



- Sustainable Development Goals
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Food Waste Management in Korea:

Focusing on Seoul



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Sustainable Development Goals

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**Food Waste Management in Korea:
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Acronyms

FWP	Food waste producers
K-eco	Korea Environment Corporation
MOE	Ministry of Environment
RFID	Radio Frequency Identification
SMG	Seoul Metropolitan Government
SRF	Solid Refuse Fuel
USPC	UNDP Seoul Policy Centre

Table of Contents

Executive Summary	6
1. Changes in Food Waste Management Practices	7
2. Relevant Stakeholders and their Role	8
3. Food Waste Discharge	10
4. Food Waste Collection	11
5. Food Waste Treatment	12
6. Financing	16
7. Related Laws	17
8.Challenges	19
9. Conclusion	20
10. References	22

Tables, Figures, and Boxes

Table 1. Status of Food Waste Management in Seoul (2017).....	7
Table 2. History of Food Waste Management in Korea.....	8
Table 3. Food Waste Measuring Methods.....	11
Table 4. Treatment Method of Food Waste (<i>Waste Management Act, 2013</i>).....	13
Table 5. Food Waste Treatment Facilities in Seoul (2013).....	14
Table 6. Food Waste Treatment Facilities in Korea (2019).....	15
Table 7. Performance Test for Public Food Waste Treatment Facilities.....	15
Table 8. Breakdown of Costs incurred by Apartments in the Gangnam District.....	16
Table 9. Financing for Food Waste Management in Seoul Local Districts.....	17
Table 10. Food Waste Management Laws and Regulations in Seoul.....	18
Figure 1. Actors and Responsibilities Related to Food Waste Management	10
Figure 2. Example of Food Waste Collection Vehicles	12
Box 1. Large Food Waste Producers in Korea	9

Executive Summary

Dr. Martin Heller defines food loss as “food leakages at upstream stages of the food supply chain such as in food production and processing, while food waste refers to discarded food at the downstream stages of the supply chain – in distribution, retail, food service and households” (Heller, 2019). Food loss and waste generate about 8 percent of global greenhouse gas emissions. Estimates indicate that if it were a country, food loss and waste would be the third-largest greenhouse gas emitter behind China and the United States*.

The impact of food waste is undoubtedly staggering and a significant threat to environmental and socioeconomic well-being. Improper handling of food waste is a significant contributor to this threat, including practices such as dumping in landfills. Hence, the reduction of food waste along with proper food waste management are integral to environmental sustainability.

The Republic of Korea (from herein Korea) has developed a remarkably efficient and well-administered food waste management system. Food waste is collected and processed into animal feed, compost, and biogas on a regular basis. The government has also consistently responded to the changing environmental demands of food waste management by improving and expanding relevant legislation.

This paper discusses the historical development of food waste legislation and processing systems in Korea. It describes a variety of challenges the Korean government met, the solutions that were formulated and the challenges that remain. In 1995, Korea introduced a volume-based user fee system, which successfully encouraged citizens to separate recyclables and food waste. However, strong odours and the secretion of harmful substances from discarded waste became a serious problem. The government responded to this challenge by passing the *Waste Management Act* in 1997. This act stipulated that food waste should be separated from other residential waste throughout the collection and treatment process to overcome these issues. Furthermore, the government continued to expand treatment facilities and was eventually able to ban food waste burial in landfills by 2005.

The Korean case highlights how public and private actors can coordinate and collaborate to manage food waste. For example, there are 240 operational food waste treatment facilities nationwide, and 140 of those are operated by private companies working under strict government regulations and guidelines. Moreover, this case study emphasizes the importance of effective coordination between national, municipal and district authorities. For example, the Ministry of Environment and the Seoul Metropolitan Government support local districts by developing treatment technologies, setting technical standards and authorizing local districts to collect user fees for collection and treatment of food waste at local facilities.

Korea is interested in sharing its experiences in food waste management with developing countries to nurture country-specific solutions. This paper suggests that the development of Korea’s food waste management framework may provide insight into initiatives that can be adapted to different country contexts along with legislative experiences that can be useful benchmarks.

*(<https://www.un.org/sustainabledevelopment/blog/2016/06/un-announces-first-ever-global-standard-to-measure-food-loss-and-waste/> Last Accessed 22 March 2019)

1. Changes in Food Waste Management Practices

In Korea food waste generated in urban areas is collected and processed for a variety of purposes. According to the Seoul Metropolitan Government (SMG), out of the city's 3,000 tons of daily food waste, approximately 60% is processed for animal feed, 30% for compost, and 10% for anaerobic digestion (SMG, 2017).

The policymaking process classifies food waste as a type of residential waste. Previously, food waste was disposed of using incinerators or landfills. In 1995, a user fee system was introduced to encourage recycling by penalizing citizens who did not separate recyclable items from discarded waste. This new system resulted in an increased proportion of food waste to discarded waste in apartments from 52% to 64% after the implementation of the user fee system (Lee BS et al., 1996).

