bank Community Development Carbon Fund enhanced financial security is financing the purchase of carbon credits for greenhouse gas emissions reductions associated with the project's waste reduction, recycling, and composting through the Clean Development Mechanism.

The Teresa Integrated Solid Waste Management Facility is a multi-waste stream materials recovery facility that processes mixed waste from the municipality. The facility has a number of distinct components, beginning with a segregation center where waste is sorted and recyclables are gathered. In a plastics recycling area, a hammermill pulverizes waste and a densifier consolidates plastic fragments into tiles, traffic barriers, tables, and other products. There is also a hollow brick manufacturing area in which sand, gravel, and cement are mixed with shredded plastic and residuals to produce concrete blocks for local builders. Organics are sent to the composting area where materials are first shredded and then composted through a bioreactor and windrow system and finally treated to final quality using a sifter and grader. The compost product is tested by growing vegetables and other seedlings on site and is sold for PHP 120 (~$3.20) per 50-kg bag—less

continues

Box 12. An Integrated Waste Management Approach in Teresa, Philippines (cont.)

than half the prevailing market price for compost—and farmers are prioritized in the sale of this compost. Other products further diversifying revenues include nets produced from coconut husks and charcoal produced from pulverized paper.

Social behavioral transformation was a key component of this project. Residents were encouraged to conduct home composting, to source segregation, and maintain general cleanliness. A competition was conducted between barangays (neighborhoods) and local schools on their performance and results were both posted in the central square and announced at Catholic mass services. Cash prizes were given to the winners at the end of the year.

Much of the success of this project is attributable to an effective partnership strategy with the private sector. Companies sponsored fliers directing residents to source separate and recycle their waste and provided bins and tarps for the publicity campaign. Farms supplied bamboo for fencing for the facility. A cement firm supplied free bags of cement each week for the manufacturing of hollow bricks. Finally, a tile manufacturer provided the salaries for local green advocates for the first six months.

This integrated effort has not only diverted 38% of waste in two years but also increased municipal revenues from recycled product sales and has provided new employment opportunities to the local community. The facility continues to educate citizens and ensure financial sustainability through its newly established Integrated Solid Waste Management Training Center that trains other local government units and community groups on managing solid waste in an integrated manner.

The Integrated Solid Waste Management Facility at Teresa, Philippines produces multiple products from recycled waste, including: paper charcoal (left), coconut husk netting (middle), and hollow concrete bricks filled with shredded plastic (right). Photo: Teresa Municipal Environment and Natural Resources Office.

Source: Philstar, 2009; Buena, 2008; Growth Revolution Magazine, 2009; Santos, 2014

3.4 Financial Risks

Whether the ultimate goal of a composting operation is financial profitability or environmental remediation, financial sustainability must be achieved for long-term continuity. Many of the drivers of financial sustainability are in the control of the operator. Some risks are easier to mitigate than others.

Risk	Description	Mitigation techniques
Unsustainable project economics	Daily revenues are not sufficient to cover operations and maintenance costs, leading to a negative margin	• Choose simple technology: Opt for simple, yet labor intensive mechanisms over complex technologies. Often, though capital grants may fund technologies, the technical knowledge and maintenance costs may exceed revenue capacity. Ensure that operations and maintenance is fully covered by ongoing revenues • Diversify revenues: Reduce reliance on product sales and tipping fees, which are subject to market fluctuations, by implementing additional revenue generation activities such as sales of recyclables and waste collection • System optimization: Ensure composting process is efficient (e.g., turning frequency of piles and volume of water added) to reduce utilities and fuel consumption. Technical assistance and knowledge sharing can inform best practices.
Operator does not deliver on objectives	Contracted party does not execute on planned or expected objectives	• Conduct due diligence: fully research potential contractors and confirm a track record of success in similar contexts and sufficient operational and financial capacity to take on project. Request operational and financial documents; interview previous clients • Pay based on results: Use an output based payment contract to ensure that results are achieved in a timely manner. For example, compensate waste haulers based on the tons of feedstock delivered to the facility. Adopt penalty provisions when daily waste quotas are not met and ensure penalties are enforceable. Similarly, vary private operator payments based on amount of compost produced or sold, such as by assigning rights to product sales directly the private operator • Diversify operators: Assign operational responsibility to multiple actors. Using contracts, delegate discrete responsibilities to different operators (e.g., building the plant, delivering the feedstock, producing the compost). Using contracts, mandate each contractor to deliver a complete, ready-to-go product or system and assume financial responsibility until adequate delivery. This can be a useful way to assign and motivate operators to complete the set task as quickly and effectively as possible • Require performance bonds: Require contractors to assume financial risk by issuing performance bonds to insure against unforeseen roadblocks • Confirm incentive structure: Ensure that the contractor is properly incentivized to perform in each required area as per the contract structure • Write sound contracts: Ensure that contracts properly detail roles and expectations, ownership of end products,and terms that can be renegotiated versus not.

continues

(cont.)

Risk	Description	Mitigation techniques
Difficulty obtaining funding	Funding is scarce; investors are hesitant to provide capital to project	• Improve creditworthiness: Ensure outstanding debts and obligations are paid on time and in full, following priority payment schedules • Provide documentation: Prepare comprehensive market and feasibility studies, business plans, financial documents, and contracts for potential investors. Enter into long-term feedstock supply and product offtake agreements • Seek investment insurance: As a municipality, insure against the investor risk in the project, or seek external investor guarantees, such as through the World Bank Multilateral Investment Guarantee Agency (MIGA) • Consider relinquishing control: Consider more compelling terms of funding that may result in providing more rights to operational decisions and even outputs to investors
Funding is lost	Investors withdraw capital from project	• Diversify funding: Ensure a mix of funding instruments and sources – for example, municipal funding vs. developmental assistance
Sales are volatile	Product sales are volatile, affecting the revenue stream	• Use offtake agreements: create offtake agreements to be used with potential customers to guarantee a constant market at either a preset or variable price
Unexpected financial losses	Large and unexpected financial losses are incurred	• Hold an operating reserve: Save a percentage of profits to serve as a "rainy day fund" for adverse financial events. There is no hard and fast rule, but 3-6 months of ongoing expenses is recommended for many institutions (Dailey, n.d.) • Purchase insurance: Insure the operation against external factors beyond operator control, such as natural disasters, political unrest, and economic fluctuations

4 Policies and Institutions

Key Messages

- Be aware that composting is a crosscutting issue that could be affected by policies related to solid waste management, agriculture, environmental, land-use, and planning. Therefore, negotiate and work with stakeholders accordingly
- Strategically navigate policies that promote synthetic fertilizers or alternative organic waste management technologies that might stunt the development of the composting sector
- Align regulatory measures and product quality standards with the buyer's needs
- Ensure that incentives are aligned for stakeholders such that the end product has market demand
- Complement policies (i.e., diversion targets) with sufficient infrastructure

One of the prevailing challenges of the policy and institutional environment around the composting sector is the number of stakeholders involved. While environment and agriculture ministries typically play the largest role in establishing a comprehensive framework, composting cuts across many urban issues including municipal solid waste management, environment, health, labor, agriculture, land use, urban planning, and at times, even trade. Beyond sectoral boundaries, a variety of stakeholders, including national and municipal government, agricultural institutions, non-governmental organizations, interest groups, and industry associations, play an integral role to the success of a compost market. These groups can be critical to technical capacity building, product testing, outreach, and education and may also serve as third party monitoring and certification entities. Coordinating across the range of stakeholders can allow harmonized efforts and a conducive atmosphere.

Beyond the complex network of stakeholders, it can also be difficult to align parties at both the local and national levels to create an enabling environment for development of the compost sector. Municipal governments are typically tasked with providing solid waste management services at the local level. Municipal services generally include waste collection, transportation, and treatment and/or disposal. A municipal agency may also be a project developer, facility operator, waste collector, contractee, or buyer of end products. National governments, on the other hand, set broad policies that guide municipalities and typically have more funding to transfer. They have the ability to liaise with other national entities and international development agencies for additional financial or technical resources. However, if national policies are absent or weak, municipal and regional governments may also act as policy makers. While the municipal or national government's overarching goals tend to be the main determinant of policies, integrating the buyer's needs and wants into the regulatory planning process improve the likelihood of success of the compost sector.

This chapter focuses on the policies and institutions that affect the composting sector—either those that lead to development of it or prevention of it.

4.1 Policies

Solid Waste Management Policies

As a national mandate, solid waste management laws can provide motivation for development of the composting sector. However, there are many instances where countries have solid waste management laws that are not implemented or enforced at the local level due to limited

Fresh compost in a farmer's hands. Photo credit: Stacy Speckman capacity. Because composting is executed at the municipal level, it is critical for national directives to be achievable and supportive to local governments.

The case studies discussed in this paper showed four common themes around policies, although several others can be employed to support the composting sector. The first policy is around quality standards for compost in addition to an enforcement mechanism of those standards. The second driving policy theme is focused on either waste diversion targets or disposal bans. These diversion or disposal policies are primarily motivated by financial concerns such as rising disposal costs or decreasing landfill space. Third, policies incentivizing other organics processing technologies or alternative products hurt composting producers unless the municipality enforces mandatory composting. Lastly, policies that directly subsidize compost production or sales help build and sustain the sector through public, private, and social sector operators.

Organic waste recycling and landfill diversion targets

Governments may have organic waste recycling or landfill diversion targets due to environmental, financial, agricultural, or spatial concerns. If enforced, targets can be an effective means to develop an organics recycling sector by guaranteeing a feedstock source. However, they should be supported by relevant programs, educational initiatives, and infrastructure. Targets may be defined in terms of an absolute quantity of organics to be diverted or a percentage of organics to be separated and recycled. This approach requires substantiated waste composition data in order to assess compliance and would be meaningless unless verification is possible. Commonly, yard waste streams are subjected to targets and mandates first, followed by commercial, and finally single-family and multi-family residential areas. Implementation strategies for waste targets are typically flexible.

Mandatory recycling policies differ from source separation mandates in the affected party. Mandatory recycling policies are binding on municipalities and their service providers while source separation mandates are binding on generators. Mandatory organic waste recycling policies typically require that organic materials be processed through composting or anaerobic digestion. In order for mandatory organics recycling policies to direct high quality feedstock to composting facilities, they must be combined with a source separated collection program. Outreach, education, and enforcement is necessary to garner public support and participation, as generators may ultimately bear the added cost of new collection routes and the construction of new composting facilities.

Disposal bans

Disposal bans prohibit the landfill disposal of specific types of materials or beyond a certain quantity. For a ban on organic materials to be effective, composting or organics processing infrastructure and end markets must be in place to absorb the diverted feedstock. Similar to bans, disposal limits place restrictions on the amount of organic material that can be landfilled by a jurisdiction. Detailed in Box 13, the European Union (EU) adopted a limit-oriented policy that incorporates a phased approach that allows infrastructure and markets to adjust more slowly to the influx of organics. Outside of a policy-oriented ban that fines organics disposal in landfills, increasing landfill taxes relative to composting gate fees can economically disincentivize landfilling and increase organics separation.

Box 13. European Union's Organic Waste Diversion Targets

The European Union issued the Landfill Directive in 1999 that requires its member countries to reduce the quantity of biodegradable municipal waste being sent to a landfill based on set targets. Each member country must reduce the biodegradable waste landfilled to 35% of 1995 levels by 2016, or 2020 for a selected group of countries. This policy is being driven by environmental concerns due to the GHG emissions being produced by food waste decomposing in landfills. Since the Landfill Directive must be followed in order to be a part of the EU, even countries aiming to join the EU are gradually preparing to comply with the policy.

Source: European Union Landfill Directive (1999/31/EC)

Box 14. Seoul, Korea, a Leader in Food Waste Recycling


Seoul, Korea. Photo credit: Pixabay

In the 1980s, Korea's waste generation and treatment was relatively unremarkable on the global front. However, today, the country boasts one of the highest municipal solid waste recycling rates amongst OECD countries: 84.4%. Food waste comprises roughly 36% of municipal waste, and even though waste generation is rising, 100% of food waste was recycled in Seoul in 2012—a city with 10.5 million residents within 605 km^2.

This remarkable success was propagated by a series of legislations restricting the disposal of food waste and enabled by the development of advanced treatment technologies. In 1995, a volume-based fee was established on waste, although landfilling remained the predominant treatment mechanism. In 2005, food waste was fully banned from landfills and source separation was required. Finally, in 2013, a food waste reduction plan was established and powered by a volume-based disposal fee.

In 2013, ocean dumping of food waste leachate was also prohibited—a formerly intuitive strategy for a country surrounded by sea. With a large volume of food waste no longer destined for landfill, and restrictions on disposal tightened, backlogs of food waste ensued and a need for new technologies and systems was clear.

The city turned to a pay-as-you-throw strategy for food waste reduction in which citizens are charged for the amount of waste they dispose. A system proliferating in urban areas is the high-tech central community bin. These bins identify individuals using RFID chips, weigh individuals' drop-offs, and automatically charges a fee. Municipalities are also testing home waste bins identifiable by chips, household disposers connected to the central sewage system (organic matter serves as feedstock for biogas), and central reducer bins that use heat and air to cut waste volume before the organic matter is processed to compost or animal feed.

On the treatment end, large investments are supporting the build-out of new treatment facilities. In Seoul, approximately 44% of food waste is treated by public facilities and 56% by private. By 2018, Seoul plans to nearly double the treatment volume by public facilities by building four new facilities. A budget of KRW 252.5 billion (approximately $220 million) for 2014-2018 was anticipated for this purpose (as of 2014).

However, food waste management principles dictate that food should be used for feed or compost before treatment. Community composting has been heavily promoted—through partnerships with NGOs, district competitions, and urban farms.

In Korea, leadership at various levels collaborate to manage waste. The central government sets the 10-year plan and research and development goals, prioritizes technologies, and promotes campaigns for waste reduction. The Seoul Metropolitan Government establishes and implements city policies and supports operations. Districts are each responsible for building a waste management plan and collecting fees and penalties.

Source: Seoul Metropolitan Government, 2014

In the absence of markets for banned or limit-constrained materials, and stringently enforced laws on dumping, waste can be hauled outside of the ban's boundaries or be illegally dumped, creating even larger problems for a community. Education as well as enforcement and monitoring, such as the inspection of incoming truck loads at the landfill, are essential to assessing compliance by generators and waste collectors alike.

While bans and limits can be a powerful driver for directing organics to composting facilities, they must be combined with a strict source separation strategy in order to be effective for municipal solid waste. Without a combined approach for source separation, large quantities of low-quality organics may be directed to composting facilities, creating operational challenges for facility operators and flooding the marketplace with low-value end products. Minimizing contamination can be improved by revising regulations on food packaging. Packaging, such as plastic, contaminates waste streams when not fully removed and prevents corporations and vendors from fully participating in source separation.

Bans and limits also have the unintended effect of directing feedstock to other types of processing facilities (e.g., waste to energy) rather than composting plants given that they typically do not specify a required destination for the diverted waste streams. Without proper source segregation schemes, waste-to-energy solutions become more attractive since they do not have the same waste quality requirements despite costing more. Therefore, when combined with organic waste separation mandates, landfill bans and limits can be more effective at diverting waste to organic recycling facilities than when implemented alone.

Competing policies

The success of the composting sector can also be challenged by policies that force technologies to compete for feedstock. Policies specifically targeted to incentivize alternative products or alternative technologies can hinder development of the compost sector. A common policy directly hurting composting is a subsidy for synthetic or chemical fertilizers. This requires governments to be strategic in balancing short-term crop yields with long-term land maintenance. In Bangladesh, synthetic fertilizer subsidies exist, but there are other financial incentives for the composting sector such as tax exemption for a period of time. Ghana coped with distorted fertilizer prices by creating higher quality compost products, as detailed in Box 15.

Another competing policy includes some type of a feed-in tariff for electricity or subsidies for renewable energy. When solely considering organic waste management, this would incentivize investment into landfill gas infrastructure or anaerobic digestion facilities instead of composting since both create a byproduct that can be converted to electricity. Depending on the anticipated capacity of cities, availability of clean organic feedstock, energy needs, and funding situation, this might be an appropriate strategy for the country. For example, in Austria, a large number of biomass incineration facilities was established using wood from energy forests and bulky green waste. This led to a considerable redirection of bulky green waste from composting to heat and energy recovery facilities, resulting in significant financial and product quality challenges across the composting sector. This is due to a combination of market forces in addition to renewable energy targets that Austria set for the country and is a clear case of how policies may conflict with the development of a thriving composting sector (European Commission, 2010).

Agriculture and Environment

Agricultural and environmental policies that could affect compost production include subsidies on fertilizer versus compost, rules on how agricultural waste is reused, guidelines on land use, and pollution control measures. For example, in Nigeria, there is a common practice of burning agricultural waste in preparation for planting (Federal Republic of Nigeria, 2012). However, this leads to air pollution and, in particular, emissions of particulate matter. Repurposing this agricultural waste for composting through legal guidelines would reduce pollution. Another pollution source is concentrated livestock sewage, which can contaminate local water bodies. Measures that restrict how agricultural waste can be managed could directly impact the development of the compost sector.

As previously discussed, contradictory policies and competing priorities determine whether users will choose compost. In many developing countries, policies

Box 15. Enriching Compost Products to Increase Market Attractiveness—Fortifer and FertiSoil Products in Ghana

Compost has experienced a challenged past in Ghana. Given that municipal source separation programs do not exist, compost products have been typically manufactured from mixed MSW. A 2006 survey of farmers revealed that 40% of respondents did not use MSW compost because of poor product quality, and 35% said that it was too costly (Danso, et al., 2006). Crops sold in urban markets, especially exotic vegetables, have a short growth period and require more nitrogen than what is available in MSW-derived compost. Additionally, farmers prefer synthetic fertilizers, due to their tenancy agreements with landowners and the need for immediate boosts in crop productivity. Further distorting the market, synthetic fertilizers were subsidized by the national government in Ghana between 2008 and 2013.

As a result of these challenges, compost manufacturers in Ghana have pursued enrichment techniques in order to increase the nutritional value of their compost products and appeal to agricultural and horticultural end markets. Today, companies are co-composting mixed MSW with a variety of animal and agricultural wastes and are pursuing innovative strategies to compete with other locally available products.

The International Water Management Institute (IWMI) in Accra has boosted the nutrient value and attractiveness of its MSW compost through:

(i) Co-composting MSW with dewatered fecal sludge;

(ii) Blending compost with synthetic fertilizer or urine to create a 'fortified' product; and

(iii) Pelletizing compost to reduce its bulkiness and create a product similar in appearance and handling to a synthetic fertilizer (Adamtey, et al. 2009; Nikiema, et al. 2014).

The branded name of this product is Fortifer. With funding from the Bill and Melinda Gates Foundation, the UK Department for International Development, Grand Challenges Canada, and the From Waste to Food program, IWMI is developing a national marketing plan for product commercialization. As of October 2015, IWMI was also supporting the construction of a new low-cost, open air composting facility to produce 500 MTPY of Fortifer in Tema (Smith, 2015).

DeCo!, an NGO in Tamale Ghana, also composts mixed MSW with other nitrogen-rich sources of waste such as fruit waste, vegetable waste, neem tree leaves, shea butter processing waste, corn cobs, groundnuts and poultry manure to improve the quality of its end product, which is called FertiSoil and was launched in 2013. In 2014, DeCo! processed 3,000 MTPY of wastes and supplied compost to 3,000–4,000 farmers. A large portion of DeCo!'s compost is sold to partner NGOs, such as Advance and Abokobi Society of Switzerland and research institutions, such as the Savanna Agricultural Research Institute (SARI), that distribute product free of charge to farmers, while a smaller portion is sold directly to end users. Due to extensive field testing, product refinement to align with farmers' needs and promotional campaigns by SARI and the Ghanaian Ministry of Agriculture, demand for FertiSoil is increasing. The group has plans to build two additional facilities with projected earnings of $1.8 million.

To further this plan and build upon the need for high nutritional value waste streams, DeCo!, in partnership with the Community Life Improvement Programme (CLIP), a community development organization, piloted the country's first household separation program in Northern Ghana in 2015. Ten households in each of 15 communities were provided with two waste bins; one for organic waste and another for non-organic waste. Organics were collected by CLIP every other day to prevent odor and vermin issues, totaling four MT per week and were processed at the company's composting facility. While DeCo! engaged in an education campaign with participating households, they discovered that when an entire family was not present for the training, individuals were susceptible to making separation errors and even using the bins to store and transport water, instead of for their intended purpose. These results highlighted the need for further education (DeCo!, 2015).

Source: World Bank

do not favor the use of compost in agriculture and sustainable land management. Instead, direct subsidies to farmers, promotional campaigns and tax incentives for synthetic fertilizers are common—implemented for the purpose of rapid harvests. While India has subsidized fertilizers over decades, it has more recently adopted a measure requiring that chemical fertilizer companies co-market and distribute organic compost along with their chemical product lines. The latter policy has forced acceptance of the compost sector in India and is further detailed in Box 16.

Such contradictory policies suppress the attractiveness of compost by communicating government preference for synthetic products. However, the shortfalls of promoting chemical fertilizers include depleted land and environmental health concerns when these fertilizers contact water sources. For example, when a chronic kidney disease spread throughout several farming communities in Sri Lanka, farmers suspected that chemical fertilizer runoff contaminated the drinking water supplies.

Quality compost avoids many of the health and environmental risks associated with synthetic fertilizers, but land use or urban planning related policies guiding the construction and operation of compost facilities should still be in place to ensure a safe composting sector. Constraints on where facilities can be built, such as avoiding residential areas, may also strengthen the composting sector.

Composting standards

Governments can set standards from the type of organic feedstock used for compost to the production and distribution of it. In Karnataka, India multiple grades of compost are produced and labeled based on the type of feedstock used. For example, there is one product made of MSW which is of the lowest value, one created from minerals and manures, and one processed into vermicompost from household and agricultural waste. Some governments then have standards to verify the quality of the compost, ranging from peer evaluation between farmers in Brazil to a third-party certification process in Sri Lanka. Lastly, when it comes to distribution of compost, there could be guidelines or requirements around the specifications used on labeling or the dissemination process itself.

Box 16. Multi-pronged Approach to Develop Demand for Urban Compost in India

The Government of India is forcing the development of the composting sector in cities with four approaches:

(1) The central government requires that all urban governments process biodegradable waste by "composting, vermi-composting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes" (Government of India's Municipal Solid Waste Rules, 2000). Quality standards are also established in the Rules to provide guidance on the proper makeup of compost.

(2) The central government is offering market development assistance to incentivize scaling up the production and distribution of compost products. There is a payment of Rs.1500 per tonne of city compost offered for sector development.

(3) Fertilizer companies are required to co-market compost with their fertilizer products through their dealers' network. The market development assistance could be channeled to these companies since they are marketing and distributing the products. In anticipation of complications ahead, the Government of India is planning to set up a mechanism between the Department of Fertilizers, Ministry of Urban Development, Department of Agriculture and the fertilizer marketing companies to solve coordination issues as needed.

(4) The Department of Agriculture, Cooperation and Farmers Welfare will lead an education campaign with regards to urban compost for farmers and the Ministry of Urban Development is planning to increase construction of compost facilities across all states.

Sources: Government of India, Municipal Solid Waste Rules 2000

A vegetable market in India.
Photo credit: Pixabay

Trade

Depending on the domestic and international markets where the compost will be sold, there may be requirements related to registration and quality assurance of the product. In Canada, all compost products, whether they are produced in the country or abroad, must adhere to strict guidelines. Amongst numerous requirements, some include assurance that additional ingredients were not incorporated after completion of the composting process; that the composition and label claims comply with Canadian standards; and that it is a solid substance produced in accordance with the *Plant Protection Act and Health of Animals Act*. Some countries do not allow fecal matter or sewage in their compost; however, imported compost often has this as an additive without disclosure. This could lead to further development of domestic markets with more stringent guidance than import requirements (Rouse, Rothenberger, Zurbrugg, 2008).

4.2 Planning and Institutions

While the national policies in developing countries may broadly state that MSW be recovered, treated, or recycled, many fall short in adopting the complementary regulations and implementation mechanisms to facilitate their solid waste management goals. Policy frameworks can fail for a variety of reasons such as a lack of stakeholder coordination or inadequate planning.

Solid waste management typically falls under the purview of the Ministry of Environment or Ministry of Urban Development. As shown in the range of policies that could affect the development and promotion of composting, it is beneficial for the relevant ministries to coordinate, with Agriculture being a crucial one, to ensure complementary policies and action. When system complexities are overlooked and policies adopted in a fragmented way, frameworks can be incomplete and even present competing agendas.

Of all of the deficiencies that are found in composting experiences around the world, one of the greatest reasons why composting systems fail is that they are conceived shortsightedly by solid waste management agencies as a purely solid waste management solution. While composting projects may be attractive because of their multiple benefits to agriculture, employment, and the environment, they are often developed within a siloed system that lacks inputs from other impacted stakeholders. Many constraints that are shared in this chapter cannot be addressed by the solid waste sector alone and require the involvement of other sectors, from the national to the local level. When stakeholders are not coordinated, mixed-price incentives may occur or waste streams may be sourced to produce energy instead of compost. When the agricultural community and other potential users are not convinced about the strategic benefits of compost, a supporting framework will not be put in place, and the

Box 17. Coordination between Ministries in Thailand

Since 1998, several ministries in Thailand have taken the initiative to strengthen solid waste management practices related to organic waste management. Composting was being seen both as an alternative disposal method as well as a way to develop an export-oriented agro-food industry.

The Ministry of Natural Resources and Environment is driving and initiating many composting projects nationally. This work is also complemented by composting-related research efforts being undertaken by domestic universities. Simultaneously, the Ministry of Agriculture and Cooperatives set quality standards in 2005 for compost and fertilizers derived from organic materials to ensure high quality products are being generated. Creating even more demand, the Ministry of Industry began promoting composting as an alternative disposal technique in 1998.

Lastly, the Ministry of Energy and the Ministry of Interior signed an agreement in 2007 to encourage mutually beneficial solid waste management practices. Their objective is to ensure that organic waste is being used productively through various technologies that would allow for compost creation and fuel production in addition to fish feed production.

Source: Institute for Global Environmental Strategies

potential for developing a successful composting sector will lessen considerably.

Due to the multisector nature of composting, it is essential for the driving government entity to coordinate across stakeholder groups to achieve project development goals. Sectors and stakeholder groups should be engaged to determine policies, processing requirements, desired inputs and end products, financial expectations, and the types of supporting source separation, collection, and distribution systems required. First and foremost, a clear objective must be identified in order for complimentary policies to be set across stake holder groups. Objectives that support composting may be to improve land quality, reduce landfill costs, and achieve cleaner streets and neighborhoods. To strategize toward this goal, stakeholder coordination can be facilitated through the creation of a working group with the key implementation entities and the end users of compost. Tasked with setting goals and crafting policies to support the unified goal, a composting working group can help ensure that a policy framework is holistic and comprehensive.

Institutional fragmentation, different cultures, lack of political will, and limited technical knowledge and capacities may all undermine a collaborative approach. Even when stakeholder coordination is optimized and comprehensive regulatory frameworks are in place, institutions may still lack the capacity to implement, monitor, and enforce new policies. Technical support from industry experts, multilateral development banks and governments that have successfully developed a composting sector may aid in institutional capacity building for longer-term sustainability of the sector.

Just as important as stakeholder coordination across different sectors and agencies is coordination between the national and local levels of government. Local government policies are typically required to be consistent with national guidelines. However, local policies have the power to encourage or stifle a composting sector beyond the drivers at the national level. For example, if the financial viability of composting is predicated on recyclable sales as a supportive revenue streams, plastic disposal bans may need to be in place. In the United States, the Environmental Protection Agency is responsible for setting national waste management standardsm, but each state and many localities can set regulations and drive activities around organics and plastics recycling (Environmental Protection Agency, 2016). Local governments should remain aware of national policies that affect composting. While uncommon, mandatory composting at a national level may result in a glut of products on the market. In contrast, favorable export policies for compost, as is forming through the EU's proposed Circular Economy package, will create new market opportunities (European Commission, 2015).

Overview of Global Case Studies

The following six chapters feature the commissioned field research on composting projects in five countries and one region: Austria, Bangladesh, Brazil, India, Sri Lanka and Europe. The success factors for each project vary based on the local context and demonstrate that municipal-level composting does not have a one-size-fits-all model. For example, widespread composting in Austria is facilitated by a distributed model on farms and benefits from strict quality guidelines from both the European Union and the national government. In contrast, composting in Bangladesh occurs in a much less mature market. However, a creative business model involving pilots, a municipal feedstock agreement, and a distribution partnership have paved the path for success.

For ease of comprehension, the following table summarizes the actors, policies and financial structures that characterize each composting project's success.

Table 4. Key Characteristics of Global Case Studies

Country or Region	Key Actors	Key Characteristics and Context	Policy Features	Financial Structures
Austria	• On-farm cooperatives (292) • Municipal (89) • Industrial (73)	• 308,000 MTPY processed on farms • Decentralized composting for both home and municipal waste • Use of compost on farms (65%) reduces need for marketing and quality monitoring	• Austrian Compost Ordinance with strict quality, production and marketing guidelines • Mandatory source separation • Ban on organic waste disposal • Supportive national and EU policy framework	• Site development and equipment paid for by combination of municipality, regional waste association, provincial government, and operator • Operator pays 25-50% of capital expenditures, rest paid through subsidies • Gate fees paid to operator for municipal solid waste (~45 euros per MT) • Farmers sell or use compost on site • Farmers contracted and paid for curbside collection in some areas
Bangladesh	• Waste Concern (main actor) • World Wide Recycling (joint venture partner) • Map Agro (distributor during pilot phase) • Advanced Chemical industries (distributor during joint venture phase) • Additionally, many small-scale operators	• 2 phases: small scale pilots and a joint venture (65-90 MTPD, anticipated 50,000 MTPY) • Joint venture utilizes clean market feedstock • Extensive partnerships (for feedstock, distribution) • Pilot was tested and replicated in 23 cities at 47 sites	• 15-year contract with municipal authority that guarantees free market waste feedstock • Tax exemption for 5-10 years, and exemption from VAT and sales tax • Strict compost standards established by Ministry of Agriculture (requires 2 growing cycles of testing) • Large subsidies for chemical fertilizers create uneven playing field	**Pilot:** • Funding from consulting fees, private investors, and UNICEF (though 50% plants closed) • MAP Agro enriched and distributed compost through pre-existing fertilizer network **Joint venture:** • World Wide Recycling helped build large scale facility in Dhaka • First composting project registered with the United Nations Clean Development Mechanism ~ $1.5 million carbon credits sold but market declined in 2012 • Equity investment by World Wide Recycling BV, Entrepreneurial Development Bank of the Netherlands, and High Tide Investment • Soft loan from High Tide Investment • Conventional loan from Dutch Bangla Bank of Bangladesh • Grant from Dutch Ministry of Economic Affairs Development Finance Company • Advanced Chemical Industries markets and distributes compost through existing sales network

Table 4. Key Characteristics of Global Case Studies (cont.)

Country or Region	Key Actors	Key Characteristics and Context	Policy Features	Financial Structures
Brazil	• Ecocitrus (Cooperative of 100 farmers producing organic orange juice and essential oils) • Other private for-profit agro-industrial composters	• Ecocitrus produces 48,000 M3/year of compost • Clean agricultural feedstock from organic farms is sourced through the cooperative and other nearby sources • Compost product targets high-end organic markets ($900 million market size) and is also used on-site • General movement toward decentralized composting in Brazil	• National solid waste policy to divert 53% of organics from landfill by 2031 • Power given to national, state, and muni governments to grant tax and other financial incentives • Source separation schemes are rare but developing • Large-scale composters must follow quality standards and register with the Ministry of Agriculture, Livestock and Food Supply • Small-scale farmers use peer-evaluation for quality assurance through a Participatory Guarantee System (in which local authorities are audited by a central body)	• Financially sustainable through gate fees from non-member feedstock providers and product sales • Regional development bank financed a biogas facility (composting capital expenditure funding is unknown) • Past investments in Brazil from development banks failed due to operational and financial issues
India	• Karnataka Compost Development Corporation (KCDC; state owned) • Terra Firma Biotechnologies (private)	• KCDC: produces 22,600 MTPY of compost per year in 3 grades: "city compost" from mixed municipal solid waste, vermicompost from household and agricultural waste, and AgriGold which uses mineral and manure additives • Terra Firma: processes 15,000 MTPY of waste • Majority of public composting plants have failed, leading to private sector business model (270 new sites) • National shift toward integrated plant nutrient management due to depletion of soil humus • Market is highly seasonal	• Mandated co-marketing of municipal waste compost for fertilizer companies • National and state subsidies for agricultural compost use • National capital subsidies to municipal governments to improve solid waste management • National Ministry of Environment mandates local composting and anaerobic digestion for organic waste, though enforcement and is funding weak • Fertilizer Control Order sets quality and operating standards • Local agency provides compost sales licenses based on lab test certification	**KCDC:** • Government subsidizes compost prices • Company sells products from other compost producers in the state • No gate fees for feedstock **Terra Firma:** • Profitable through gate fees, compost sales, and recyclable sales • Sells compost to other distributors, education and consulting services • Purchased land and equipment using equity (no debt) **General:** • Jawaharlal Nehru Urban Renewal Mission provided grants to 60 cities to improve SWM, leading to PPPs • Shortage of long-term debt

Table 4. Key Characteristics of Global Case Studies (cont.)

Country or Region	Key Actors	Key Characteristics and Context	Policy Features	Financial Structures
Sri Lanka	• Balangoda Compost Plant (municipal) • 115 municipal facilities (from Pilisaru Project; 12 large scale)	• Balangoda Compost Plant produces 148 MTPD • Products are enriched with animal and fecal sludge • Uses agents and sellers to reach markets (100% is sold) • Country had many compost plant failures despite widespread international aid, which led to new $40 million national Pilisaru Project • Land has very low organic matter content due to fertilizer overuse • Health issues have arisen due to fertilizer use and runoffs	• Guidelines for Pilisaru Project prevent most lending for operations and maintenance, requiring long-term financial sustainability • Quality standards for municipal waste and agricultural waste compost is issued by the Sri Lanka Standards Institute (certification not required to sell compost) • SLS Marks Scheme provides third party compost certification • Ministry of Agriculture invested $710,000 in on-farm composting • No programs exist to promote adoption of MSW compost	• Central Environmental Authority and provincial council funded plant construction at $300,000 • Pilisaru Project provided capital for expansion and subsidized salaries • Land Reform Committee provided free land • Operations and maintenance costs are $1,340 per month, covered by Balangoda Urban Council until profitable • Cost recovery through garbage tax and door-to-door collection (no charge for source separated waste), recyclable sales, vocational training and certification, compost sales, and gate fees from waste drop offs
Europe	• Estimated 2500 compost plants within European Union • Additional 800 small-scale, on-farm facilities concentrated in Austria and Germany	• 27 million MTPY of waste are treated • 42% of all biodegradable waste is recycled through composting or anaerobic digestion • Seven countries in Western Europe account for 2/3 of all composting activity • Scale ranges from large centralized facilities to on-farm composting and home composting • Push for waste disposal reform originally driven by land scarcity and cost	• EU Landfill Directive sets ambitious recycling landfill diversion targets for member states • The overarching Waste Framework Directive (2008) sets a household recycling target of 50% by 2020 • The Landfill Directive (1999) requires organic waste landfill diversion of 35% of 1995 levels by 2016 for most states, and 2020 for others • Each member state can develop individual strategies and enforcement methods to comply with overall EU directives, leading to source separation requirements, landfill taxes and bans, and recycling targets • National quality assurance systems drive demand and are integrated into national regulations in 6 states and exist in some form in 15 states • The European Compost Network established harmonizing standards in 2008 and support national governments in developing their own standards • Newly proposed Circular Economy Package outlines targets for waste management, including a 65% municipal waste recycling rate and 10% landfilling rate by 2030	• EU offers several grants for member states, totaling €174 million for allocation between 2014 and 2020 • European Investment Bank provides loans and financial products with favorable terms for investments in organics recycling • National government funding opportunities vary • National funds obtained through landfill taxes often used to support other waste infrastructure projects • Household fees are common, including a Bio-Bin fee based on collected waste volume and frequency (€25 – 120), and pay-as-you-throw based on residual waste volume

Small-scale community compost bins at a local farm. Photo credit: © Ian Keirle | Dreamstime.com

5 Case Study: Decentralized Composting in Partnership with the Agriculture Sector in Austria

Key Success Factors

- The promotion of home composting, which reduces the overall quantity of organics in the waste management stream
- The use of small-scale, low cost windrow composting technologies as opposed to capital intensive in-vessel systems
- A supportive national and European policy framework that mandates source separated collection, requires organic waste diversion from the landfill and ensures high quality compost production through a recognized quality assurance scheme
- High materials processing and compost quality standards imposed by the farmers managing the waste because they are using 70 – 90% of the product on their own crops (Amlinger, 2012)
- Limited need for marketing and product sales

Austria is a leader in solid waste management across Europe and the world due to its long history of progressive policies and unique, decentralized approach to organics management. Since the 1990s, Austria has employed a system that 1) promotes home composting, 2) mandates source separated collection of organic municipal waste and 3) places municipal waste collection and composting in the hands of the local agricultural sector in rural and semi-urban areas. Municipal organics from urban areas are managed by local authorities and processed in either municipal or private sector composting or anaerobic digestion facilities. As a result, the country has surpassed the landfill diversion requirements set forth by the EU Landfill Directive. The amount of biodegradable municipal waste going to a landfill is below 3% of the 1995 baseline with nearly 1,000,000 MT of organics treated in composting facilities each year (European Environment Agency, 2013).