Unfortunately, the combination of food waste with other household waste led to an unexpected problem – the release of large amounts of leachate* and strong odour from the collection and treatment process. The Sudokwon Landfill, used by SMG, Incheon City, Gyeonggi Province, and other neighbouring regions, attempted to address this issue. In September 1996, there was a declaration that waste could no longer be treated in landfills unless additional policies related to food waste were introduced. The government advised for the separation of food waste from other residential waste through the collection and treatment process as a solution. This led to the revision of a sub-decree in the *Waste Management Act* in 1997. In addition to this revision, food waste burial in landfills or cities with a population of 100,000 or more was banned from 2005 onwards. From 1998 to 2004, the government supported municipalities financially and technically in order to establish collection systems and construct food waste treatment facilities. During this period, the government also encouraged private companies to participate in the treatment of food waste. Additionally, it established a long-term food waste treatment plan and recycling method, and also provided guidance on the installation and operation of treatment facilities. In 2005, a separate management system was established for food waste generated by households, restaurants, food service establishments, and retail outlets nationwide.

Table 1. Status of Food Waste Management in Seoul (2017)

Items		2005	2009	2011	2013	2015	2017
Food waste generation (ton/day)		3,188	3,447	3,344	3,070	3,166	2,871
Treatment methods (%)	Animal feed	57.7	59.2	60.5	62.0	62.2	64.4
	Compost	38.5	40.6	34.7	27.0	26.7	32.5
	Anaerobic digestion	3.8	0.2	4.8	10.1	11.1	3.3

Source: Seoul Metropolitan Government (<http://data.seoul.go.kr/dataList/datasetView.do?infld=371&srvType=C&serviceKind=2>)
Last accessed 20 October 2019)

At the Sudokwon landfill, food waste decreased from 36% in 2000 to 8% in 2014 (Sudokwon Landfill Corporation, 2015). As a result, the strong odour emitted by food waste in landfills and from incineration facilities became less of an issue. Nevertheless, food waste treatment facilities were strongly opposed by

*Leachate refers to a liquid that has dissolved or entrained environmentally harmful substances that may enter the ecosystem. (<https://en.wikipedia.org/wiki/Leachate>, Last accessed 02 March 2018)

residents living in the vicinity. This posed a serious challenge as the amount of food waste steadily increased in addition to the demand for more facilities. The government introduced an alternative plan to reduce food waste. It involved applying the user fee system to food waste and supplying food waste reduction devices to producers (Green Growth Committee, 2010). As part of this plan, Radio Frequency Identification-based (RFID) food waste weighing devices were installed in city apartments.

However, challenges remain as the demand for the introduction of garbage disposal (which is presently not used in Korea), conflicts with the location of treatment facilities, and the increase in treatment costs. Despite these challenges, separate food waste management in Korea coupled with planning efforts has significantly reduced the issue of strong odours surrounding treatment facilities. The country has also introduced the Solid Refuse Fuel (SRF) initiative by decreasing the water content of discarded residential waste and increasing the heating value of SRF*.

Table 2. History of Food Waste Management in Korea

Period	Flow of Food Waste	Status
Up to 1994	Discarded residential waste	<ul style="list-style-type: none"> • Nanji landfill closure and Sudokwon landfill opening (1992) • Construction of incinerators in Seoul
1995-1997	Discarded residential waste	<ul style="list-style-type: none"> • Implementation of volume-based user fee system (1995) • Odours caused by food waste becomes an issue (1995~) • Notice of intent to ban food waste in landfills by 2005 (1997)
1998-2004	Discarded residential waste/partly separate collection	<ul style="list-style-type: none"> • Construction of food waste treatment facility (1998~)
2005-Current	Fully separate collection/encourage source reduction	<ul style="list-style-type: none"> • Ban of food waste in landfills (2005) • Introduction of user fee system by the government (2012) and enforcement by Seoul Metropolitan Government (2013) • Self-assessment of food waste reduction by local districts (2015)

Source: Yoo K., 2014 *Waste Management System in Seoul: From A to Z*, The Seoul Institute

2. Related Stakeholders and their Role

Besides food waste producers, various stakeholders (collectors, processors, and the government) are involved in food waste management. The 25 local districts under the Seoul Metropolitan Government (SMG) play an important role in food waste management. Each local district is responsible for supervising: the separate discharge of food waste, developing discharge regulations, setting up a collection and treatment system, collecting food waste, treating it at a local district-managed facility, and collecting user fees from waste generators.

*Solid Refuse Fuel (SRF) is obtained from municipal wastes and used as an alternative fuel. Through this initiative, a city can both reduce its solid waste and utilize its fuel instead of relying on less eco-friendly options such as coal and oil.

In Seoul, the main food waste producers are households, restaurants, cafeterias, and food markets. The city has approximately 4.2 million households, 50,000 restaurants, 3,000 cafeterias, and 300 food markets. The average amount of food waste generated in 2015 was 3,166 ton/day or 0.32 kg/capita. On average, one household generated 0.12-0.25 kg/capita of food waste in a day, 60% of it consisting of vegetables and fruits, 15% cereal, 5% fish, and 20% other food waste. According to a 2009 Seoul Metropolitan Government survey: 60% of households discard food waste once every 2-3 days, 30% of households every day, and 10% once a week. Additionally, households on average spend 8 minutes daily treating their food waste (SMG, 2011).