Initiated by local farmers due to their need for high quality soil products for on-site use, the Austrian compost sector has become a best practice for collaboration between municipal authorities and the agricultural sector.

Context: Austria is home to 8.4 million inhabitants and in 2010, generated 4.96 million MT of MSW. In 2009, approximately 751,900 MT of municipal organic and green waste were collected and treated separately, 1,505,000 MT were processed through home or on-farm composting, and 550,000 were treated on privately owned property or non-registered facilities (European Compost Network, 2016). Austria's landfill ban on untreated waste requires that 100% of MSW be treated prior to landfill disposal. All MSW disposed in residual waste bins are processed through one of sixteen mechanical biological treatment (MBT) facilities before being biologically treated, recycled or converted through waste to energy.

As of 2012, 454 composting plants were installed across Austria (Table 5), of which 64% were *on-farm* facilities treating a total of 308,000 MTPY. Unlike large-scale, centralized municipal and industrial composting facilities, the average facility processes 1,100 MTPY of feedstock and can serve an approximate population of 14,500. Because of this captive system, only 35% of the compost produced *nationwide* in on-farm, municipal, and industrial facilities is sold into local markets while the rest is used on-site by farmers (Amlinger, 2012). Reflecting the high quality requirement associated with on-farm use, 94% of all compost is derived from bio-waste or green waste, and only 6% is produced from sewage sludge and mixed waste (ORBIT and European Compost Network, 2008).

The benefits of this system are numerous and have led to its widespread success (table 6). All single family homes are encouraged to undertake home composting which decreases the amount of organics entering the solid waste management system and reduces downstream transport and treatment costs. Home composters may opt out of organics collection, which is facilitated through a bio-bin program. Through the bio-bin program, waste generators pay based on the quantity of organic waste that is being disposed of. Depending on the bin volume and collection frequency, a bio-bin fee ranging from €25-120 per year is assessed. Home composters avoid this fee and produce compost that can be used for gardening. Generators that are not willing or able to participate in home composting are required to source separate their kitchen and yard waste, according to Austrian law.

Policy/Regulatory Framework: Austria has a supportive and comprehensive policy framework for composting that includes source separation mandates, landfill organics diversion measures including targets, bans and taxes, and compost quality assurance schemes. A mandatory source separated collection policy was successfully adopted in 1992 followed by the implementation of the Austrian Compost Ordinance in 2001, which regulates compost quality, production, marketing, and labeling for the purpose of limiting environmental impacts and increasing product competitiveness in local markets. While approaches vary across Europe, the Austrian Compost Ordinance was Europe's first "end of waste" regulation and clearly defines the inputs, processes, and finished product criteria by which organic waste becomes a saleable product. In addition, it designates three quality classes of compost and articulates the corresponding labels and potential application sites for each product type (European Compost Network Website, n.d.):

- **Class: A+, Label:** "Quality Compost Class A+", **Application:** Suitable for use in organic production of agricultural products

Table 5. Distribution of Composting Facilities in Austria

		On-Farm Facilities		Municipal Facilities		Industrial Facilities	
	All Facilities	No.	% of Total	No.	% of Total	No.	% of Total
Number of Composting Facilities	454	292	64%	89	20%	73	16%
Total Organic Waste Composted in Austria (MTPY)	976,000	308,000	32%	237,300	24%	431,000	44%
Average Facility Capacity (MTPY)	2,800	1,100		2,700		5,900	

Source: Amlinger, 2012

Table 6. Main Benefits of Austria's Decentralized Composting Strategy

Promotion of Home Composting	Source Separated Collection	On-Farm Composting
• Reduced transport • Sustainable garden management • Low implementation cost to the municipal waste management system • Reduced municipal hauling and waste treatment costs • Low to no cost to citizens	• Generation of clean, organic feedstock for composting facilities • Reduced organic waste in residual waste stream, thereby reducing residual waste collection and treatment costs	• On-site application of compost to improve soil • High quality standards imposed by farmers due to internal incentives • Reduced synthetic fertilizer use • Additional income for farmers (paid for waste collection services, compost sales) • High levels of transparency for participants

Source: Amlinger, 2012

Fresh organic waste is added to windrows at an Austrian farm composting facility. Photo credit: 100-First Zero Waste & Organic Cycle Organisation

- **Class: A, Label:** "Quality Compost Class A" or "Quality Sewage Sludge Compost", **Application:** Conventional Agriculture,
- **Class: B, Label:** "Compost", **Application:** Non-agricultural use (e.g., Land reclamation, landscaping)
- **Class: N/A, Label:** "MSW Compost", **Application:** Cannot be marketed freely and must be transported directly to end-user. May be used as a landfill cover. MSW Compost is not considered compost in Austria, and therefore is not assigned a class.

An Austrian landfill tax was introduced in 1989, and rates were differentiated in 1996 to account for the variation in technical quality of different landfills and different waste streams. The fee for landfilling biodegradable waste rose from €44/ton in 2001 to €87/ton in 2006. Most recently, in 2009, Austria issued an outright ban on the landfill disposal of waste with a total organic carbon content over 5% and lowered the landfill gate fee for biodegradables to €29.8 in 2012 (European Environment Agency, 2013). This is predicated on the fact that all biodegradable waste must be processed at a MBT facility prior to landfilling, thereby increasing total processing costs. The ban has allowed Austria to be the first country in Europe to exceed the EU Landfill Diversion targets. While the targets require Member States to reduce the amount of biodegradable waste landfilled to 75% of 1995 levels by 2006, 50% by 2009, and 35% by 2016 (with an extension to 2020 for certain Member States), Austria successfully met the 2016 target prior to 2008.

Large scale and agricultural compost producers participate in different quality assurance systems (QAS). Large-scale producers are most commonly associated with the Austrian Compost Quality Society (KGVO) while agricultural producers are associated with the Austrian Compost and Biogas Association (ARGE). Both systems rely on the Austrian Compost Ordinance and the Austrian Guideline for State of the Art Composting issued by the Ministry of Environment. All composting plants undergo regular inspection, and compost samples are tested in one of several independent, authorized laboratories to ensure compliance. The European Compost Network has a separate quality assurance scheme to help harmonize existing national initiatives. Their scheme has two labels that they award: 1) a conformity label for compliant national quality assurance schemes and 2) a quality label for compliant composting and digestion plants. KGVO and ARGE are two of four national QASs across Europe to have received the conformity label.

Program Structure: The predominant technology in use across Austria's decentralized compost sector is a low-cost windrow system, with some farmers choosing to operate open windrow systems and others utilizing synthetic covers. This technology is possible given land availability, high-quality feedstock, and relative distance from odor sensitive areas. Depending on the operating model, pre-sorting may or may not occur on-site. The four different decentralized organic waste management operating models in use across Austria are (Amlinger, 2012):

- Model 1: Two farmers cooperate as partners carrying out source separated collection and composting of organic waste streams in a rural area.
- Model 2: A group of 20 farmers operate as partners of the regional waste authority to provide the collection and composting of residential organic waste.
- Model 3: A small group of 3-5 farmers receive source separated organic waste from an entire county in alternating fashion with bulky yard waste supplies by areas immediately surrounding the farm.
- Model 4: Food waste is pre-treated at a large centralized pre-treatment plant in a city and then transported to a cooperative of farmers for composting and direct use.

Financial / Economic Features: In most cases, the on-farm composting facility enters into a contract with the municipality or the regional Waste Management Association to manage a specified quantity of organic waste and/or garden/park waste, presuming feedstock does not contain more than 2% impurities. Gate fees at on-farm facilities range between €45-€60/MT of organic waste and €15-€45/MT of garden/park waste (Amlinger, 2012). These are well below the cost of MBT plus landfilling and of incineration which can exceed €150/MT. Generators pay a general waste fee along with an annual organics fee to support collection and processing costs. The classical model includes contracts for composting only with

Box 18. Graz, Austria—An Example of Decentralized Composting

The municipality of Graz serves a population of 356,000 people in the city and surrounding villages. The Graz municipal authority is responsible for the collection and pre-treatment of approximately 30,000 MTPY of organic waste. Source separated waste is pre-treated with sorting, screening to remove inert materials, shredding, and homogenization in a centralized facility. The pre-treated raw material is then transported from the centralized facility to 18 decentralized on-farm composting facilities. The contracted farmers, who process between 200 and 3,000 MTPY of feedstock, operate open windrow composting systems and are responsible for covering all on-site capital and operating expenses.

Aerial view of Graz, Austria. Photo credit: Pixabay

The local authority is responsible for guaranteeing the quality of compost produced. On behalf of the town administration, compost samples are taken one time each year from agricultural composting plants to be tested at an external, independent laboratory. If the test results comply with the Austrian compost standards for agricultural use, for the farmer can use the compost on their agricultural lands or market it. In other instances, the municipality becomes the owner of a portion of the compost product for public use and distribution to residents. There are periodic inspections in Graz to ensure compliance with the quality standards. If the compost product does not comply with national standards, it is used by the city of Graz for non-agricultural purposes, such as for land reclamation.

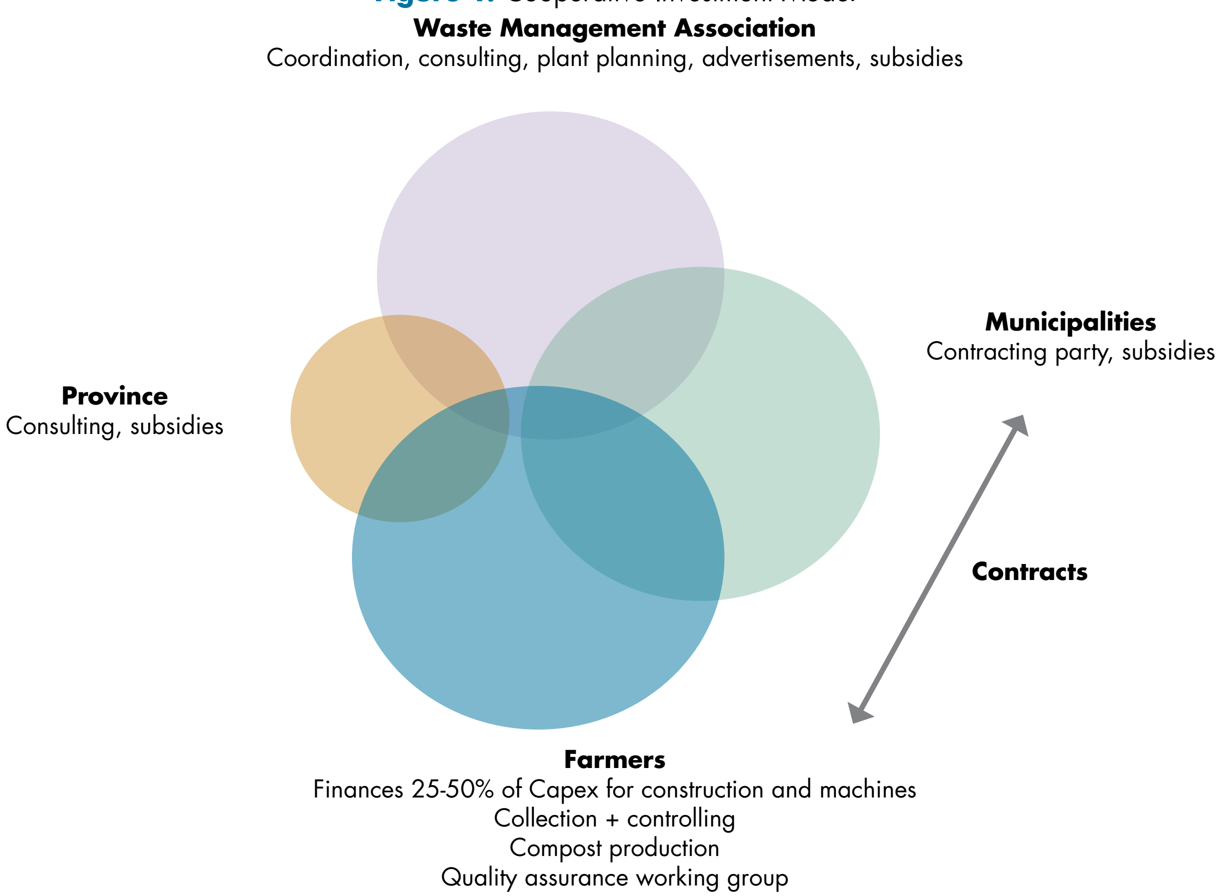
Source: Amlinger, 2012

collection performed by either the municipal solid waste authority or their contracted service provider. However, in some rural areas, farmers are also contracted to carry out the curbside collection of organic waste. Collection receptacles (bags, buckets, or bins) are tailored to the specific needs of the jurisdiction, as are receptacle capacities. This minimizes investment and operating costs for waste collection.

In Austria, the financing of a new decentralized composting facility is typically done through a cooperative investment model whereby the municipality, the regional Waste Management Association, the provincial government, and the compost facility operator all contribute to the site development and equipment costs. The compost facility operator traditionally finances 25-50% of the total capital expenditures with the remaining funds provided by the aforementioned government entities in the form of subsidies (Figure 1).

Moving Forward: Austria's organic waste management system continues to function with outstanding success and has been evaluated for replication in other countries, including Bulgaria. Even if proposed revisions to the current EU Landfill Directive to phase out the landfilling of biodegradable waste by 2025 move forward, Austria is well ahead of meeting that target in addition to targets it has already achieved. The National Ministry of Agriculture, Forestry, Environment and Water Management introduced a waste prevention program in 2011 aimed at minimizing organic waste production from industries and households and the food sector, including food production, retail and large-scale catering establishments. Activities included under the expected program are: dissemination of best practice examples, the establishment of networks, and removal of legislative barriers (European Environment Agency, 2013).

Figure 1: Cooperative Investment Model



Excavator shovel working on a large heap of organic fertilizer. Photo credit: Maren Winter

6 Case Study: Composting Market Waste in Bangladesh with a Joint Venture Company

Key Success Factors

- Revenues from the sale of carbon credits until 2012, when the market price for carbon declined significantly
- Sourcing of large volumes of clean, organic feedstock from a vegetable market
- Proof of concept established through pilot projects and several years of relationship building and model development
- Innovative partnership model that leverages established national distribution networks through a partnership with Advanced Chemical Industries (ACI), the largest synthetic fertilizer distributor in Bangladesh, and foreign direct investment through a joint venture with World Wide Recycling

Waste Concern, a social business enterprise based in Dhaka, has become a critical player in building local capacity around biodegradable waste management in Bangladesh, where the environment around composting has traditionally been challenging. The adoption of compost products has been low due to prevailing subsidies for synthetic fertilizers and poor marketing. National policies have been developed in recent years, but they lack infrastructural support mechanisms to be fully implemented.

Founded in 1995, Waste Concern is the first entity to take a step towards the successful implementation of a composting industry in Bangladesh. It has evolved into a multi-faceted organization that develops and operates waste collection and processing infrastructure, provides consulting services to local and international clients, and operates a recycling training center and compost laboratory. Waste Concern has become an internationally recognized NGO for their unique and successful community-based, decentralized composting model that has been replicated across Bangladesh and other countries in Asia including Sri Lanka, Vietnam, and Pakistan. A 2005 joint venture between Waste Concern and a Dutch recycling company named World Wide Recycling led to the operation of a 130 MTPD capacity composting project. This project became the first successfully registered composting project through CDM.

Context: Bangladesh is home to 166 million people based on a 2014 estimate. Per capita MSW generation rates range from 0.25-0.30 kg daily in rural areas to 0.47-0.50 kg daily in urban areas, with urban areas producing around 4.86 million MT of MSW each year. 75-85% of MSW comes from households, while 15-20% comes from commercial generators. Waste collection typically occurs in two steps: 1) residents, community waste collectors, or NGOs transport mixed waste from a home or business to a centralized drop off center and then 2) the local authority transports waste from the drop off center to a disposal site. Some cities have implemented door-to-door waste collection for which they pay a service fee. Tipping fees are not customary at disposal sites across Bangladesh.

Although source separation does not occur formally, recyclables are separated at the household and sold to traveling buyers and recovered by informal recyclers at drop off centers and disposal sites. Biodegradable waste is an estimated 70-85% of the total MSW generated. Despite this, as of 2012 only 2% of the total MSW generated in Bangladesh was composted (Bangladesh Municipal Development Fund, 2012). Low composting rates are the result of a variety of factors including: agricultural practices that favor nationally subsidized synthetic fertilizers, competition with locally available and less expensive products such as cow dung and poultry litter, and sharecropping agreements that encourage quick crop yields and neglect long-term soil health.

Farmers in Bangladesh generally rely on chemical fertilizers for intensive crop production, which deteriorate soil conditions. It is estimated that 83% of cultivated lands in Bangladesh have less than 2% organic matter content. Beginning in the 1960s, the country underwent a green revolution that included programs aimed at increasing food production and fostering self-sufficiency. Thus began the use of high yield seeds, chemical fertilizers, pesticides, mechanical plowing, and large-scale irrigation. The program included a widespread campaign promoting the use of chemical fertilizers, increased accessibility to loan and credit facilities for farmers, and tax incentives to import chemical fertilizers and to build fertilizer factories.

Organic waste composting is relatively new in Bangladesh, only beginning to emerge in the early 2000s. Municipalities, NGOs, community organizations and private companies are all active in the production, marketing, and sale of compost products. Several project development structures exist involving varying degrees of municipal support. A municipality may own and operate a facility, own the facility and contract with a private company for daily management, or provide feedstock for a privately owned and operated plant.

The majority of composting plants in Bangladesh are decentralized and small in scale (1-5 MTPD). Together, the private sector and NGOs operate an estimated 60% of the country's composting facilities, with municipal authorities managing the rest (Waste Concern, 2016). In 1995, Waste Concern, an NGO promoting the development of community-based composting plants, was established. They launched a successful pilot that year, expanded to the cities of Sylhet and Khulna in 2000, and then to 14 additional cities in 2002 with funding from The United Nations Children's Fund. Half of these facilities were operated by municipal authorities, which lacked trained operators, leading eventually to decommissioning. The remaining facilities were operated by NGO's and the private sector and still function today. As of March 2016, the Waste Concern model has been replicated across 56 sites throughout Bangladesh, including the country's only large-scale facility in Bulta, Narayanganj, which has an installed capacity of 130 MTPD (Waste Concern, 2016). Recently, the Department of Environment of the National Ministry of Environment and Forests launched a program to develop composting in 64 districts in Bangladesh. Initially, the Department of Environment will establish 4 composting facilities ranging in capacity from 12 to 20 MTPD with funds from the national Climate Change Trust Fund.

Compost prices in Bangladesh are very high relative to alternative local products and compost prices in other parts of the world. RUSTIC, a private compost manufacturer sells compost on a wholesale basis for BDT 7/kg ($90/MT)[iii] while manufacturers in Faridupr, Gaibanda and Mymensingh sell compost for BDT 8–25/kg ($100 – 320/MT). By comparison, cow dung

Box 19. Innovative Marketing Strategies

The composting market in Bangladesh is limited. Compost manufacturers are successfully producing compost but fail to sustain operations due to a lack of demand and poor marketing strategies (Ali 2004; Zurbrugg 2003). Innovative campagins are underway to increase confidence levels in compost. Innovision, a private company, has been promoting compost among farmers by highlighting its benefits, including improved crop yield and soil amelioration. In partnership with Annapurna Agro Service, a private composting company, Innovision using a mobile van equipped with a movie screen, to educate farmers on the benefits of compost. Innovision conducted 240 screenings in 7 months time, reaching more than 16,000 farmers and effectively changing consumer mindsets toward reducing dependency on chemical fertilizers and applying more compost.

Source: Rashid, 2011

and poultry manure sell for BDT 0.50/kg ($10/MT) and synthetic fertilizers for BDT 6.59/kg ($80/MT). Although markets for compost are currently limited to nurseries and vegetable growers, organic farming is a growing market across Bangladesh with approximately 177,700 hectares, or 2% of the total agricultural lands being managed organically (International Federation of Organic Agriculture Movements & Research Institute of Organic Agriculture, 2006). However, without significant education on the benefits of compost, along with incentive structures similar to those for synthetic fertilizers, the compost sector in Bangladesh can expect to remain small and dependent on niche markets.

Policy/Regulatory Framework: In Bangladesh, municipal authorities are responsible for managing MSW and ensuring that the principles of waste reduction and recycling are followed. In 2008, the Ministry of Agriculture adopted the Fertilizer Act 2006, which includes compost standards, along with facility registration and product certification requirements. In practice, the certification process is time consuming and complex, involving laboratory analyses and field-testing. Unlike other Asian countries that require field testing for one growing season and issue temporary permits in the interim, Bangladeshi composters undergo field testing for two growing seasons. They must also undergo certification for each product they manufacture and are prohibited from marketing compost commercially until certification is achieved. This has been a major barrier to the growth of community-scale composting in Bangladesh. As of 2016, 70 composters had achieved certification (Waste Concern, 2016), with many more composters still in queue.

The Department of Environment ratified a National 3R (Reduce, Reuse and Recycle) Strategy in 2010, directing local governments to develop action plans that include organic waste recycling through composting, bio-gas and refused derived fuel. While the strategy also made source segregation mandatory, implementation and enforcement was weak because local governments struggled to provide basic waste services, let alone segregated waste collection. A source separation pilot has been rolled out in Dhaka and Chittagong, where the Department of Environment has distributed three bins to households for refuse, organics, and recyclable wastes. The pilot is intended to generate a clean organic feedstock for composting facilities planned for development in the cities.

A host of national policy documents exist in Bangladesh to varying degrees of implementation. The National Solid Waste Management Handling Rules was drafted in 2010 highlighting financial and technical capacity building measures; however, as of 2014, it was still pending ratification. Incentives have been implemented at the national level to promote organic waste recycling. For example, the National Ministry of Finance has given all waste treatment and recycling plants, including composting facilities, a tax exemption for five to ten years and compost products are excused from value-added tax and sales tax. In addition, import duties on environmentally friendly technologies have been reduced. While the government encourages integrated nutrient management and the blending of compost with synthetic fertilizers, no specific purchasing incentives exist and, in fact, fertilizers still benefit from product subsidies (BDT 7500/ton of urea), creating an uneven playing field (Waste Concern, 2006).

Technical Features: Today, approximately 16 million people live in Dhaka and generate 5,000 MTPD of MSW. Dhaka City Corporation (DCC) is responsible for providing waste management services but is only able to collect 60% of the waste produced, of which 80-85% is dumped and 15% is recycled (Financial Express, 2016). Waste Concern has become an important player in the collection and management of organic waste in Dhaka, beginning with a pilot composting facility erected in 1995. The initial pilot employed four workers to collect waste from 800 households, had a processing capacity of three MTPD, and could produce 600 kg/day of finished compost. Four to six additional workers sorted incoming feedstock to remove inert materials and managed the composting process. The site utilized a box composting technique due to its low cost, low level of mechanization (reduced turning requirements compared to traditional windrow systems) and suitability to Bangladesh's climate conditions. The process took 40 days for decomposition and an additional 10-15 days for maturation. The compost product was then screened to produce different grades and sold through a partner company, MAP Agro, who purchased the compost and enriched it with micronutrients before distributing it to their pre-existing agricultural customers.

Organic waste collected from vegetable markets and other sources (left). Matured compost pile in the shed at Waste Concern's Bulta facility (right). Photo credit: Waste Concern

Waste Concern partnered with Dutch recycling company, WWR, in 2005 to develop a large scale composting facility in Dhaka. Through a joint venture called WWR BioFertilizer Ltd. Bangladesh, the company successfully registered the first composting project through the Clean Development Mechanism of the United Nations Framework Convention on Climate Change in 2008. The composting project initially had a planned capacity of 700 MTPD, spread across three processing sites. However, due to the collapse of the carbon market in 2012, only a single site was constructed in 2009. This facility located in Bulta, Narayangaj (greater Dhaka) has an installed capacity of 130 MTPD and is currently operating at 60% capacity due a lack of carbon revenues and current negotiations with the DCC around the supply of organic feedstock. To date, the facility has processed a total of 102,183 MT of waste from food markets and produces between 2,200 and 3000 MTPY of compost (Waste Concern, 2016).

Incoming waste undergoes a pre-sort process to remove inert materials. The plant then uses static pile composting with forced aeration followed by maturation. The site consists of eight composting cells and a maturation area, weigh bridge, drum screen, wheel loader, blowers, measuring equipment for temperature and moisture, a crusher, and a bagging machine. The product has been approved and certified by the Ministry of Agriculture. ACI, a partner company and the largest synthetic fertilizer distributor in Bangladesh, distributes compost through its established network in addition to undertaking promotional branding (leaflets, posters, stickers, and television advertisement), enhancing brand awareness (farmers' meetings and demonstration farming), and facilitating product launches and meetings with the Department of Agriculture Extension. According to ACI, there is high demand for the product.

Financial / Economic Features: During the first three years of piloting and developing their preliminary composting model in 1995, project costs totaled BDT 700,000, which they obtained through consulting fees and private investors. During operation, the pilot facility's compost production costs were BDT 1.80/kg. The product was sold to MAP Agro for BDT 2.50/kg; MAP Agro would then enrich the product and sell it for BDT 6/kg (Rahman, 2010).

In 2011, typical capital costs for replicating three sizes of Waste Concern's decentralized, community based composting model ranged from $14,609 in capital expenditures for 3 MTPD to $73,043 for 20 MTPD (Table 7).

The total investment cost of the joint venture's (WWR BioFertilizer Ltd. Bangladesh) first facility was $3.6 million (Center for Clean Air Policy, 2013). The project was financed through a combination of grants, equity, loans, and carbon credits. At its inception, the International Business and Cooperation of the Dutch Ministry of Economic Affairs provided a €500,000 grant. WWR Bio Holdings financed the joint venture through three equity investments from World Wide Recycling BV, the Entrepreneurial Development Bank of the Netherlands, and High Tide Investment, a Dutch investment firm. High

Table 7. Waste Concern Projected Cost of Community-Based, Decentralized Composting Facility

Items	Capacity		
	3 MTPD	10 MTPD	20 MTPD
Land Required per plant (ft^2)	5,040	14,400	25,200
Fixed cost per plant (USD)	14,609	41,739	73,043
Operating cost per plant (USD)	4,348	14,493	28,986
Workers per plant	4	12	25
Compost produced per day (kg)	750	2,500	5,000

Source: United Nations Development Program, 2011, Currency in USD 2011

Tide Investment also provided a soft loan. Finally, the Dutch Bangla Bank of Bangladesh provided a conventional loan in local Bangladeshi Taka. These investors were attracted by a strong jointly-prepared business plan by Waste Concern and WWR. This business plan assumed a compost sale price of BDT 6000/ton and carbon emission reduction credits of $8 per CO_2 equivalent.

According to the project design document issued to the UNFCCC, the project would not have been financially viable without revenues from the sale of carbon credits having a net present value of $ -1,439,067, assuming a discount rate of 12% and an internal rate of return of 1% (Waste Concern Fact Sheet). Up until 2012 when the facility ceased receiving revenues from the sale of carbon credits, 55% of the project revenues came from the sale of compost, with the remaining 45% coming from the sale of carbon emission reduction credits. Today, 100% of project revenues come from the sale of compost.

The production cost of compost, including the waste collection, is approximately $63/MT. Waste Concern has been responsible for collecting and transporting market waste to their site according to a 15-year waste collection agreement with the DCC that began in 2007 and therefore, the facility does not receive a tipping fee. However due to a lack of carbon revenues, and the National 3R Strategy which stipulates that municipal authorities should deliver waste free of charge to recycling facilities instead of landfills, the CDM board under the office of the Prime Minister is currently evaluating whether the DCC should supply feedstock for the Bulta facility at no cost to Waste Concern.

ACI purchases bags of the finished compost from the facility for $79/MT.[iv] ACI then sells the compost to the farmers through its distribution network (up to 500 km from the plant) (Asian Development Bank, 2013, Waste Concern, 2016) for a higher price, which includes storage, transportation, and promotional costs. The estimated amount of GHG emission reductions over the life of the project is estimated at 386,236 MT CO2 equivalent. During the first reporting period dating from August 2010 to December 2012, a measured 22,786 MT CO2 equivalent were reduced (CDM Monitoring Report, 2013).

Moving Forward: Waste Concern continues to operate a successful social enterprise business having undertaken the development of countless composting facilities, consulting studies, and technical assistance endeavors around the globe. The company's understanding of the unique challenges of developing and maintaining composting operations in low-income environments have resulted in a replicable model that can be applied in urban and rural settings, and at small, medium or large scales. Waste Concern operates a recycling training center in Dhaka that was built in 2006 with support from the United Nations Development Program and the Bangladesh Ministry of Environment and Forests that is a destination for waste practitioners from around the world. Waste Concern is currently exploring alternative ways to decrease system costs in the absence of carbon revenues and is advocating for incentives such as the free delivery of waste, land allocations for compost facility development, additional tax incentives, soft loans, leveling the playing field regarding subsidies for synthetic fertilizers and export permissions, as other countries are demanding compost products at a higher price than that in Bangladesh (Waste Concern, 2016).

Students visit a screening and composting plant in Brazil. Photo credit: www.guarani.mg.gov.br

7 Case Study: Promoting Organic Agriculture in Brazil

Key Success Factors

- Utilization of high quality, low contaminant agro-industrial feedstocks from cooperative members and other nearby industries
- Production of a quality end product that meets national requirements for use in conventional and organic agricultural markets while satisfying a growing domestic demand for certified organic compost
- Derivation of revenues from a mix of gate fees received from non-member feedstock providers and product sales

Ecocitrus (Cooperativa dos Citricultores Ecológicos do Vale do Caí Ltda.) is a successful organic citrus farmers' cooperative located in the small town of Montenegro, Brazil, 60km from Porto Alegre, the capital city of the State of Rio Grande do Sul. In the early 1990s, a group of 14 citrus producers decided to invest in organic fruit production and founded the cooperative with the support of the Secretary of Agriculture and Food Supply of the State of Rio Grande do Sul and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). Since then, Ecocitrus has been growing rapidly, and the cooperative now has 100 members managing 500 hectares of farmland. EcoCitrus operates a facility that produces certified organic fruit juice for domestic and international markets and organic essential oils for the cosmetic industry in France. Waste from approximately 200 nearby industries along with waste products from the cooperation's primary business operations are used as feedstock for an on-site composting and biogas facility.

Context: Brazil was home to 201.4 million people in 2013 with an estimated 183,482 million MT of MSW collected daily (IGBE, 2010; IBGE, 2014). Although approximately 51.4% of the collected MSW is biodegradable waste, only 1.2% is processed in composting facilities (MMA, 2012). Brazil has experienced a technically challenged past with composting. Despite significant investments in in the 1980s and 1990s from the national development bank, Banco Nacional de Desenvolvimento Econômico e Social (BNDES), Fundação Nacional de Saúde and multilateral development banks such as the World Bank, the majority of MSW composting facilities were decommissioned due to operational or financial failures. In a recent effort to stimulate the composting sector, the Brazilian government established a National Solid Waste Policy (NSWP) in 2010 (Federal Law 12.305/2010, regulated by Federal Decree 7.404/20100) mandating the closure of all uncontrolled dumpsites by 2014 and outlining a graduated plan to divert 53% of organics from landfill disposal by 2031. The NSWP requires state and municipal governments and other commercial/industrial generators to establish and adhere to solid waste management plans as a condition for obtaining access to federal resources such as financing from federal credits entities and other incentives. The policy also grants national, state, and municipal governments the authority to create and deploy tax, financial or credit incentives (Brazilian National Policy on Solid Waste, 2010). Criminal penalties and administrative provisions for non-compliance were established previously by Law Number 9,605, February 12, 1998, and are binding on all activities deemed harmful to the environment outlined in the NSWP.

Despite this significant step towards improved solid waste management practices, many municipalities have proven ill equipped to respond to the NSWP due to crippling financial and technical constraints. This has raised widespread concern over their ability to meet future organics diversion requirements and led to a call for additional government support.

Brazil is an important producer of grains, sugarcane, and meat and therefore agricultural demand for compost products is high with agribusinesses responsible for 23% of GDP. The organic agriculture market in Brazil, which is well suited to organic-based soil products such as compost and biofertilizers, is growing at a rate of 15-20% each year with an estimated market size in 2014 of $900 million (CI Orgânico). In 2012, 76 Brazilian companies exported $129.5 million in certified organic products including food, beverages, cosmetics, ingredients, cleaning products, and textiles through a joint initiative between the Instituto de Promocao do Desenvolvimento (IPD) and Apex-Brazil of the Brazilian Ministry of Trade and Industry, called Organics Brazil.[v]

According to a 2008 study, 211 or 3.8% of Brazil's 5,564 municipalities were operating composting facilities; however, of those processing MSW, none were producing compost that met the national regulations and norms for use in agriculture. This compost was relegated to low value end-uses such as reforestation, erosion control and as a soil amendment in parks, which in many cases was given away free of charge. Bolstered by supporting legislation and certification schemes for organic projects, generators of agro-industrial wastes have begun developing private for-profit organics processing facilities to manage their own waste products while at the same time, producing a valuable end product that can be utilized on-site or sold to the country's growing, higher value end markets.

Recognizing past failures, some municipalities in Brazil are beginning to move away from mixed waste collection and centralized, MSW composting. Composta Sao Paolo was initiated in 2014 to promote home composting, in addition to the city simultaneously pursuing the adoption of a decentralized organic waste processing system. With savings realized through reductions in waste hauling and processing costs, Composta Sao Paolo has provided 2,000 homes with free composting boxes and educational services. Once it is expanded across the city, the program is expected to reduce household biodegradable waste generation by 33% by 2033. By 2023, the City plans to roll out the source-separated collection of all remaining household biodegradable wastes. The city's decentralized processing approach includes constructing 8 small scale, 50 MTPD composting plants by the end of 2016 for processing waste from 833 markets, installing 3 mechanical biological treatment plants by 2019, and gradually integrating 4 larger scale composting facilities by 2023 (ISWA, 2015).

Policy / Regulatory Framework: The Brazilian Government has put a supportive policy framework in place to help create a market for compost. The framework includes minimum quality standards and maximum contaminant limits for products sold into conventional agricultural markets as well as more stringent versions for products sold into organic agricultural markets.

For compost products to be sold into organic agricultural markets, they must meet the following conditions:

- Biodegradable wastes are separated at the source;
- Compost is stable and avoids contact with the edible parts of the plant; and
- Compost is applied according to regional use guidelines to avoid possible negative environmental impacts.

Although compost derived from MSW is permitted for use in organic agriculture, it is currently not occurring due to a general lack of source separation programs.

According to Brazilian legislation, all compost producers, as well as their traders, exporters and importers must formally register with the Ministry of Agriculture, Livestock and Food Supply (MAPA). Large-scale producers of organic products must also register with MAPA and certify their products according to the norms and regulations of the Brazilian Organic Conformity Evaluation System. Products must bear the official organic seal, the name of the certifying body, and contact information for the producer on their packaging.