Food waste producers are responsible for reducing the amount of food waste and ensuring proper separation and discharge. Food waste producers include actors that produce small and large amounts of waste. The former consists of houses and small-scale restaurants, where generated food waste is collected and treated by local districts. Food waste producers with large amounts of waste can either treat their own food waste or consign it to a treatment facility regulated by the government. All food waste producers that consign food waste to public or private treatment facilities must bear the cost of collection, transportation, and treatment conducted by local districts or treatment facilities. More recently, some producers have begun to treat food waste on their own by using earthworm compost bins or decomposition devices.

Box 1: Large Food Waste Producers in Korea

Large food waste producers in Korea include:

- Cafeterias providing meals to more than 100 people a day
- Restaurants operating in an area of 200 sqm or more
- Wholesale markets, joint wholesale markets, and integrated distribution centres for agricultural and fishery products*, as defined by *The Distribution Industry Development Act*, established in 1997 and revised in 2016
- Lodging businesses for tourists that are regulated by the *Tourism Promotion Act*, established in 1976 and revised in 2017

Source: Yoo K., 2014 *Waste Management System in Seoul: From A to Z*, The Seoul Institute

Collected food waste can only be treated at facilities authorized by the government. Authorized treatment facilities include those operated by the local government, government-licensed private facilities, and farms who use food waste as feedstuff for their livestock or for compost. Additionally, the government mandates that waste collection/treatment equipment and facilities should be maintained and operated in accordance with established regulations.

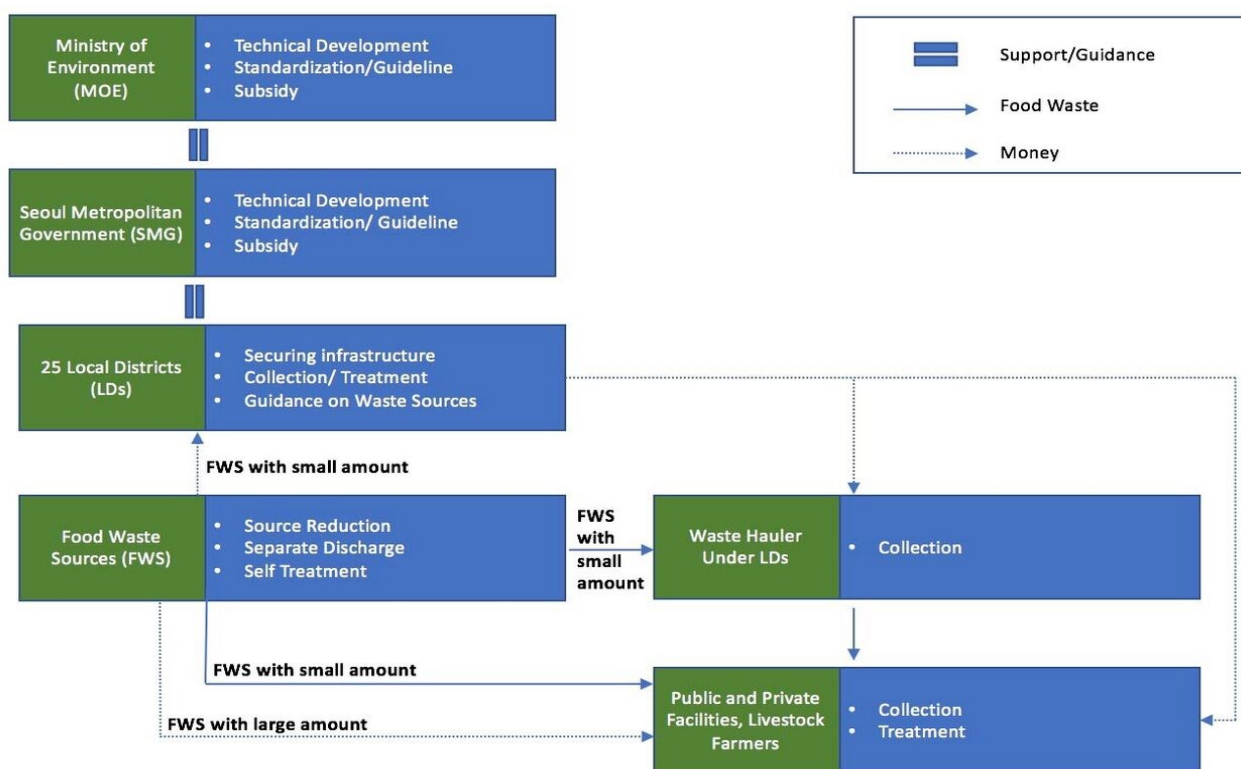
The Ministry of Environment and Seoul Metropolitan Government help local districts and food waste producers by developing treatment technologies and setting up technical standards and guidelines to

*Integrated distribution centre for agricultural and fishery products refers to a business establishment that has the necessary facilities for the logistical activities of companies selling agricultural and marine products such as collection, packaging, processing, storage, transportation, sales, and related business facilities to diversify shipping routes of these products and reduce logistical costs. (*Land Use Glossary*, 2011, Ministry of Land Transportation)

ensure that food waste is treated properly. They also provide subsidies to local districts to construct food waste treatment facilities and check the operational status of treatment facilities. If any local district wants to construct a food waste facility, it has to produce a basic plan and feasibility study of the project capacity.