Small-scale peasant farmers follow a different product certification process known as the Participatory Guarantee System. Unlike traditional third party certification schemes, this system is based on mutual agreement and trust between producers, traders, and consumers. Peasant farmers organize themselves into local groups, called Local Social Control Organizations (OCS), and then form a Commission of Ethics to carry out inspections on each other's farms and verify compliance with national standards. A Participatory Organic Evaluation Organization, which is accredited and audited by MAPA, is comprised of representatives from all OCS's within a region. The Organizations undertake the evaluation and verification of forms submitted by the OCS's and issue certification and an organic stamp to the peasant farmers. Certification through the Participatory Guarantee System is less expensive, facilitates the efficient dissemination of information across farmer groups, and allows for a continuous certification process as farmers harvest different crops each season. Farmer participation in the program has increased from 138 families in 2009 when the participatory certification program was first implemented to 678 families in 2011 and 900 in 2012 (IFAD, 2013).

Technical Features: The Ecocitrus composting facility began operations in 1995 with a capacity of 3,400 MT/month as a means to reduce chemical fertilizer use across its members and assume control of the entire production chain. The facility initially operated as an open windrow system but underwent an upgrade in 2008 to expand processing capacity and incorporate new pre-sorting and forced aeration technologies to decrease composting time and improve the quality of their end product. In 2012, Ecocitrus and Naturovos, a local chicken farmer, with support from Sulgás, a methane distributor, established the *Verde Brasil Consortium* to produce GNVerde, biogas derived from biodegradable waste. The consortium co-located a pilot-scale digester with the composting facility producing 1,000 m^3/day of biogas comprised of 96% methane, which is currently being used as a replacement for natural gas to operate several vehicles owned and operated by the consortium. Today, the solid waste processing facility occupies 13 hectares and has a licensed processing capacity of 192,000 MTPY of Class II industrial organic wastes (NBR 10004/2004). It is large in comparison to MSW composting facilities which process an average of 5,106 MTPY (adapted from MCIDADES/SNSA, 2014[vi]). Ecocitrus currently produces certified class A, B, and D (IN 25/2009) compost totaling 48,000 m^3/year in addition to 24,000 m^3/year of liquid bio fertilizer and 6,000 m^3/year of ash, which can be used as a soil conditioner. The facility employs 25 people with skill sets spanning technical, operational, marketing and administrative fields. Technical staff ensure that end products meet regulatory requirements while marketing staff disseminate information about the nutritive value of organic compost and its suggested uses.

Financial / Economic Features: Project capital and operating costs are not known. Financing for the pilot biogas facility was provided by regional development bank, *Banco Regional de Desenvolvimento do Extreme Sul*.

According to Ecocitrus, the composting system is financially sustainable with gate fees paid by neighboring agro-industrial waste generators and revenues from selling compost and liquid bio fertilizers. A portion of the compost produced is given away free of charge to cooperative members, depending on the results of the soil analysis from each farm and with the technical supervision of an agronomist. The majority of the compost is sold to organic and conventional agricultural markets. Average bulk sale prices are:

- To certified organic producers: BRL 50/MT
- To non-organic producers: BRL 80/MT
- To forestry industry: BRL 40/MT

Ecocitrus' Class B compost is also sold in smaller bags onsite for household use. Prices range from BRL 3 per 3 kg bag to BRL 13 per 40 kg bag[vii].

Moving Forward: Ecocitrus continues to treat agro-industrial waste from its members and other nearby industries. The consortium is now undertaking steps to advance its pilot-scale biogas facility into a commercial phase. Pending the release of biofuel use guidelines from the National Fuel Agency, the project is expected to soon generate 20,000 m^3/day of biogas for vehicle use for sale into local markets. Assuming biogas is produced 365 days/year, that the biogas is 50% methane and is upgraded to compressed natural gas, and that a vehicle can conservatively drive 20 km per kg of the compressed natural gas, the facility can power 50 million km per year.[viii] Sulgas will be responsible for the distribution and marketing of GNVerde.

Rows of compost maturing in the sun. Photo credit: Photoroller

8 Case Study: MSW Composting in Bangalore, India—Two Differing but Complementary Approaches

Key Success Factors

- Utilization of low-cost, low-tech composting equipment
- Subsidies in the form of gate fees per tonne (Terra Firma) and compost subsidies from the state government (KCDC)
- Production of differentiated end-products that match local market demand
- Diversification of revenues streams across tipping fees, compost sales and recyclables sales (Terra Firma)
- Well-developed distribution networks
- Willingness to sell product manufactured on-site in addition to acting as a distributor of products produced by other composters (KCDC)

Karnataka State in India has been a pioneer in MSW Management by establishing the only successful state-owned composting corporation in the country while also encouraging the involvement of the private sector. The Karnataka Compost Development Corporation (KCDC), located in Bangalore, has achieved long-standing success by utilizing a combination of indigenous, low-cost composting technology and an efficient marketing system for the sale of MSW-derived compost. Established in 1975 as a state-owned corporation, KCDC has been operating continuously for 40 years and in 2012, produced 15,000 MT of their three compost products: "city compost", "vermi-compost" and "AgriGold". Bangalore generates 4,000 MTPD of MSW, of which KCDC receives 200 MTPD.

A second operator, Terra Firma Biotechnologies, is a private company also located in Bangalore and was established in 1994 by a group of professionals with chemical engineering and agriculture expertise. The company constructed a vermicomposting facility and successfully operated it from 1995 to 2007, after which it scaled up operations to include a new 42 hectare integrated solid waste management facility processing more than 500 MTPD of mixed MSW. Between 1998 and 2003 the company also promoted franchises, establishing 38 MSW processing facilities across India.

Context: India is home to 1.24 billion people (2014 est.), with more than one-third of the population residing in urban areas. The per capita MSW generation rate is 0.45 kg/person/day with an estimated 48.5 million MT of MSW generated in 2013. Municipal corporations, who bear responsibility for providing waste collection and treatment/disposal services, collect approximately 36.5 million MT/year with 28% of the collected MSW being treated across 480 waste recovery facilities. The remaining collected waste is disposed of either in a dump or landfill without treatment.

In 2011, 42.51% of the MSW delivered to processing facilities was biodegradable waste although very little of it is collected in a source-separated manner (Indian Planning Commission, 2014). With a vibrant informal recycling sector in place, recyclables are positively sorted at the curb and throughout the waste collection process, removing inert materials from the waste stream and increasing the relative proportion of organic material arriving at composting facilities. Urban planners and policy makers have long supported composting as a means for managing MSW in an environmentally friendly way. In the mid-1970s, twelve government-run MSW composting facilities were established across India, but only KCDC is operational today. Sixty additional plants were constructed in the 1990s and early 2000s, of which six are still in business. Since 2005, a shift away from composting as a public sector waste management solution to a private sector business model has resulted in the development of more than 270 new sites. Today there are a total of 279 composting and 172 anaerobic digestion facilities in operation across India with the majority of municipal-scale composting facilities processing between 200 and 400 MTPD of MSW, while larger facilities process between 500 and 750 MTPD of MSW. Despite the growing number of organic waste processing plants, several challenges still exist. The lack of awareness around the benefits of MSW compost, high transportation costs, comingled waste streams, challenges managing non-value, inert waste components, inability to access long-term debt, and seasonal market demand for compost have left the Indian composting sector operating at less than 10% of its potential capacity.

In 2005, demand for soil amendments in India was estimated at 270 million MT/year, which is currently being met with a variety of synthetic fertilizers, composts, and locally available products such as cow dung and poultry litter (Indian Ministry of Urban Development, 2005). Even if 100% of the MSW generated in India were collected and the biodegradable fraction converted to compost, it would only supply 2% of the current market. However, under present conditions, MSW compost production supplies only 350,000 MTPY or 0.1% of the total demand. Demand in urban areas for home use is marginal due to prices ranging from $160 to $200 per MT. Agricultural end users represent 95% of the total demand, although purchases are concentrated between May and July, prior to monsoon season, and between October and December, which precedes the second annual crop season. Prices paid by famers range from $30 to $65 per MT (delivered).

The excessive use of commercial fertilizers and intensive agricultural production has led to a decrease in plant and animal matter content in Indian soils. In recent years, a national shift in focus towards integrated plant nutrient management and away from synthetic sources of nitrogen, phosphorus and potassium, combined with state subsidies for agricultural end users of compost and co-marketing strategies with synthetic fertilizers have resulted in a modest increase in demand for MSW compost products. However, awareness building is needed to educate farmers on the long-term benefits of compost use in order to realize a more measurable increase.

Policy/Regulatory Framework: In 2000, the National Ministry of the Environment and Forests established the MSW Management and Handling Rules 2000 mandating that local bodies use composting and anaerobic digestion for the treatment of organic waste; however, implementation has been challenging due to funding constraints and lack of enforcement. The national government has provided support by issuing compost product subsidies to farmers, capital subsidies to municipal government for the development of composting, vermicomposting and sanitary disposal facilities, along with grants through the Jawaharlal Nehru Urban Renewal Mission, whereby 60 cities received funds to improve their solid waste management systems. The result has been an increase in public private partnerships whereby the municipal authority either constructs a composting facility and then contracts operations to a private company or a private company constructs the facility and the municipal authority provides a per tonne tipping fee.

The Fertilizer Control Order (1985, 2003, 2013) sets compost quality standards, provides operating guidelines for composting facilities, and criteria for registration (called a certificate of registration) for manufacturers, dealers, wholesalers and importers. State and municipal facilities and those producing less than 50 MT/year via vermicomposting are exempt from obtaining a certificate of registration. A certification of registration is valid for a period of three years. Product licenses are required to sell compost and are issued by a local authorizing agency, typically the state department of agriculture. In Karnataka, a compost manufacturer must obtain a certificate from an authorized lab indicating that the product meets criteria, along with providing details about the facility and its operating practices. The authority approves the application and issues a license, which must be renewed annually. An Inter-Ministerial Task Force on Integrated

Plant Nutrient Management was convened and a report issued in 2003. One significant recommendation was that chemical fertilizer companies be required to co-market and distribute organic compost along with their chemical product lines to open up product distribution channels for compost. The measure was adopted and today, numerous chemical fertilizer companies are either producing their own compost for sale or acting as distributors. The companies procure compost product from numerous producers, perform quality testing, package it in a branded bag and transport it to end-users. Two of the companies, Coramandel Fertilizers and Nagarjuna Fertilizers are thought to trade more than 200,000 MT/year of compost. While compost manufacturers that sell to distributors receive a lower price for their compost products, they avoid the capital and operating costs associated with distributing product to end users.

Technical Features: The KCDC facility sits on 11.7 hectares of land and receives 200 MT per day of MSW from the administrative body responsible for municipal services in the Greater Bangalore metropolitan area, Bruhat Bangalore Mahanagara Palike (BBMP). MSW is sent directly to aerobic windrow composting where it is sprayed with an additive to speed up decomposition and reduce odors. The windrows are turned once per week with a front-end loader for 7 to 8 weeks. Following treatment the product undergoes screening to produce multiple grades of compost with the rejected materials being sent offsite for landfill disposal at a BBMP owned facility. The compost production rate stands between 15% and 20% of the total incoming feedstock (KCDC).

KCDC produces multiple products including: "city compost" from mixed MSW, "vermi-compost" from household and agricultural wastes and AgriGold, a granulated product comprised of a variety of manures and mineral additives.[ix] Compost is sold to 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 demands of their buyers. From April 2013 to March 2014, KCDC sold approximately 45,000 MT of product. 10,000 MT of "city compost", ~2,600 MT of vermi-compost and 10,000 MT of AgriGold were produced at the KCDC facility while the remainder was sourced from other composting facilities across the state (KCDC, 2016).

The Terra Firma solid waste management facility occupies 52.6 hectares and is comprised of a windrow composting facility, testing laboratory, recycling center, landfill, and biogas facility. Terra Firma also receives more than 500 MTPD of mixed MSW from the BBMP and other waste producers. Incoming MSW undergoes upfront manual and mechanical sorting to separate organics from inert recyclable materials. Terra Firma has developed a network of local buyers in the city of Bangalore for processed plastics and other recyclables while the rejects are disposed in a landfill on-site. Organics are then mixed with an additive and composted in an aerobic windrow system, followed by a 4 mm screen. Terra Firma produces and sells over 15,000 MT of compost each year. With established distribution channels in place across the states of Karnataka, Andhra Pradesh, Tamil Nadu and Kerala, the company sells compost under its brand name directly to end users in addition to supplying compost to other companies for re-branding and sale.

Financial/Economic Features: KCDC is jointly owned by the Karnataka Agro Industries Corporation, the Bruhat Bangalore Mahanagara Palike and the Karnataka State Co-operative Marketing Federation Limited, with 52%, 24%, and 24% ownership stakes respectively. Facility revenues at KCDC are solely from the sale of compost. KCDC does not receive tipping fees from the BBMP or revenue from the sale of recyclables. Reject disposal costs are incurred by the BBMP. Compost is available to agricultural end users at a subsidized price of Rs 3800/ MT ($56/MT) for "city compost", Rs 4050/MT ($60/MT) for "Vermi-compost", and Rs 8800/MT ($130/MT) for AgriGold, including delivery. Prices for non-agricultural buyers are Rs 3200/MT ($47/MT) for city compost, Rs 3400/MT ($50/ MT) for Vermi-compost, and Rs 8800/ MT ($130/MT) for AgriGold and are exclusive of the cost of delivery (KCDC Website).[x] KCDC is able to sell its product throughout the year, with the majority of the sales occurring between May and July. KCDC sells its product to state agricultural extension farmers in various districts in the state of Karnataka. Because compost sales are facilitated in collaboration with government departments, the composting subsidy is provided directly to KCDC.

Operating costs incurred by KCDC are attributed to labor (40 workers plus 10 management staff), electricity and fuel, packing materials, additives, administration expenses, taxes, bank charges, contract service charges, and marketing expenses. Operating costs total Rs 2,700 (~$40) per MT of compost manufactured and are covered by revenues generated from the sale of compost. A minimum net profit of Rs 100 ($1.5) per MT of compost is achieved with higher margins received on compost traded by KCDC from other producers.

Terra Firma's business model is built upon revenues from tipping fees, the sale of compost, and the sale of recyclables. The company also provides a variety of educational and consulting services. Terra Firma owns the land and receives waste from BBMP and other major waste generators for which it receives a per tonne tipping fee. The primary cost components are labor, fuel, electricity, and transportation, which account for more than 60% of the company's annual operating costs of Rs 3,100 (~$46) per MT of compost produced. The company employs 230 workers at the facility, including 10 management and 15 administration staff. Earned revenues are almost equally spread across different sources: compost sales, recyclables sales and tipping fees paid by the BBMP and other waste producers. The company has been profitable since operations began in 1995, except for a few years where capital investments were made, through a diversification of revenue streams and keeping costs low through the selection of low cost, labor-intensive composting technologies.

Challenges: KCDC and Terra Firma have both encountered challenges to their ongoing success and future expansion. Both companies have experienced negative sentiments from the surrounding communities, and KCDC's potential for expansion has been limited as a result. Moreover, as a state-owned company, management of KCDC changes regularly, causing discontinuity in vision and operational management and threatening the overall financial and managerial performance of the company. Terra Firma and KCDC have both had to adapt to the changing composition of MSW by modifying their processing requirements and technology. Terra Firma has also felt pressure from the municipal body to accept more waste than it is capable of processing, which they have strived to accommodate. The company has also recognized that solid waste management projects become unviable if they have to service debt resulting from high capital costs and has therefore deployed simple technologies and purchased land and all equipment with equity rather than debt.

Moving Forward: KCDC and Terra Firma have survived various challenges over the years, but both continue to operate financially sustainable businesses. In 2014, the Government of Karnataka and the Karnataka Urban Infrastructure Development Finance Corporation Ltd earmarked funds for the development of nine additional MSW processing facilities, including a 500 MTPD plant adjacent to KCDC. KCDC requested Rs 600 Crore to expand the composting center to process a total of 700 MTPD.

9 Case Study: Using a National Grant Program to Develop Composting Capacity in Sri Lanka

Key Success Factors

- Grants from the national government for initial plant construction and ongoing facility upgrades thereby eliminating debt service
- Access to a variety of organic feedstock, including fish, slaughterhouse waste and dried fecal sludge that enrich the end product
- Utilization of product distribution partners to reach markets in Eastern Sri Lanka
- Revenue diversification through the sale of recyclables in addition to tipping fees from waste received from other authorities

In 2008, Sri Lanka initiated the US $40 Million Pilisaru Project for the purpose of maximizing the utilization of resources and managing waste in an environmentally sustainable way. Increasing composting across the country was a key focus area of the Pilisaru Project. Despite funding from a variety of international aid organizations, numerous composting projects failed across Sri Lanka in the years prior to 2008. This was due in large part to grants that covered capital and operating expenses for a period of time. Once grant funds were extinguished, the facilities floundered. In learning from these failures, the Pilisaru Project redefined lending practices, in most cases, excluding ongoing subsidies for operations and maintenance, which required composting facilities to achieve financial viability on their own. Today, more than 115 municipal-level composting facilities are in operation in Sri Lanka, 76% of which are constructed at capacities less than or equal to 5 MTPD. Numerous facilities are successfully selling compost products and some are even generating a profit. One such facility is the Balangoda Compost Plant located in the Sabaragamuwa Province. Owned and operated by the Balangoda Urban Council, the facility processes 14 MTD of mixed MSW, source separated commercial organics, dried fecal sludge, and animal wastes to produce a nutrient rich compost.

Context: In 2014, Sri Lanka was home to 21.9 million people with 16.3% of the total population residing in urban areas and 83.7% in rural areas (Wijerathna, 2012). Waste collection services are provided in urban areas while households with land are expected to manage waste on their premises. In rural areas, it is common to burn non-degradable waste and use food waste for animal feed and home composting purposes. Due to these practices and consequently the low percentage of generated waste under formal management, the total amount of MSW generated in Sri Lanka is not well understood; however, estimates suggest 6,400 MTPD of MSW are produced.

On average, 62% of the waste collected is biodegradable. The majority of urban waste in Sri Lanka is disposed of in open dumps, which are usually located close to water streams, marshy lands, and forest areas, creating adverse impacts on the environment and public health. In 2014, only one engineered landfill existed in Sri Lanka. Local authorities are responsible for solid waste management, and generators are typically not charged a fee for service. MSW is collected as mixed waste, with the exception of a few cases where source separation programs have been implemented to create a clean feedstock for composting facilities. Many initial attempts at implementing source segregation failed, so local authorities have enacted different strategies to promote segregation. The most

Woman tending plants in Sri Lanka. Photo credit: Lakshman Nadaraja | World Bank successful strategies are (a) to refuse to collect mixed waste or (b) to introduce a fee to collect mixed waste, while extending the free service for source-segregated waste.

Agricultural soils in Sri Lanka have a 1-2% organic matter content, compared to typical agricultural soils, which have around 5% (Sri Lanka Department of Agriculture, 2014). High subsidies for synthetic fertilizers have led to their prolific use which has reduced the organic matter content retained in the soil. Subsidies vary by crop type and reach 90% of the total product cost for some farmers, such as rice growers. However, the excessive use of chemicals has created widespread environmental and health concerns. For example, a chronic kidney disease of unknown origin has spread throughout several farming communities in Sri Lanka. While the root cause is still unknown, farmers suspect that agro-chemical runoff in drinking water supplies is to blame, creating negative perceptions of synthetic fertilizers.

Due to poor overall waste management practices and high quantity of organics in the Sri Lankan waste stream, organic waste management is a priority of the National Government. Prior to 2008, numerous international aid agencies including the World Bank, Asian Development Bank, Japanese International Cooperation Agency, the United Nations Industrial Development Organization, the World Health Organization, and the United Nations Environment Program, along with the Sri Lankan Ministry of Local Governments, provided funding for the construction and operation of several composting plants. Capital costs were provided in the form of a grant, and operations and maintenance were subsidized for an agreed upon period. Nearly all of these plants were abandoned when the subsidies ended due to an inability to achieve financial sustainability through the sale of end products.

In 2008, a $40 million national solid waste management project named Pilisaru was launched with the goal of promoting resource utilization and environmentally sustainable waste management. In addition to providing financial resources for the establishment of composting facilities, the project also includes, amongst others (Dassanayake, 2011):

- Data collection on waste generation and management practices
- Capacity building and awareness building through media campaigns and targeted events
- Technical assistance for local authorities
- A legal framework to address non-compliance
- Monitoring requirements
- Provision of home composting bins to local authorities at a subsidized price
- Construction of low-cost, regional sanitary landfills for waste disposal

By 2013, 115 composting plants had been constructed. With one-third of the country's 355 local authorities having access to composting facilities (CEA 2013), the Project was extended through 2018 and allocated additional funds from the national treasury. Unlike previous grant programs, Pilisaru provided capital grants directly to local authorities and public institutions for composting facility buildings, access roads, equipment, and training for workers. In order to incentivize the construction of large-scale composting plants that serve more than one local authority, they can receive subsidies to cover the cost of operations and maintenance for a period of one year, but small-scale plants that serve one authority cannot. So far, 12 of the 115 composting plants are large-scale, regional facilities. Because the Pilisaru composting plants are owned and operated by local authorities, the national government does offer a form of an indirect subsidy by paying the salary of some of the plant workers. Each local authority is designated an approved number of subsidized workers, so some composting facilities employ some subsidized workers while paying others directly.

Nearly all of the existing composting plants in Sri Lanka were funded through the Pilisaru Project. With a total installed capacity of 640 MTPD and with 400 MTPD of MSW being organic, the facilities have the potential to treat 10% of the total waste generated in Sri Lanka. Compost prices ranged from $0.05-$0.12/kg in 2014. While the majority of facilities are operating at or even above their installed capacities, high waste processing ability has not necessarily led to high compost production rates or product sales. Assuming that 50% of the organic stream is reduced during the composting process, operating facilities should be able to produce 200 MTPD of compost, however, compost production efficiency is 25% less than what was expected at

148 MTPD of compost produced nationwide. It is unclear why this is occurring. The average cost recovery across operating facilities is also one third of the annual operating costs (with variances from 3 to 106%), highlighting the fact the debt repayment would not have been possible in many cases and threaten the long-term sustainability of the sector. This is attributed to the low demand for end products, with the nutrient value of MSW compost often falling short of meeting national voluntary compost standards and the need to compete with subsidized synthetic fertilizers and other less expensive soil amendments (Rostami, et al., 2012; Central Environmental Authority, 2013). Actual product sales range from 1 to 100% of the compost produced, depending on the facility (Fernando, et al., 2014b) with some compost manufacturers having adopted methods to increase the nitrogen, phosphorus and potassium levels in their end products through co-composting and product blending.[xi]

The Ministry of Agriculture (MoA) is actively involved in promoting the purchase of organic fertilizers through training and awareness programs targeted to different user groups, conducting field demonstrations and regular testing of compost products, encouraging source separation and formulating product application rates. Through these and other initiatives, the MoA expects to reduce synthetic fertilizer imports by 25% and increase the use of organic manure and organic fertilizer by 100% (Sri Lankan Ministry of Agriculture Website, 2012). The MoA also promotes on-site composting of agricultural waste and in 2012, had spent $ 0.71 million[xii] advancing on-farm composting systems. As a result, farmers participating in this program had produced 34,191 MTPY of compost for their own use.

Policy / Regulatory Framework: Solid waste is regulated at the national level and managed at the local level in Sri Lanka. Provincial government plays an oversight role in certain provinces more than others. National regulations embrace the "polluter pays" principle, which entails the waste generator paying based on the quantity produced. The governments emphasized a commitment to reduce, reuse, and recycle through the National Policy on Solid Waste Management (2007). To date, no mandatory source separation or organics diversion policies exist although the MoA reportedly encourages the practice (Sri Lankan Ministry of Agriculture Website, 2012) along with local compost manufacturers.

Sri Lanka does have a third-party compost certification scheme, known as the SLS Marks Scheme, and in 2003, the governing body, the Sri Lanka Standards Institute, issued compost quality standards (Standard number: SLS 1246:2003) for MSW and agricultural waste compost. The Institute has the authority to issue certificates for compliant products; however, the standard is not legally required to sell product in Sri Lanka since participation is entirely voluntary.

Technical Features: The Balangoda Compost Plant is currently owned by the Balangoda local authority, the Balangoda Urban Council (BUC), and is located in the Sabaragamuwa Province. The population of the urban area is 23,220. The plant became operational in 2000 at which time it only processed waste from a weekly festival. Due to public outcry over poor management of waste in Balangoda and the associated contamination of local rice paddy fields, the Balangoda Compost Plant was turned over to a private company for a short time in 2002. However, the company reduced the salaries of its workers, and following a second public outcry, the BUC ultimately resumed control of the facility again later that year. Beginning in 2005, a series of site development improvements were made to the facility and a training center was established. In 2009, an excreta cleaning system was co-located with the composting plant with a processing capacity of 10,000 liters/day. Water from the system is used to maintain moisture levels in the compost piles and nutrients are used to enrich the compost. By 2010, the BUC had formalized a garbage tax and introduced door-to-door collection, including source-segregated collection for commercial generators. Commercial generators currently receive source-segregated collection free of charge while mixed waste is collected for a fee.

Today, the facility receives 20 MTPD of waste. Four MTPD are recovered as recyclables through hand sorting and 2 MTPD are disposed of in an open dumpsite. With a 14 MTPD capacity, all remaining wastes are treated via composting. The waste is predominantly comprised of mixed MSW from households and source separated biodegradable waste from commercial generators but also includes fecal sludge, fish waste, and slaughterhouse waste. As a result of product blending and co-composting with high nutrient waste sources, the facility is able to produce nutrient-rich compost, which is sold into local markets.

Once the composting process beings, piles remain untouched for a period of 6 weeks. Leachate collected from the piles is blended with water and re-circulated through the piles. After 6 weeks, the piles are turned, and then turned again in another 2 weeks. Following this active composting period, the material is cured for a minimum of one to two weeks. Compost is screened through a 6 mm sieve when a purchase order is received, leading to extended maturation periods.

To add nutritional value to the compost product, additional strategies are applied during the composting process:

(a) Animal waste is buried in the middle of the pile,

(b) Partially-charred rice husks are incorporated,

(c) Rock phosphate is added to increase the phosphorous content, and

(d) Finished compost is blended with dried fecal sludge.

The composting site is located eight meters away from households, and therefore it is important to adhere to strict processes to avoid odors. Plant operators pay close attention to turning piles at appropriate intervals, keeping the site clean and removing mixed waste from the site. At present, citizens are very satisfied with these achievements, and due to the success of the venture, BUC is now accepting waste from other local authorities for a nominal gate fee. The composting plant employs 17 people and operates a vocational training center on-site. The center offers a certificate in waste management and recycling and includes comprehensive exposure to field-work. The course is offered by the BUC in collaboration with the National Vocational Training Authority and the Learn Asia Organization. The BUC received the President's Award for SWM in 2008 and the Green Job Award in SWM Waste Management and Pollution Control in 2009 and 2010.

Financial / Economic Features: The Central Environmental Authority and the provincial council funded construction in 1999 at a cost of $300,000. Expansions were funded through the Pilisaru Project between 2005 and 2009 and totaled $ 81,296.[xiii] The National Land Reform Commission provided land for the project at no cost. Operation and maintenance costs are estimated at around $1,340 per month. The BUC covered initial operating costs until the project achieved break even. Total tipping fees paid by other local authorities are unknown but when combined with other revenue streams, allow the facility to cover their annual operating and maintenance costs (Balangoda Waste Management Center).

Compost products are sold to farmers in eastern Sri Lanka through sales outlets and agents. Soil in this region is sandy, making synthetic fertilizers ineffective. Frequent tests are conducted at an on-site laboratory to ensure the quality of the end product and results are communicated to buyers. MSW compost sells for $0.08/kg, and a compost product blended with 13% dry fecal sludge sells for $0.11/kg. One hundred percent of the compost is sold, and in 2011, cost recovery was achieved with a very nominal profit of $162/kg. In addition to selling compost, the BUC sells recyclables to material processors for double the cost of collecting and sorting them.

Moving Forward: The success of composting projects in Sri Lanka seems to be dependent on political commitment, which was very strong in the case of the Balangoda Compost Plant, an ability to increase the nutritional value of MSW compost, and a diversification of revenue streams so that plants are not 100% dependent on the sale of compost.

While Sri Lanka has numerous successful, small-scale composting facilities in operation thanks to the government's Pilisaru Project, the long-term financial sustainability of these plants is still uncertain. By extending the program, the Sri Lankan government has signaled their continued support for improving solid waste management systems; however, markets for compost must be further developed to achieve the long-term, desired outcomes. Existing subsidies for synthetic fertilizers will suppress adoption, as will the lack of binding compost quality and standards. Efforts to address these barriers will increase the likelihood of developing a vibrant composting sector in Sri Lanka.

Steam rises as warm, maturing compost is turned. Photo credit: 100-First Zero Waste & Organic Cycle Organisation

10 Case Study: A Longstanding Tradition of Organics Recycling in Europe

Key Success Factors

- Aggressive and binding biodegradable waste recycling targets set by the European Commission
- National compost standards and legislation including technical requirements (best available technology documents) for construction and operation of composting plants
- National quality assurance systems for compost (e.g., Germany, Belgium, Austria, Italy, The Netherlands, Hungary)
- Cost prohibitive alternatives due to environmental taxes
- Freedom to develop individual strategies by each Member State to comply with EU legislation, which has allowed for different approaches. Most successful countries have adopted mandatory source separation programs in combination with landfill taxes or bans

Europe has achieved tremendous success in creating a robust organic waste recycling sector over the past 40 years. The European model combines ambitious landfill diversion targets for biodegradable waste with supporting national policy frameworks that instill confidence in compost products. Member States have adopted differing approaches to organics recycling; some have embraced mandatory source separation while others have focused on the development of MBT facilities that process mixed waste streams. The combined effect is that 42% of all organic MSW generated in Europe is recycled through composting and anaerobic digestion.

Context: The European Union (EU) is home to 503 million people (2015) spanning 27 Member States. In 2011, Member States produced 2.5 billion MT of waste. Daily per capita waste generation rates vary dramatically between countries, ranging from 0.75 kg in Romania to 2.04 kg in Denmark in 2013 (EuroStat, 2015). Up to 80% of the waste produced has the potential for reuse or recycling with the most prominent fractions being kitchen waste (25%), paper and cardboard (18%), and plastics (12%) (Zero Waste Europe, 2012). In some Member States, compostable organics can be up to 45% of the total waste stream.

Organics recycling rates vary considerably across Member States with Austria having recycled 151 kg of biodegradable waste per capita in 2010, while Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, and Romania collectively treated 11.9 kg per capita. Seven member states, Austria, Belgium, France, Germany, Luxembourg, Italy and the Netherlands, represent nearly 2/3 of Europe's total biodegradable waste treatment capacity. Composting is by far the leading method for biodegradable waste recycling due to its relatively low cost and long history in Europe. In 2009, the European Compost Network estimated that the sector had 2,500 composting plants with a total annual waste input of 27 million MT. Forty percent of the composting plants manage only garden waste. An additional 800 small-scale, on-farm composting plants are in operation throughout Europe, primarily concentrated in Austria and Germany.

Member States have developed different approaches to organics recycling. In the Netherlands, large centralized facilities with an average waste input of 45,000 MTPY are favored, while Austria has developed a decentralized system of small-scale facilities averaging 3,000 MTPY, led by the agricultural sector. Home composting is also an integral aspect of some Member States' biodegradable waste management strategies. The EU allows countries to count home composting towards their 2020 recycling targets. In countries with advanced biodegradable waste recycling schemes, it is estimated that between 35% and 60% of the entire biodegradable waste stream is processed through home composting.

Anaerobic digestion is growing across Europe due to the added benefit of energy production and related renewable energy incentives. In 2014, 244 large-scale AD facilities were in operation with a capacity of ~8 million MTPY. An additional 7,500 agricultural biogas facilities processing energy crops, manure, and some organic waste from restaurants and the food processing industry also exist. Germany and Spain have the largest installed capacities, and in the Netherlands, the government has launched a plan to replace 15–20% of natural gas with a methane-based gas by 2030, further catalyzing the development of anaerobic digestion (De Baere and Mattheeuws, 2012).

History of Europe's Composting Sector: Economic development and population growth led to rapid increases in MSW production through the 1950s and 60s, causing Europe's landfills to quickly fill up. With limited space to construct new disposal sites, countries began exploring ways to reduce waste volumes. Beginning in the late 1960s and continuing on into the early 1980s, countries experimented with mixed waste composting technologies such as open windrow and forced aeration. In the mid-1970s piles were moved inside enclosed buildings and air filters were incorporated to ameliorate odor issues and increase waste volume reduction. Given that composting's primary function at that time was waste volume reduction, the resulting end product was poor in quality and typically disposed of in a landfill after processing. As facility operators began viewing compost as a marketable end product, they introduced sorting technologies to remove metal and plastic contaminants; however, with few exceptions, negative perceptions around MSW-derived products and potentially harmful pollutants prevented the development of a market for compost.

Pilot source separation programs began in Germany and Switzerland in 1983 and in Austria in 1986. News of successful separate household biodegradable waste collection schemes began to spread and programs were replicated across Europe. By 2015, 13 member states conducted door-to-door collection of all biowaste, 2 member states collected garden waste only, and 13 did not collect biowaste separately as part of primary collection systems (Seyring et al., 2015). As sensitivity to the preservation of soil quality and healthy food production increased, MSW composting facilities were converted to source separated biowaste composting sites, or MBT facilities[xiv], as a means to manufacture products that met the needs of agricultural and horticultural end users. Between 1990 and 2000, national standards and regulations on compost quality, along with supplemental quality assurance schemes were developed, establishing a policy framework that would become the foundation for a robust and growing composting sector. Once renewable energy regulations were adopted in the late 1990s, the market was able to support the production of compost products made from higher-cost technologies such as anaerobic digestion, which required less land and had the added benefit of capturing and utilizing methane for electricity and/or heat. Initial pilot projects processed manure and crop residues and after 2005, began incorporating municipal biodegradable waste. Today, anaerobic digestion is most common in northern European countries where winters are long and cold and require a supply of commercial heat, which increases the economic viability of the technology.

Not all countries in Europe have followed a similar trajectory. While many Member States, particularly those in Western and Northern Europe, have adopted source separated collection and the composting and/or anaerobic digestion of household and commercial biodegradable waste, France, Greece, Portugal and some regions of Spain have continued their tradition of mixed waste and/or green waste composting (table 8). Reasons for this are manifold: concerns that dedicated organic waste collection will increase overall collection costs, a lack of regional policy or regulatory drivers for source separation, a lack of restrictions on low quality compost use, a lack of market demand for high quality compost, and a fear of low participation rates from citizens.

Policy/Regulatory Framework: *EU Framework:* The EU follows the principles of the waste hierarchy, which emphasizes a reduce-reuse-recycle approach to waste

Table 8. Status of Source Separation, Green/Biodegradable Waste Composting, MSW/MBT Composting and Anaerobic Digestion across EU Countries

Country	Source Separation	Green Waste Composting (GWC) and / or Biowaste Composting (BWC)	Anaerobic Digestion of household and commercial biodegradable/ food waste	MSW Composting (MSW-C) and MBT composting (MBT-C) with use regulations for compost-like-output
Austria	✓	GWC/BWC	✓ (ca. 10 %)	MBT-C landfill + biofilter
Belgium (Flanders)	✓	GWC/BWC	✓	Ø
Denmark	✓	GWC	AD (marginal)	Ø
Finland	✓	GWC	Ø	Ø
France	Ø only few projects	GWC	households: Ø commercial: ✓	MSW-C agriculture
Germany	✓	GWC/BWC	✓ (ca. 15 %)	MBT-C landfill
Hungary	✓ partly	GWC/BWC	Ø	MBT-C landfill + restricted use
Greece	Ø	GWC	Ø	MSW-C agriculture
Ireland	✓ green waste & commercial biowaste waste only	GWC/BWC	✓ (? %)	Ø
Italy	✓ depending on province	GWC/BWC	✓ (ca. 5 %)	MBT-C landfill + restricted use
Luxemburg	✓	GWC/BWC	✓ (? %)	Ø
Netherlands	✓	GWC/BWC	✓ (ca. 5 %)	MBT-C restricted use (marginal)
Norway	✓	GWC/BWC	✓ (ca. 25 %)	Ø
Portugal	Ø	GWC	Ø	MSW-C agriculture
Spain	in minority of autonomous states; obligation only in Catalonia	GWC/BWC	✓ (ca. 50 %)	MSW-C and MBT agriculture
Sweden	✓	GWC	✓ (ca. 95 %)	Ø
Switzerland	✓	GWC/BWC	✓ (? %)	Ø
UK	✓	GWC/BWC	✓ (? %)	MBT-C landfill + restricted use

Ø Not implemented or applied.