The Ministry of Environment and the Seoul Metropolitan Government support local districts and food waste producers by developing treatment technologies and setting up proper technical standards and guidelines. They also provide subsidies for local districts to assist with the costs of constructing food waste treatment facilities. However, to receive subsidies, a feasibility study of the project must first be conducted which covers areas such as capacity, treatment process, site construction costs, and projected budget. If the project is approved, MOE and SMG will provide a subsidy to the local district and follow up with strict monitoring to determine proper utilization.

Figure 1. Actors and Responsibilities Related to Food Waste Management



Source: Yoo K., 2014 *Waste Management System in Seoul: From A to Z*, The Seoul Institute.




3. Food Waste Discharge

Small quantities of food waste can be disposed of using one of three measures: a standard plastic bag, a standard box with a chip, or a Radio Frequency Identification (RFID) based weighing machine. A RFID-based weighing machine is the only way to identify producers and locations. It also enables a more accu-

rate measurement of food waste quantities for the purpose of collecting user fees, in addition to keeping collection systems clean. An RFID-based weighing machine is considered highly effective for encouraging the reduction of food waste at the source. Local governments install weighing devices at locations such as apartments or larger restaurants, if there is sufficient space to install the device. However, it is a complicated and expensive tool to install and maintain.

A standard plastic bag or chip can be purchased at stores designated by the local government. In addition to the source reduction of food waste, the standard plastic bag or chip can be used by any food waste producers, thus incurring a lower cost for program maintenance. In terms of collection, SMG recommends that local districts collect food waste after sunset to keep waste collection out of sight from the public and away from vermin. District ordinance regulations instruct on how to discard food waste, while the government provides guidelines on the implementation of the user fee system which includes guidelines on waste bins, fees, and discharge methods.

Table 3. Food Waste Measuring Methods

Items	RFID-based weigher	Standard box with a chip	Standard plastic bag
Food waste generator recognition	Generator recognized using electronic tag or card	Generator unrecognized	Generator unrecognized
Methods of measurement	Weight	Volume	Volume
Discharge container	Individual containers	Individual containers	Individual plastic bag
Used at	Apartments, larger restaurants that have enough space	Detached houses, smaller restaurants with limited space	Detached houses, smaller restaurants with limited space
Payment method	Deferred payment	Prepayment	Prepayment
Image			

Source: Ministry of Environment, 2013 *2012 Resources Circulation Bureau*. KIIR, -K-eco .

4. Food Waste Collection

According to the *Waste Management Act* passed in 1987 and revised in 2013, food waste collection should be disposed of by waste haulers, licensed private facilities, or livestock farmers who use food

waste as feed for livestock or compost. Small quantities of food waste are typically collected by waste haulers managed by the local districts. As of 2014, there are 114 authorized waste haulers in Seoul who collect food waste two to three times per week between sunset and dawn.

For collection purposes, 5-ton capacity vehicles are used most frequently, whereas 1-ton capacity small vehicles are used occasionally in some areas. If the treatment facilities are located far away from the source, collected food waste is transferred to a 11-ton capacity vehicle for more economical transportation. This transfer occurs at 46 transfer stations across the Seoul metropolitan area. It is a large operation with 114 waste haulers employing 1,400 people and utilizing almost 500 vehicles to transport food waste from producers to transfer stations or facilities.

Figure 2. Examples of Food Waste Collection Vehicles



Source: Yoo K., 2014 *Waste Management System in Seoul: From A to Z*, The Seoul Institute.

5. Food Waste Treatment

Collected food waste is treated at licensed facilities according to a method set by MOE. Food waste that can be disposed of at landfill sites is limited to non-recyclable materials and residue from the treatment facility. All treatment facilities must comply with government regulations which mandate the recovery and recycling of at least 70% of incoming dried solid food waste. The government outlines that food waste can be utilised as: i) compost in farmland or animal feed for livestock; ii) top soil in landfills or as soil conditioner; iii) raw materials in fertilizer manufacturing facilities; iv) raw materials in feed manufacturing facilities; v) absorbents of environmental pollutants through the carbonization process; vi) a means to produce biogas using anaerobic fermentation.

Adhering to these guidelines, various types of facilities are utilized, including aerobic/anaerobic decomposition, feedstuff* production, and composting facilities.

*Feedstuff refers to any of the constituent nutrients of an animal ration

Table 4. Treatment Method of Food Waste (*Waste Management Act, 2013*)

Items	Guidelines
Principles	<ol style="list-style-type: none"> 1. All recyclable components should be recycled 2. Residuals from decomposition devices at waste sources should be recycled 3. Disposal of food waste in landfills prohibited, only residues and contaminants from treatment facilities are allowed 4. Treatment and recycling facilities should recover more than 70% of dried food waste
Uses for recycled products	<ol style="list-style-type: none"> 1. Compost in farmland or animal feed for livestock (in compliance with related regulation on fertilizers and animal feed) 2. Composted material used as topsoil for landfills, or as a soil conditioner (in compliance with the Ministry of Environment regulations) 3. Fertilizer (in compliance with the "Fertilizer Control Act") 4. Absorbents of environmental pollutants through the carbonization process 5. Animal feed (in compliance with the "Control of Livestock and Fish Feed Act") 6. Recovered biogas through anaerobic digestion (in compliance with related regulation)
Treatment facility	<ol style="list-style-type: none"> 1. Decomposition devices: microbial decomposition devices with a daily capacity of 100kg, such as aerobic or anaerobic fermenters. 2. Biological recycling facilities: recycling facilities with a daily capacity of 100kg, such as animal feed, composting (including dry composting, earthworm casting, and quick lime treatment), and mushroom cultivation facilities.

Source: *Waste Management Act, 2013* revision.

There are five food waste treatment facilities in Seoul, with a total treatment capacity of 1,360 ton/day. However, Seoul generates 3,400 tons of food waste daily, and only a third of the total can be treated by the city's facilities. The remaining food waste is transported to approximately 30 different private facilities located in various provinces, including Gyeonggi Province and Chungcheong Province.

Out of the five food waste treatment facilities in Seoul, three have adopted the animal feed production process. This allows for a shorter retention period for food waste (less than two days), smaller site requirements, and easier odour control. While anaerobic fermentation facilities have the advantage of recovering biogas and utilising it for power generation, it is not easy to control odor and waste gases*. As a result, the private sector tends to avoid anaerobic fermentation.

*Through anaerobic digestion in wastewater treatment, organic matter is decomposed to produce carbon dioxide gas or methane gas and is referred to as 'waste gases'

Table 5. Food Waste Treatment Facilities in Seoul (2013)

Facility	Capacity (ton/day)	Treatment method	Areas in Seoul covered by the facility
Kangdong	360	Animal feed production	Kangdong-gu*, Gangnam-gu, Kwangjin-gu, Dongjak-gu, Seongdong-gu, Eunpyung-gu, Seongbuk-gu
Dobong	150	Animal feed production	Dongbong-gu, Dongjak-gu
Songpa	450	Animal feed production	Songpa-gu, Dongjak-gu, Seongdong-gu, Gangnam-gu
Seodamun	300	Composting	Jongno-gu, Seodaemun-gu, Yongsan-gu, Mapo-gu
Dongdaemun	100	Anaerobic fermentation	Dongdaemun-gu

Source: Yoo K., 2014 *Waste Management System in Seoul: From A to Z*, The Seoul Institute

A total of 240 food waste treatment facilities are operational nationwide, including 100 public facilities operated by local districts, and 140 facilities operated by private companies with government permission. In terms of treatment methods, existing public facilities are most likely to adopt composting methods, while private facilities prefer the animal feed production method (MOE, 2014). This disparity is due to the fact that public facilities place a greater emphasis on the smooth supply and demand of products, while private facilities tend to focus more on cost efficiency.

Since the anaerobic fermentation process has significant drawbacks in regards to odour and cost, no private facility has adopted this process. In recent years, the animal feed production process has been increasingly utilised by public facilities due to the shorter retention time needed for waste, smaller site requirements, and improved capacity for controlling odour.

All food waste treatment facilities must be inspected by the government. Furthermore, food waste treatment facilities operated by local districts must conduct a government-administered performance test every year to prevent the installation of oversized facilities. This is required to ensure facilities operate economically, and that the emission of environmental pollutants is below the maximum threshold. Additionally, wastewater, odour, and noise generated in treatment facilities must be kept below the levels specified in the *Water Quality and Aquatic Ecosystem Act (2008)*, the *Clean Air Act (2016)*, and the *Noise and Vibration Act (2013)*.

*Gu = a smaller administrative division within cities in Korea, the equivalent of a district.

The following table shows the status of food waste facilities in Korea in 2019.

Table 6. Food Waste Treatment Facilities in Korea (2019)

Items	Public Facilities	Private Facilities
Number	Nationwide: 115 facilities (5 in Seoul)	Nationwide: 231 facilities
Treatment method	Pre-treatment facilities: 27 Animal feed facilities: 27 Composting facilities: 39 Anaerobic fermentation facilities: 22 Other facilities: 4	Pre-treatment facilities: 5 Animal feed facilities: 166 Composting facilities: 42 Other facilities: 18
Utilization	Facility capacity (A): 9,132 ton/day Input (B): 7,432 ton/day Operating rate (B/A): 81.4%	Facility capacity (A): 13,517 ton/day Input (B): 5,398 ton/day Operating rate (B/A): 39.9%
Operator (In 2012)	Local districts: 28 operators Consignment: 70 operators	Owner: 125 operators Consignment: 27 operators
License (In 2012)	No license required	Intermediate recycling business: 111 licenses Comprehensive recycling business: 41 licenses

Source: Ministry of Environment, *Operation Status of Food Waste Treatment Facilities*, 2019. (http://www.me.go.kr/home/web/policy_data/read.do?menuId=10265&seq=7350 Last accessed 20 October 2019.

The following table illustrates the performance evaluation system for public food waste treatment facilities. These treatment facilities were evaluated out of 100 points under three categories by the Ministry of Environment. They are awarded or deducted points according to the categories noted below.