(a) Estimated digested percentage in relation to biodegradable waste composting. Where data was available, estimated portion of source separated domestic and commercial biowaste.

(b) MSW-C: traditional mixed waste composting produces a compost product for use on farmlands. MBT composting refers to stabilization and volume reduction of the organic fraction in MSW prior to landfilling.

management. The EU Commission has established a number of binding directives that establish recycling and landfill diversion targets for Member States including the Waste Framework Directive 2008/98/EC (WFD), the Industrial Emissions Directive 2010/75/EU (IED), the Animal By-Products Regulation No 1069/2009, and the Landfill Directive 1999/31/EC (LD). Member State and local-level governments determine the desired strategies by which to comply with the directives and adopt supporting policies and enforcement mechanisms to facilitate their chosen strategies.

The WFD was first established in 1975, amended in 1991, and again in 2008. It provided the legislative framework for waste collection, transport, recovery, and disposal, and set a household recycling target of 50% by 2020 (excluding Turkey and Switzerland) and required Member States to have devised waste reduction programs by 2013.

The LD obligated Member States to reduce the amount of biodegradable municipal waste sent to landfill to 75% of 1995 levels by 16 July 2006, 50% by 16 July 2009 and 35% by 16 July 2016, with exceptions for some countries, which have until 2020 (European Commission Website, 2016). EU legislation does not currently include biodegradable waste recycling targets. Compliance with the LD is evaluated through a European Commission-led review of Member State policies and practices. A failure to comply results in legal action against the Member State. The Commission first issues a written warning to the state requesting a response to its allegations. The Commission may then choose to issue a final warning stating a clear violation of EU law. If the Member State fails to address the violation within a specified period, the Commission can bring the case before the European Court, potentially resulting in fines (European Commission, 2007).

National quality assurance systems (NQAS) have been established across Europe to drive market demand for compost and digestion products. QASs are typically comprised of quality criteria, product declaration and labeling guidelines, and recommendations for proper use by different sectors. Fifteen Member States either have a QAS for compost or are in the process of preparing one; six Member States embedded their QAS in national regulations, although to a varying statutory extent. In 2008, the European Compost Network established a Europe-wide QAS (ECN-QAS) to harmonize existing standards and support national governments in the development of their own systems. Under the ECN-QAS, NQASs first achieve certification. Composting and AD facilities, monitored by NQASs can apply for a quality label from the ECN-QAS in addition to receiving a product quality label for their end products. Today, four NQAS' and four composting facilities have been certified by the European Compost Network (European Compost Network).

National Framework: In Europe, Member States adopt guidelines, standards, and regulations at the national level while waste management is carried out at the local level. Regulations are commonly a part of national solid waste laws; however, some member state consider biodegradable waste an organic fertilizer product and regulate it under fertilizer legislation. Types of organic waste legislation typically include:

1) General obligations or binding targets for separate collection of biodegradable waste;
2) Quality criteria for compost;
3) Technical requirements of composting plants (best practice techniques);
4) Standard implementing structure and functions of a national QAS for compost;
5) Standards/national guidelines for the proper use of compost and digestate resulting from anaerobic digestion in various application areas;
6) Enforcement mechanisms to ensure the strategic goals of the WFD are met;
7) Landfill restrictions or bans for biodegradable waste;
8) Financial drivers such as a landfill tax

Member States employ a variety of obligations and targets pertaining to source separation and biological treatment. Obligations are mandatory in nature, while targets are aspirational and must be supported by additional policy measures to fulfill. Obligations and targets set by select Member States are listed in Table 9 (CEWEP, 2014).

Table 9. Obligations and Targets by Country that Drive Source Separation and Organic Waste Treatment

General OBLIGATIONS for source separation and biological treatment	
Austria	Compulsory separate collection for garden and kitchen waste since 1995 where organic waste treatment (composting or anaerobic digestion) is available. Exemption: home composting. Landfill ban on waste with a total organic carbon content over 5% in 2009.
Catalonia / ES	Compulsory separate collection of organic household waste for all municipalities with a population greater than 5000 mandated since 1995 and recently extended to cover all municipalities; Additional targets include treating 40% of total biodegradable waste produced by 2003 and 55% by the end of 2006.
Belgium/Flanders	Landfill ban on untreated household waste; Landfill Tax: 31.70 – 84.89 €/t (depending on public/private and combustible/noncombustible waste). Compulsory schemes for separate collection and biological treatment of vegetable, fruit and garden waste.
Bulgaria	Compulsory separate collection and treatment of all garden and park waste from public greens maintained by a public entity. Obligation for all commercial entities producing organic waste to set up a separate collection system and organize biological treatment and recycling in an approved composting or anaerobic digestion plant. Landfill Tax: 1.53 €/t (landfills compliant with Landfill Directive), 3.06 €/t (landfills not compliant).
Germany	Schemes for separate collection went into effect between 2011 to 2015; Energy recovery via biomass incineration is only allowed for materials with an energy value of more than 11,000 kJ per MT. Landfill ban for untreated MSW since 1.6.2005.
Ireland	Compulsory source separation and biological treatment for commercial food waste since 2010. Small businesses that produce less than 50 kg of food waste per week were exempted from complying for one year. Landfill Tax: 75€/t.
Italy	Separate collection of garden and park waste is compulsory in four regions (Lombardia, Piemonte, Veneto, Sicily). Landfill Tax: 1–10€/t inert waste, 5–10 €/t other waste 10–25 €/t MSW, depending on Region.
The Netherlands	Compulsory schemes for separate collection and treatment of vegetable, fruit and garden waste, and pure garden and park waste. Landfill Tax: 17 €/t.
Slovakia	Separate collection of garden and park waste since 2006, source separated collection of organic household waste since 2010.
Switzerland	Compulsory separate collection for garden and kitchen waste since 1990. Exemption: home composting. Landfill Tax: 2.3 €/t in inert landfills, 13 €/t for stabilized waste.
Specific TARGETS for source separation and organic waste treatment	
Bulgaria *(in preparation)*	Phased targets for introducing separate collection and biological treatment of biodegradable waste. The targets are defined as a percentage of the biodegradable waste generated in 2014: 25% treated by 2016; 50% treated by 2020 and 70% treated by 2025.
Italy	Organics recycling targets to be fulfilled by each Province are set at: 15% by March 1999, 25% by March 2001, 35% by March 2003. Fines are charged to those provinces where organics recycling targets have not been met.
United Kingdom	*England:* Combined recycling and composting target of household waste: 40% by 2010, 45% by 2015 and 50% by 2020. *Wales:* Combined recycling and composting target for all sectors including businesses, households and the public sector: 70% by 2025. *Scotland:* Combined recycling and composting target: 40% by 2010, 50% by 2013, 60% by 2020 and 70% by 2025. *Northern Ireland:* Combined recycling and composting target: 35% by 2010, 40% by 2015 and 45% by 2020.

Biodegradable Waste Recycling Costs: Due to environmental taxes, composting is nearly always cheaper than incineration, MBT, and landfilling. Tipping fees, otherwise known as gate fees, reflect the price paid by a local authority to process one tonne of waste. While tipping fees are a common point of comparison across technologies and facilities, they are not always an accurate representation of cost. Composting facility tipping fees in central and western European countries range from €35/MT to €70/MT for biodegradable waste, depending on the technology in place. When AD is integrated as a first step in the process, facility tipping fees range from €70 to €120/MT. In comparison, incineration facility tipping fees in Europe are above €100/MT, frequently exceeding €150/MT in Austria, Switzerland, Germany, and Italy.[xv] In some Member States, landfill taxes are assessed on top of tipping fees and range from €10 to €85/MT. In some cases, the tax effectively doubles the landfill tipping fee, making the cost of landfilling comparable to incineration.

Organics processing costs are highly impacted by the type of collection system and processing technology in place, as well as the size of the composting facility. A 2002 survey revealed net processing costs for in-vessel systems on the order of 20,000 MTPY of Euro 40-60 per tonne (Eunomia Research and Consulting Ltd., 2002). While the assumption that source separated collection programs lead to overall increases in biodegradable waste recycling costs, several examples in Austria show that source separated collection can decrease overall MSW processing costs when residual MSW disposal volumes are reduced. Three programs across Austria revealed cost savings ranging from €20-€45/household per year due to decreased frequency of residual waste collection and reduced landfilling costs, which are higher on a per tonne basis than composting in Europe.[xvi]

Financial Mechanisms: Public financing options are also a key aspect of Europe's biodegradable waste recycling sector. The EU offers several grant instruments that Member States can access including the Environment and Climate Action Fund, the Cohesion Fund of the Economic Social and Territorial Cohesion Program, and the European Agricultural Fund for Rural Development. The three funds collectively have ~€174 million for allocation between 2014 and 2020, each with different qualifying criteria. The European Investment Bank also offers loans with attractive financial conditions and recently launched new financing products dedicated to small-scale investments in organics recycling, including composting and biogas plants, in order to support local resource efficiency.

National governments also provide funding opportunities for waste management although national financing tools vary by member states. Funds obtained through landfill taxes are commonly used to support other waste infrastructure projects, such as source separate collection programs and recycling facilities. Local governments adopt different household fee structures to support the development of their biodegradable waste recycling sectors. The most frequent model, which has been adopted in Austria and Germany, charges a household collection fee for the use of the Bio-Bin. Fees vary depending on volume and collection frequency and range from €25-120 per household per year. Households who want to home compost their biodegradable waste must apply for an exemption to the collection program. Programs that charge based on residual waste volume collected, known as pay-as-you-throw, are also common across member states.

Moving Forward: It is likely that the biodegradable waste recycling sector will continue to grow in Europe as we approach the upcoming 2016 and 2020 deadlines set in the LD. The countries that have progressed the furthest towards meeting or exceeding the requirements of the LD are Austria, Germany, Belgium, Denmark, the Netherlands, Sweden, and Switzerland. It is not surprising that these are also the countries that have mandated national source separation programs, landfill taxes (excluding Germany) and bans, and ambitious recycling goals (Eunomia Research and Consulting Ltd., 2014). These countries are expected to maximize biodegradable waste recycling rates while also adopting more stringent waste minimization measures.

While significant gains have been made by many, it is predicted that 15 Member States will exceed the amount of biodegradable waste they are allowed to landfill in the target year, with Slovakia, Romania, Latvia, and Cyprus likely to miss the target by a significant margin (Eunomia Research and Consulting Ltd., 2014). Common across all lagging countries is that solid waste management infrastructure was not nearly as advanced when joining the EU. A strong pre-existing dependency on landfill disposal, coupled with a lack of biological waste processing infrastructure, have made it difficult for these Member States to catch up. Mixed MSW collection services covered 63% of the population in Romania in 2013 and 80% in Latvia, with little to no emphasis on source separated collection. In many countries, priorities have focused on increasing basic services, including closing uncontrolled dumps and bringing landfills into compliance, rather than on devoting resource to composting and AD programs.

To help close this gap and to promote a more sustainable, resource-efficient economy, the European Union proposed a Circular Economy Package in December 2015, a legislative proposal outlining quantitative targets to "close-the-loop" on product lifecycles. Targets outlined around waste management include:

- 65% recycling of municipal waste by 2030
- 10% landfill rate for municipal waste by 2030
- Landfill ban on separately collected waste
- Revised regulation on fertilizers

The European Commission has proposed a roadmap to revise the current fertilizer regulation with emphasis on boosting recycling of organic matter and increasing market access through cross-border trade. The Circular Economy Package will be supported by funding from the European Structural and Investment Funds (EU main policy investment facility), 650 million euros from Horizon 2020 (EU funding program for research and innovation), and 5.5 billion euros from structural funds for waste management. There will also be circular economy investment at the national level to enable local success.

Peat mining. Photo credit: Thinkstock.com

Appendix 1: Comparison of Different Scales of Composting

Model	Objectives	Planning Requirements	Quality Assurance	Financing Opportunities
Home Composting	• Promotes municipal waste minimization goals • Generates compost for home use • Reduces waste management costs to municipality	• Does not require specific equipment • May not be suitable in warm, humid climates • May attract vectors • Difficult to process feedstocks like meat • Requires space for materials processing and curing	• Does not have to meet commercial compost requirements • Consumer confidence is not required given that product is produced and used on-site	• Governments may offer subsidy programs to incentivize the purchase of compost equipment, or offer other economic incentivizes to drive waste minimization (i.e., variable rate pricing)
Internalized Composting (On-farm, Other Large Generator)	• Generates compost for on-site use • Reduces waste management costs to municipality (only when waste was previously managed by the authority)	• Feedstock is available on-site • External feedstock may be required to meet a suitable compost mix (C:N)	• Does not necessarily have to meet commercial compost requirements • Consumer confidence is not required given that the compost is processed and used on-site (familiarity with product)	• Typically self-funded • Running costs internalized with the operator • Labor and own equipment that can be used for other purposes • Offset waste management costs • Compost purchases
Community Composting	• Addresses waste collection challenges in a specific neighborhood (i.e., a slum) • Reduces municipal waste collection and treatment costs	• Requires a dedicated community or NGO • Feedstock is readily available within close proximity • Quality can be difficult to ensure	• No need for a national policy framework however, facilities may be subject to local operating and product standards • Driven by the local community and potentially those directly involved in compost production	• Limited. Running costs usually covered by grant to facility operator
Municipal Composting	• Manages MSW in an environmentally sustainable manner • Reduces waste volume and results in landfill diversion • Mitigates GHG emissions	• Capital cost intensive • Feedstock transportation costs and product distribution costs may be prohibitive • Requires consistent supply of feedstock	• Requires comprehensive policy framework • Driven by regional buyers. Influenced by product quality, outreach and education and ability to comply with standards, and QASs • Product quality and consumer confidence may be low due to the use of MSW derived feedstocks, if no source separation in place	• Financial incentives necessary due to high capital cost. Combination of grants, loans, and equity. Running costs covered by avoided costs, waste fees, product sales, product subsidies, and/or tipping fees

Model	Objectives	Planning Requirements	Quality Assurance	Financing Opportunities
For profit composting	• Creates valuable end products that can sustain profitability • Likely to improve soil health and productivity	• Capital cost intensive • Requires long-term feedstock supply and offtake agreements	• Requires comprehensive policy framework • Driven by regional buyers. Influenced by product quality, outreach and education, and ability to comply with standards and QASs. • Confidence may be higher given the selectivity of inputs and emphasis on high quality end products	• Financial incentives help, but profitable businesses may also bear all capital and operating costs, depending on the market price of compost and additional revenue streams

Appendix 2:
Examples of Compost Project Finance Structures

Country & Income Level	Activity Name	Ownership	Facilities and Capital Expenditure Financing	Operations and Maintenance Financing	Other Key Financial Characteristics
Ghana *(Low)*	• Jekora Ventures Limited (JVL) Pilot Composting Plant	• PPP (Owned by the Community of James Town and operated by JVL)	• Constructed with grant money from CHF International	• Avoided landfill transportation cost of $19-28/MT • Compost sales (70% sold, 30% given free of charge to NGOs, schools and farmers for field trials)	• JVL provided MSW collection services to the community and therefore was able to offer commercial generators a 20% discount on waste fees for source separating which increased the value of their compost and reduced on-site pre-processing costs
Pakistan *(Lower-middle)*	• Lahore Compost Ltd. (Subsidiary of Saif Group)	• PPP (City of Lahore and Lahore Compost Ltd) – Build-Operate-Transfer (BOT) with 25-year concession	• $3.1 million financed by combination of long-term debt from parent company ($2.87 million) and equity ($2.6 million) • Land provided by city	• Unknown	• Carbon credits were expected to cover operating expenses and compost sales were expected to cover debt service
Bangladesh *(Lower-middle)*	• WWR BioFertilizer Limited	• Private (Joint Venture between Waste Concern and World Wide Recycling)	• Equity investment by World Wide Recycling BV, Entrepreneurial Development Bank of the Netherlands, and High Tide Investment. • Soft loan from High Tide Investment • Conventional loan from Dutch Bangla Bank of Bangladesh with commercial interest • Grant from Dutch Ministry of Economic Affairs Development Finance Company of €500,000 • Total costs ~$3.5 million	• Sale of carbon emission reduction credits through 2012 (45% of total revenues) • Sale of compost through fertilizer distributor	• First composting project registered through the Clean Development Mechanism • No tipping fees received although Waste Concern is currently negotiating the free delivery market waste to compensate for the loss in carbon revenues

Country & Income Level	Activity Name	Ownership	Facilities and Capital Expenditure Financing	Operations and Maintenance Financing	Other Key Financial Characteristics
Indonesia *(Lower-middle)*	• Temesi Recycling	• PPP (between village foundation and the Regency of Gianyar (*administrative subdivision*))	• Initial investment by Rotary Club of Bali Ubud and Bali Fokus Foundation (NGO) • $1.5 million in carbon credits through clean development mechanism (theoretical) • Land provided by government (closed landfill)	• Sale of compost (below 100% due to 90% subsidy on chemical fertilizers)	• Significant expenditures in the Clean Designated Mechanism's registration and validation process, totaling $70,000 • Initial cash flow challenges—carbon credit revenues are initially low • International organizations (Department for Water and Sanitation in Developing Countries (SANDEC) and Swiss Federal Institute of Technology) provide technical assistance • Local administration, Regency of Gianyar, provides free health care to employees
Sri Lanka *(Lower-middle)*	• Balangoda Urban Council Composting Plant	• Public	• National grant program (Pilisaru Project) provided capital for initial construction and facility upgrades	• Sale of compost and recyclables • Tipping fees received from neighboring municipal authorities for composting waste	• Composting facility is co-located with an excreta processing unit which supplies inputs (water and nutrients) to the composting process, reducing costs and increasing the value of end products
Brazil *(Upper-middle)*	• EcoCitrus	• Private Farm Cooperative	• Composting capital expenditures unknown, associated biogas facility funded by regional development bank	• Gate fees from non-member feedstock providers • Sale of compost	• Clean agricultural feedstock directly sourced from citrus farm waste