Table 7. Performance Test for Public Food Waste Treatment Facilities

Items	Contents
Objects	<ul style="list-style-type: none"> Food waste treatment facility owned by local districts
Evaluation categories	<ul style="list-style-type: none"> Technology (40 points): number of waste collection days, operating rate, production rate of feed and compost, facility management Economic efficiency (30 points): operating expenses, operating balance, efforts to improve economic efficiency Environment (30 points): energy usage, odour management, use of feed and compost, safety management Additional points: collaboration with other local districts (+2 points), integration of other environmental infrastructure, like sewage facilities (+1 point) Penalty points: administrative disposition (-1 point/time), failure to submit data by deadline (-1 points)
Number of evaluations	<ul style="list-style-type: none"> Once a year for facilities operating for more than 6 months
Evaluation procedure	<ul style="list-style-type: none"> Establishment of evaluation plan (K-eco) → Authorization of Plan (MOE) → Submission of operational results (local district) → Field verification (K-eco) → Evaluation (K-eco) → report of evaluation result (K-eco → MOE) → Notification of results (MOE → local district)

Source: Ministry of Environment, 2014.

6. Financing

Food waste management is an expensive process. The 25 local districts in Seoul operate and manage manpower and equipment for food waste collection, and also install and operate treatment facilities. If the local districts do not have their own facilities, food waste is transferred to nearby public or private facilities. As shown in Table 8, food waste management costs for an apartment building ranges from 200,000 won/ton* to 315,000 won/ton depending on the discharge method, collection, treatment, and distance to facilities. The best way to cover these costs would be to utilize the profits earned by selling the waste as animal feed, compost, or biogas. However, there are only a few facilities that charge for products; most facilities provide products free of charge. This can be attributed to the difficulty of selling recycled products from food waste treatment facilities. Unfortunately, even when these recycled products are sold in the market, it is difficult to cover the total cost of food waste management.

Table 8. Breakdown of Costs Incurred by Apartments in the Gangnam district, Seoul

Steps of Food Waste Management	Lower Cost Management Options	Higher Cost Management Options
Waste bin	<ul style="list-style-type: none"> • Standard plastic bag + 120 liter intermediate box • Cost: 11,354 won/ton 	<ul style="list-style-type: none"> • Discharge at RFID-based weighing machine • Cost: 37,661won/ton
Collection	<ul style="list-style-type: none"> • Weekly pick-up by local district waste hauler • Cost: 81,995 won/ton 	<ul style="list-style-type: none"> • Weekly pick-up by local district waste hauler • Cost: 117,929 won/ton
Treatment	<ul style="list-style-type: none"> • Animal feed production facility • Cost: 111,032 won/ton 	<ul style="list-style-type: none"> • Anaerobic fermentation facility • Cost: 146,951 won/ton
Facility location	<ul style="list-style-type: none"> • Within Gangnam district 	<ul style="list-style-type: none"> • Urban areas • Transportation cost: 13,000 won/ton
Total	<ul style="list-style-type: none"> • Cost: 204,381won/ton 	<ul style="list-style-type: none"> • Cost: 315,541won/ton

Source: Gangnam-gu, *Plan for Stable Treatment of Food Waste*, 2013.

There are three main methods by which local districts in Seoul cover the cost of managing food waste: i) subsidies from the government and SMG; ii) collection of user fees from food waste sources; and iii) provision of the local governments' general revenue for any shortfall. The Government of Korea and SMG each support 30% and 35% of the construction cost for food waste treatment facilities. User fees are collected through the sale of standard plastic bags, chips, and the use of RFID-based weighing machines. In the case of the Songpa district in Seoul, the price of a standard plastic bag was 80 won/litre for houses and 100 won/liter for restaurants (Ordinance of Songpa-gu, 2014). The 25 local districts in Seoul collected user fees of 29.4 billion won, which only cover 24% of the total food waste management costs of 120.3 billion won (MOE, 2015). The cost of food waste management not covered by government subsidies or SMG user fees is covered by the general revenue of local districts.

*1 dollar = 1122.33 KRW (As of 31 Oct 2017)

The following table illustrates financing methods for food waste management in Seoul's 25 districts.

Table 9. Financing for Food Waste Management in Seoul Local Districts in Seoul

Items	Details
Government and SMG subsidies	<p>Government (MOE, 2014):</p> <ul style="list-style-type: none"> • 30% of construction costs of anaerobic fermentation facility • 30% of construction costs of public treatment facility <p>SMG:</p> <ul style="list-style-type: none"> • 35% construction costs of public treatment facility
User fees	<p>Collection of User Fees:</p> <ul style="list-style-type: none"> • Sale of plastic bags*, RFID chips • Monthly fee for use of RFID-based weighing machine
Local districts	<p>Local Districts:</p> <ul style="list-style-type: none"> • Cover expenses not subsidised by the government, SMG, and user fees** • Cover cost of facility, treatment, collection

Source: Yoo K., *Waste Management System in Seoul: From A to Z*, The Seoul Institute 2014.

7. Related Laws

The Waste Management Act (2015) outlines discharge separation, waste collection, and the treatment of food waste. Regulations related to recycling facilities are covered in the *Act on Saving and Recycling of Resources (2016)*, the *Feedstuff Management Act* and the *Fertilizer Management Act (2016)*. Environmental pollutants such as wastewater, noise, and odours emitted from food waste treatment facilities or recycling facilities are subject to regulations based on the *Water Quality and Aquatic Ecosystem Act (2008)*, the *Clean Air Act (2016)*, and the *Noise and Vibration Act (2013)*. Additionally, recycling facilities or treatment facilities can only be established in permitted areas as per the *National Land Planning and Utilization Act (2017)*.

As noted in Section 1 of this report, garbage disposal units (food waste grinders) used in some countries are not allowed in Korea. *The Sewerage Act (2016)*, Article 33 states that “A Minister of MOE must restrict the manufacturing, import, distribution or use of a specified product supposed to deteriorate water quality severely without Minister’s approval of exception” and Article 23 of enforcement ordinance reads “a specified product is a food waste grinder.” This issue is explained further in the next section.

The quality and distribution of food waste recycling products are covered by the *Act on Saving and Recycling of Resources (2016)*, *Fertilizer Management Act (2016)*, *Feedstuff Management Act (2016)*, and the *Act on the Development, Use and Distribution of New and Renewable Energy (2013)*. Local district’s ordinances include methods for discarding and collecting food waste, charging user fees, and fines for illegal activities. These acts state that specific food waste reduction and recycling projects will be planned and implemented through an integrated waste management plan.

Table 10. Food Waste Management Laws and Regulations in Seoul

Items	Laws and Regulations
<p>Timeline of Food Waste Management Laws and Regulations</p>	<ul style="list-style-type: none"> • First national waste treatment comprehensive plan (1993-2001) • Second national waste management comprehensive plan (2002-2011) • Comprehensive plan to reduce food waste (1996-2001) • The Master plan of food waste reduction and recycling (1998-2002) • Comprehensive measures for food waste (2004-2007) • Food culture improvement and food waste comprehensive plan (2006-2010) • Comprehensive plan to reduce food waste (2010-2013)
<p>Discharge</p>	<p>Small food waste producers: Primary regulation: <i>Waste Management Act</i> Regulation of discharge methods: Local districts' ordinances, guidelines of MOE</p> <p>Large food waste producers: Primary Regulation: <i>Waste Management Act</i></p> <p>Food waste grinders: Primary regulation: <i>Sewerage Act (prohibits use of grinders except in case of certified products)</i></p>
<p>Collection</p>	<p>Collectors: Primary regulation: <i>Waste Management Act</i></p> <p>Compliance: Regulation of transportation and storage standards: <i>Waste Management Act</i> Regulation of leachate treatment: <i>Waste Management Act, Water Quality and Aquatic Ecosystem Act</i></p>
<p>Treatment</p>	<p>Treatment facilities: Primary regulation: <i>Waste Management Act</i></p> <p>Installation and operation of treatment facilities: Regulation of standards and performance tests: <i>Waste Management Act</i> Regulation of environmental pollutants: <i>Waste Management Act, Water Quality and Aquatic Ecosystem Act, Clean Air Act and Noise and Vibration Act</i></p> <p>Facility location: Regulation of types of buildings: <i>Building Act</i> Regulation of land planning: <i>National Land Planning and Utilization Act</i></p>
<p>Recycling</p>	<p>Recycling: Primary regulation: <i>Act on Saving and Recycling of Resources</i> Regulation of compost: <i>Fertilizer Management Act</i> (must notify rural development administration) Regulation of animal feed: <i>Feedstuff Management Act</i> (must notify Ministry of Agriculture, Food and Rural Affairs) Regulation of renewable energy: <i>Building Act, Act on the Development, Use and Distribution of New and Renewable Energy</i></p>

Source: Yoo K., *Waste Management System in Seoul: From A to Z*, The Seoul Institute 2014.

8. Challenges

Food waste management is a complex and multistep process. The problems of leachate and residential waste odour triggered the implementation of the user fee system. Furthermore, Korea began addressing the issue by collecting and treating food waste separately. However, there are still some issues that have not been resolved, such as the ban on garbage disposals, the technical complexity of RFID-based weighing machines, and the establishment of an appropriate ratio between public and private facilities for food waste treatment.

Garbage disposals are known as convenient and hygienic devices that have been used in countries such as the United States of America, Canada, and Australia for a long time. In Korea, about 24,000 such devices were sold from 1985 to 1992. However, in 1995 these devices were banned based on studies stating that they place a heavy burden on the sewerage system (Kim KS, Yoo KY, 2010). In 2005, the prohibition of the direct disposal of food waste into landfills led to renewed questions about whether garbage disposals should be allowed. Some residents, local governments (including the SMG), scholars, and sewerage authorities have voiced their support for this disposal system. In contrast, waste management authorities, some citizen groups, and experts remain concerned about potential negative environmental impacts.

Since most housing in Korea consists of apartments, advocates of garbage disposals note that these machines should be used to improve sewerage performance and possibly recover solids from sewage treatment facilities. Through this process, particles of food waste settle down in grit chambers or in a settling tank, and then, as sludge gets pumped to anaerobic fermenters it can generate biogas. However, critics of garbage disposals argue that these devices could lead to source reduction, poor recycling of food waste, a loss of organic resources, and additional consumption of water and electricity (K-eco, 2013). From 2010 to 2015, a number of public forums were held, and each time the pros and cons of using the devices were discussed. It is likely that the dispute over the use of such disposals will continue unless a more efficient system for conveniently discarding food waste is developed.