Country & Income Level	Activity Name	Ownership	Facilities and Capital Expenditure Financing	Operations and Maintenance Financing	Other Key Financial Characteristics
Austria *(High)*	• Decentralized Composting in Partnership with Local Agricultural Sector	• Cooperative Financing Model	• Farmer finances 25-50% of capital expenditures • Remainder capital expenditures paid for through municipal, regional, and provincial government subsidies • Regional and provincial governments provide consulting services and project support	• Gate fees ranging from €45 to €60/MT of biowaste and €15 to €45/MT for garden/park waste • Avoided costs from synthetic fertilizer purchases • In some cases, compost sales for a small portion of end product	• Either the farmer is contracted to process source separated municipal biowaste and collection services are provided by the municipality or an independent waste hauler (semi-urban areas) OR the farmer is contracted to both collect and process municipal biowaste (rural areas) • In some instances, farmers use majority (70-90%) of compost on-site and can sell the rest, in others the municipality retains ownership of a portion of the compost for public use
United States *(High)*	• Zero Waste Energy Development Company LLC	• Private corporation	• Privately funded $11.8 million on facilities, equipment, and landfill closure • Bond issuance (amount unknown) • $203 million in tax-free bonds	• Sale of biogas and power • High quality compost sales	• Facility was sited on an unclosed landfill. $11.8 million financed landfill closure and infrastructure development, which served as lease prepayment • Tax-free bonds issued through California's Pollution Control Tax-Exempt Bond Financing Program

Appendix 3: Summary of Common Compost Project Finance Instruments

Financing Structure	Lending Institution	Lender Requirements	Additional Details
Equity	Banks, private individual investors, venture capital, NGOs, for-profit companies, and business partners	• Share of profits proportional to ownership in entity (performance-based), though principle does not need to be repaid • Clear revenue potential (market analysis, carbon credit value, feedstock supply, offtake agreement, diversified revenues), such as through a business plan	• VC funds may require majority ownership and major involvement in operations • Decision-making authority decreases as external ownership of the company increases
Debt Financing	Banks, credit unions, savings institutions	• Typically require 20-30% owner equity (cash, stocks, bonds, inventory, land/equipment, angel investor or venture capital fund *(if project is high capital)*) • Personal guarantees of debt repayment by business officers and owners (e.g., pledged assets) • References, credit rating, detailed pro-forma and business plan, financial statements • Signed feedstock and offtake agreements (letters of intent or contracts) diversified across multiple customers	• Lender may require borrower to demonstrate cash flow to debt ratio of 1.5 times the value of the loan
International Aid	International and multilateral development banks, national development agencies, NGOs, other humanitarian organizations	• Promotion of economic development and welfare • May require co-investment by recipient government • Alignment of objectives with recipient policy environment • Clear metrics for success • Political stability	• International grants should only be used to support capital costs; operational and maintenance costs require a clear path to sustainably
Government Financing	Tax credits (equipment tax credit or property tax credit), grants, direct loans through a third party intermediary, repayment guarantees on bank loads, issuing bonds (for public sector projects)	• Mission alignment to national policy objectives • Proof of long-term financial sustainability through business plan and contracts • Social and environmental benefits, including jobs, carbon reductions, cost mitigation	• Grants typically cover capital costs and are not used to cover annual O&M • Government guaranteed loans can be more expensive than traditional financing and be more onerous to obtain and manage
Own Source Revenue	N/A	• N/A	• Enabling factors include: supportive market for tipping fees, strong demand for compost at a reasonable price, ability to sell other outputs (recyclables, biogas, training, etc.)

Appendix 4: Contract provisions for private and community operators

Public-private partnerships are a common and effective way to operate a sustainable composting plant. Contracts outlining this collaboration structure are a key determinant to the success of the partnership. At a high level, contracts should clearly outline the responsibilities of the government entity versus the responsibilities of the contracted party, the construction and/or operations process to be followed, quality standards, and the timeline. In addition, ownership and payout provisions, such as payment type (upfront versus results based) and rights to final assets should be clearly delineated. A well-constructed contract will naturally incentivize a contracted operator to deliver quality outputs.

Below is an overview of considerations that should be taken when choosing to engage the private sector as well as common provisions that are included in an operator contract. These are mainly presented in the form of guiding questions. This overview is not intended to be comprehensive, nor does it suggest optimal contract structures. The final contract should be developed based on the unique needs of the project and the parties involved, under the counsel of professional legal advice, and include appropriate provisions to cover legal risks as per laws in the relevant country.

A4.1 Procurement and Design

Criteria and needs:

The scope at which the private sector will be engaged will depend on the goals and limitations of the local context and the project plan.

- Will the facility operate at a regional or a local scale?
- Is there sufficient availability of public land for the facility, or will private land be needed?
- What assets are needed from the contracted party? These may include land, equipment, and skills, such as marketing.
- Are there economic, agricultural, or other seasonal fluctuations that may impact timing?
- Does a market analysis demonstrate a potential for profitability for the private entity (this may be provided by the bidder)?
- What design aesthetic preferences does the municipality envision for the facility?
- Are multiple waste management or resource recovery activities occurring concurrently (for example, composting with anaerobic digestion) and if so, can economies of scale be achieved? Will the municipality be taking an integrated waste management approach, and if so, must mixed waste be considered along with landfilling and recycling?

Scope of service:

Before engaging the private sector, the government must identify the scope of responsibility the private sector will take. The private sector may take responsibility for the end to end process of designing and operating a facility, be solely involved in the design or build, or conduct other discrete activities. Contracting a private entity for a larger scope of responsibilities relinquishes control. However, greater efficiency and economies of scale can be achieved. For example, operations may begin in part before the facility is completed.

- Permitting:
  - Will the private sector be responsible for permitting, will the municipality be responsible, or a combination of the two?
- Design – Build:
  - Will the private sector be solely responsible for the design and build of the facility?
  - Is the municipality prepared to operate the facility and market the product?
  - Will operation and marketing be conducted by a second entity?

- Design-Build-Operate:
  - Will the private sector be responsible for both the design and build of the facility as well as daily operations and marketing of the product?
  - Does the private operator have a pre-existing market presence that can be leveraged?
- Other roles:
  - What other roles will be contracted to one or more entities? Collection? Sorting? Transportation? Sales and marketing?

Firm evaluation:

The criteria for evaluating bids should go beyond price. This enables the government to select an appropriate firm other than the lowest bid.

- What is the anticipated project schedule and is it realistic?
- What staff or company qualifications are needed based on the requirements of the project?
- Does the bidding entity have a track record of success?
- Is the proposed approach viable based on technology availability, climate, waste composition, staffing, and other proposed factors?
- Are the appropriate environmental considerations in place?
- Does the proposed approach align with the government's goals and business guidelines?
- Does a detailed financial analysis exist? Are the projected costs and revenues accurate and feasible?
- Do the proposed sales channels coincide with preferences for compost end-use?

Risks:

Before engaging a contractor, it is essential to be aware of the risks and limitations of the anticipated project.

- What environmental controls are needed? For example, those surrounding location, noise, odor, air, and water and storm water channels.
- Do the design parameters allow for the option to expand, account for non-organic waste disposal, and include buffer zones?
- Are renewal options in place?
- What are backup disposal sites and how will waste be disposed of if there are delays in the construction or operation of the facility?
- Are the capital costs of improvement over time, or of repairs and maintenance, considered?
- What are the expected channels of feedstock and are there any risks around quality or availability of this feedstock?
- What criteria should be in place in performance guarantees during facility development and construction? These include schedule, cost, design standards, throughput, environment, product quality, quantity of residuals, disposal practice, and product price

A4.2 Operations

Feedstock

A component of a contract should discuss the responsibilities around sourcing and processing feedstock, the type of feedstock accepted, and any fees involved. Properly assessing responsibilities around feedstock are critical to the project's success.

- Sourcing
  - Who will collect and weigh the waste? Will the waste be collected, aggregated and delivered by the municipality, or will it be sourced on-site or in the community by the contracted party? Is a community drop-off model relevant?
  - What changes are needed in waste collection from the status quo?
  - Who is responsible for the quality of the incoming feedstock?
- Materials
  - What feedstock materials can be used in the composting operation—agricultural waste, market waste, park and yard waste, source or processed municipal solid waste?
  - In what proportions can these waste streams be used?
  - Will any pre-mixing or treatment occur at a central locality before waste streams are delivered to the

- composting facility? If not, how is the composting facility to manage this waste?
  - What are upfront quality requirements of the feedstock input, and are there moisture, composition (e.g., wood, animal by-products), or contamination guidelines?
  - Is the technology proposed consistent with the anticipated feedstock characteristics (e.g., moisture, nutritional content)? Will additional processing or additives be required?
- Fees
  - If the composter will be accepting feedstock from the municipality or communities, are there gate fees to be paid by the municipality to the contracted party and what price will be paid per ton? Will there be a fixed amount?

Production

- Amount
  - How much of each type of compost should be produced each year (as a total amount or fraction of inputs)?
  - How often will progress be measured?
- Incoming materials
  - What are the guidelines for receiving incoming organic materials, unloading, sorting, debagging and grinding, screening, and removal of excess waste materials?
  - Which roles should the owner be responsible for vs. the operator?
  - What is the maximum hold period for feedstock delivered, that is, should feedstock be processed within a certain time period of receipt?
- Process and hygiene
  - What are the requirements on incubation vs. turning (and other technical standards)?
  - What is the frequency of temperature monitoring and maximum temperatures that can be reached in the piles?
  - What additional steps should be taken to maintain compost hygiene and safety, such as material mixture, odor control, and pile fire avoidance?
- Equipment
  - Who is responsible for providing equipment (and back-up equipment) along the production chain (e.g., trucks will be supplied by the municipal waste association, but windrow turners, tractors by composting cooperative or farmer)?
  - What other assets and equipment will be used, and who will provide them (scales, trailers, appliances, tools, labor, fuel, and storage)?
  - What technology that should be used, for example, open windrow composting vs. in-vessel technology (cost of equipment, maintenance, and complexity should be considered here—typically simpler is more sustainable)?
  - Is a clean and secure storage area available for excess feedstock and compost?
- Final processing steps
  - Who will weigh outputs?
  - Who will dispose of reject materials and where will it go?

Sales and End Use

- Quality assurance and final product testing
  - Who is responsible for output quality?
  - What are requirements around final screening and trash removal? What is the required screen / maximum particle size?
  - What are requirements around percent organic matter, percent moisture, maturity, and weed content?
  - What does a clean, market-ready compost product look like in appearance?
  - Who will submit a sample of the compost for testing?
  - Who pays for testing?
  - What certified facility should conduct the testing?
  - What national or local certification, seals, or labels must be issued?
  - What are the timing requirements around product testing?
  - How often will product testing occur?
  - What happens to compost that does not pass standards (e.g., supplement with nutritional add-ins, use as filler, discard)?
  - What are the nutritional standards of the end product?
  - What percent dry matter is required per unit of compost?

- Ownership of the end product
  - If a private company is exclusively sourcing, operating, and producing the compost, do they have full rights to the end compost project?
  - If the compost operation distributed between the municipality and the composter, what is the split ownership structure (e.g., 40% at the discretion of municipality, 60% for farmers own use and sale)?
- Marketing
  - Any guidelines on marketing, such as co-sale with chemical fertilizers, packaging requirements and quality assurance labels?
  - Are there any use cases that the compost will not quality for?
- Sales
  - What sales channels / customers are permitted (e.g., sale on site vs. through secondary retailers and wholesalers)?
  - Who will perform loading operations for customers and who will transport to end points of sale?
  - Who owns the revenue and under what conditions (e.g., by site of sale, method of sale, channel of sale)?
- Waiting period for grazing / harvesting
  - Is there a grazing hold period necessary for compost spread on lands, and for what input materials does this apply to (e.g., EU Agricultural Byproduct regulation requires a 21 day holding period for compost made from animal byproducts)?

Legal, Administrative, and Other Considerations

- Basic Provisions
  - Are all parties and entities, including the municipality, officials, and contractor, as well as the terminology used clearly defined?
  - Are basic “housekeeping” items included? Such as the contract period and terms of renegotiation and renewal, the contract amount and how and when payment will occur, a broad summary of the scope of services
- Performance and deliverables
  - How quickly should incoming feedstock be processed?
  - What is the maximum end-to-end processing time for compost?
  - What are details around the payment structure, including terms, amount, frequency, invoicing, and renewal process?
  - What process should be followed if results are not up to quality and quantity standards?
- Labor
  - What are rules around hiring and firing of personnel taking into consideration cyclicality and labor needs?
  - How will employees be paid, and what is the minimum wage?
  - Who is responsible for processing payroll?
  - What are legal requirements around labor that must be adhered to?
- Record keeping
  - Who will keep records of materials amounts, sales quantities and revenues, and operational records?
  - How this information will be shared between the contractor and the municipality
- Permits, insurance, safety, and other
  - What permits must be acquired to process waste and compost in the local area based on national standards (e.g., Bulgaria requires a RIEW waste permit for recycling and recovery facilities)?
  - What environmental regulations pertain to the composting plant’s build and operation, such as dust control, water runoffs, erosion, and other regulations such as fire codes and labor laws?
  - Should insurance be purchased of any kind?
  - How should safety be ensured in terms of signage, procedures, equipment standards and inspections?
  - What are the anticipated utilities requirements, and who is responsible for procurement?

Source: City of Palo Alto, 2012; Amlinger, 2012; Prince William County, 2005

Appendix 5: Relative Disposal Costs by Solid Waste Activity

Solid waste activity ***(Cost in USD/ton)***	**Low-income countries**	**Lower-middle income countries**	**Upper-middle income countries**	**High-income countries**
Collection	20-50	30-75	40-90	85-250
Open dumping	2-8	3-10	NA	NA
Composting	5-30	10-40	20-75	35-90
Sanitary landfill	10-30	15-40	25-65	40-100
Anaerobic digestion	NA	20-80	50-100	65-150
Waste-to-energy incineration	NA	40-100	60-150	70-200

Source: Hoornweg and Bhada-Tata, 2012

Notes on methodology:

- All values provided in the table are exclusive of any potential carbon finance, subsidies, or external incentives. Costs included are for purchase (including land), operation, maintenance, and debt service.
- Collection includes pick up, transfer, and transport to final disposal site for residential and non-residential waste.
- Composting excludes sale of finished compost (which ranges from $0 to $100/ton).
- Anaerobic digestion includes sale of energy from methane and excludes cost of residue sale and disposal.
- Includes sale of any net energy; excludes disposal costs of bottom and fly ash (non-hazardous and hazardous).

Appendix 6: Estimated Emissions by Municipal Solid Waste Activity

Disposal Practice	Emissions (million tonnes CO_2e)
Landfill with no methane capture	5.2
Open dump (unmanaged, >5m deep)	4.6
Recycling all paper/cardboard, metal, glass, and plastic (assuming remaining waste is sent to landfill)	2.9
Composting all food waste, yard waste, and wood (assuming remaining waste is sent to landfill)	2.9
Landfill with 50% methane capture	2.6
Anaerobic digestion of all food waste, yard waste, and wood (assuming remaining waste is sent to landfill)	2.6
Open burning	1.7
Incineration (continuous with stoker)	1.5
Composting all food waste, yard waste, and wood and recycling all paper/cardboard, metal, glass, and plastic (assuming remaining waste is sent to landfill)	0.6

Waste Composition (Rio de Janiero, 2014)	Percent
Organic Waste	53%
Food Waste	48%
Yard Waste	5%
Paper/Cardboard	18%
Plastics	16%
Glass	7%
Textiles	2%
Other	2%
Metal	2%
Rubber and Leather	1%
Wood	1%

Notes on methodology:

- These emissions estimates were calculated using the tool CURB: Climate Action for Urban Sustainability developed by the World Bank in partnership with AECOM Consulting, Bloomberg Philanthropies, and the C40 Cities Climate Leadership Group
- Emissions are primarily calculated using the Intergovernmental Panel on Climate Change methodologies
- Emissions are calculated for a proxy city: Rio de Janiero, Brazil using waste composition and generation data collected by the World Bank in 2014. Total quantity generated was 3,665,600 tonnes which assumed 0.58 tonnes/capita/year
- Any residual waste that cannot be processed using the outlined method was assumed to be disposed in a landfill with no methane collection
- No energy capture was assumed for the treatment methods, unless otherwise mentioned
- Greenhouse gasses considered are methane, carbon dioxide, and nitrous oxide

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Endnotes

i Defined as having low (1-2%) or very low (<1%) organic carbon content

ii In Germany, a market survey revealed that 94% of professional customers expect "a uniform, high quality product that is independently monitored and accompanied by product use specifications"

iii Exchange rate 3/2016: 1 BDT = $0.013

iv Reported price by Waste Concern, March 2016 was 6200 BDT/MT. Exchange rate used: 1 BDT = 0.01 USD

v The program brings growers together with manufacturing and processing companies and provides help to farmers through training, business management, marketing and promotional support.

vi Based on a survey of 47 MSW composting facilities operating in 2012

vii Bulk price, freight not included

viii Conversion rate: 1 m^3 CH_4 = 0.6802 kg

ix Includes poultry litter, rock phosphate, muriate of potash, dolomite, gypsum, neem cake, zinc sulphate and borax

x Exchange rate in March 2016: 1 USD = 0.015 Rs

xi Typical nutrient values are 0.9% N (standard is more than 1% by mass), 0.4% P (standard is more than 5% by mass) and 0.8% K (standard is more than 1% by mass). SLS Marks Scheme Standard Number is 1246:2003

xii Assuming 1 USD = LKR 130

xiii Total over 5 years = LKR 11,775,000. Exchange Rate used: LKR/USD = 144.84022

xiv By design, a MBT facility separates organic from non-organic wastes streams. Non-organic materials are recovered for recycling, while organic materials are further processed by composting or anaerobic digestion. MBT facilities fulfill the requirements of the EU Landfill Directive 1999/31/EC, stating that all wastes must be treated prior to landfilling. Stabilized MBT output, also known as compost-like-output can be co-incinerated in a cement plant, landfilled or used under certain restrictions, such as for landscaping but not for agriculture.

xv Reported prices include environmental taxes and do not necessarily reflect actual treatment and disposal costs.

xvi Reference communities: Rohrback, Freistadt and Gaenserndorf

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