In 2010, after five years of banning the direct disposal of food waste into landfills, Korea set up a comprehensive plan for managing food waste in order to reduce it at the production, distribution, and consumption stages (Green Growth Committee, 2010). The Ministry of Environment (MOE) recommended the introduction of the food waste user fee system, which allowed producers to select among the three methods: RFID-based weighing machines, chips, or standard plastic bags, in accordance with local guidelines as illustrated earlier in Table 3. In the case of the chip recovery and standard plastic bag methods, food waste must be kept indoors until a container is filled with food waste (K-eco, 2013). Taking into account the high density of food waste, which is about 750kg/m³ (discarded waste 195kg/m³), a weight-based user fee system was strongly recommended (The Seoul Institute, 2014). The Ministry of Environment (MOE) and the Seoul Metropolitan Government (SMG) provided subsidies for RFID device installation.

Following a test run, the RFID-based weighing machine showed a 31% reduction of food waste, which

was significantly higher than the chip recovery (14%) and plastic bag (13%) methods. In addition, the use of RFID-based weight machines has been evaluated as convenient since these devices can discharge food waste as needed. The main challenge with this method is the high cost; it is two to three times more expensive than other methods and is applicable to only large housing complexes or apartment buildings. Local districts are reluctant to install additional devices unless the government and SMG provide subsidies. Whether the additional use of RFID-based weight machine becomes more common will depend on the government and SMG's financial assistance (The Seoul Institute, 2014).

As shown earlier in Table 6, there are 115 public facilities and 231 private facilities in the country, with a total capacity of approximately 22,000 ton/day. The amount of food waste treated is 13,000 ton/day, so the capacity of those facilities is approximately 40% higher than the amount generated in 2019. However, most local districts tend to secure their own facilities because it is cumbersome to renegotiate contracts with private facilities every year, and also because of the high costs involved in consigning to private facilities. SMG encourages local districts to install their own food waste treatment facilities, as the five treatment facilities in Seoul (as noted in Table 6) can handle only about one-third of the total food waste generated (Ministry of Environment, 2019).

Few public utilities have been built in recent years due to opposition from residents living nearby and private facility owners. Critics point out that, since the utilisation rate of current private facilities is only 51% the construction of additional public facilities is inefficient. However, as long as private facilities charge high processing fees, local districts will likely continue to invest in their own facilities.

9. Conclusion

In Korea, the system of separate food waste collection and treatment began as a way to address the odour problems triggered by landfills. Since the unveiling of the separate collection and treatment system in 2005, odour complaints have decreased significantly. In addition, the food waste collection process has become cleaner and more hygienic, with an increase in the fuel value of discarded waste, and transformation into alternative resources such as feed, compost, and biogas.

In the initial phase of the separate collection and treatment system, there was an urgent need to secure food waste treatment facilities. The government urged local municipalities to secure public treatment facilities by giving them the responsibility of collecting and treating food waste discharged in small quantities from houses and restaurants. Producers of large quantities of food waste instead were given the responsibility to treat the waste themselves or entrust it to private facilities licensed by the government. The Korean experience illustrates that the total capacity of treatment facilities nationwide and regionally should be considered to ensure the number of operating facilities remain at an optimal level.

When selecting food waste processing methods, it is critical that local conditions are taken into account. In urban areas, smaller sites and the minimal emission of odour is required to reduce conflict with residents. For facilities in suburban or rural areas, there are other factors to consider, such as ensuring the supply of products and easy operation. Composting in particular has proven to be a promising option. These experiences may be useful when considering food waste treatment options in developing countries.

As noted throughout this paper, separate collection and treatment of food waste is costly. In the case of Korea, large food waste producers are responsible for treating food waste and bear associated costs. Local districts, meanwhile, are tasked with the collection and treatment of smaller amounts of food waste. Recognizing this burden, the government and SMG subsidize cost of public treatment facilities by 30% and 35% respectively. Also, local districts in Seoul have adopted a user fee system (RFID-based weight machines, standard boxes with a chip, and standard plastic bags) to help pay for the costs of food waste management. The RFID system is the most promising and disposes of food waste effectively, but has significant drawbacks since it can only be deployed in large apartment buildings and is expensive to install and operate. The advantage of the chip or plastic bag method is that it can be applied almost anywhere, and has a lower maintenance cost. However, the latter two methods are not as effective in reducing the amount of waste generated.

In closing, treatment facilities should be equipped with the operational capability to deal with food waste while avoiding environmental pollution. The question of who should be responsible for treating food waste, which products should be made from food waste, and what level of quality these products should adhere to should be addressed by the government. To reduce the environmental impact of treatment facilities, it is critical that regulations regarding water quality, air quality, and noise are followed actively.

Unfortunately, the subject of food waste treatment is contentious, with communities often opposing proposed facilities. This “Not In My Backyard” (NIMBY) principle is not new, and concerns are often justified. While difficult, these concerns have provided stakeholders in Korea with an opportunity to discuss the importance of food waste source reduction. As the need for solutions has become more critical, new treatments have been developed, such as potting and vermicomposting. These alternatives can be applied in cities with low population densities, or where food waste sources are located in residential areas with high average annual temperatures. The Korean experience highlights the necessity of constantly developing and improving food waste management processes for environmental sustainability and public well-being.

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