



# SUSTAINABILITY INSIGHTS: SHANGHAI'S FOOD WASTE MANAGEMENT

Authors: Jun Zhang, Chuchu Zhang  
Editor: Jessika Bella Mura  
Designer: Daniel Ringhold  
Collective Responsibility  
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# INTRODUCTION

As China has experienced double-digit economic growth over the past 30 years, more than 300 million people have moved into its cities. These cities have seen and created an enormous amount of economic benefit, and their middle class residents have become avid consumers.

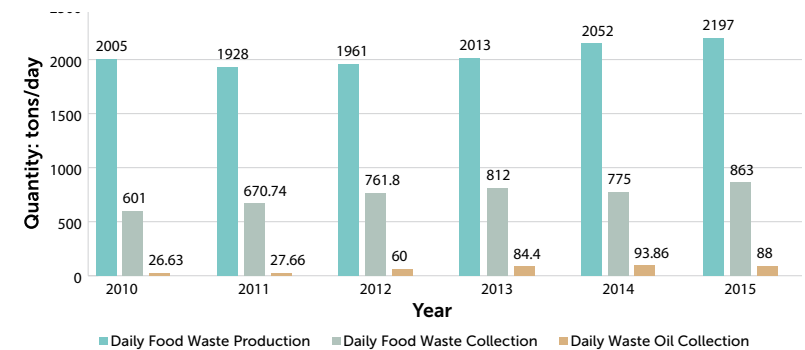
Through this process, the relationship between people and food, and food waste, has changed. Whether attributable to increased affordability, convenience, or displays of wealth, major Chinese cities produced approximately 88.65 million tons of food waste in 2016 (E20 Research Institute, 2018). This figure is likely to grow as China's economy soars, urbanization expands, and living standards improve.

First-tier municipalities like Beijing and Shanghai produce 1,000 to 2,000 tons of food scraps daily, putting significant pressure on food waste management systems to efficiently and effectively deal with this particular waste stream.

At present, a significant portion of food waste ends up in landfills or incinerators without undergoing proper treatment, or is illegally diverted into the informal system to feed livestock or produce cooking oil through practices that have resulted in serious food safety problems. This food waste has not only incurred economic losses and negative environmental impact, but it also threatens China's agricultural capacity to deliver fresh, safe, and affordable produce to its rising middle class and urbanites.

As one of the most populous cities in the world and one of China's most advanced models for urban planning, Shanghai has been on the leading edge of many of the challenges that China's cities have faced in the past 25 years.

In Shanghai, with more than 2,000 tons of food waste generated daily by its restaurants, schools, and commercial and residential buildings, accounting for approximately 59% of its municipal solid waste (MSW). Only 40% of this food waste is collected by the formal food waste management system (Figure 1).



**Figure 1.** Food waste generation and collection in Shanghai (2010–2015).  
Source: Annual Announcement Shanghai Solid Waste Pollution Prevention; Prediction of Food Waste Output in Shanghai.

Recognizing the growing size and scale of this challenge, the Shanghai city government started developing its formal food waste management system in 2000, with the introduction of more stringent regulations and technological innovations.

This report examines the food waste management systems of urban China, using Shanghai as a case study, and identifies lessons and experiences that other Chinese cities can learn from. It explores the post-consumer food waste management streams, formal and informal, in Shanghai, as well as the challenges and opportunities for consideration by leaders from the private, public, academic, and nonprofit sectors.

# DRIVERS OF FOOD WASTE

The changes in consumer demand driven by the rising middle class have compounded complexities for an already fragmented food supply chain in China. These changes in consumption growth and patterns have been shaped by a new generation of free-spending, sophisticated customers, and the prevalent role of e-commerce in China (World Economic Forum, 2016). Below are some key trends we have observed to be contributing to these changes.

## Affordability and Availability

China's economic growth has increased the purchasing power of the average consumer. According to China's National Bureau of Statistics, urban disposable income increased to more than 30,000 RMB in 2015, almost five times what it was in 2000.

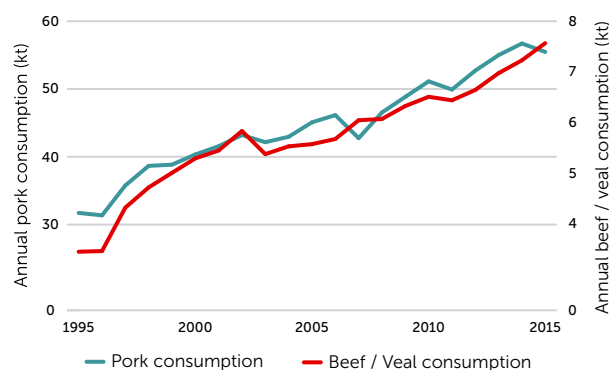
In line with this expansion in disposable income has been the increased affordability and availability of food, through transport from China's farthest provinces, from global imports, or through the explosion of restaurants that have been supported by the increased spending of urban consumers.

As all these trends have grown, consumers have developed the habit of ordering in larger quantities, and their relationship to food cost has changed. As a result, Chinese consumers who once would have been chided for wasting any amount of food now view food waste through overordering as a sign of wealth.

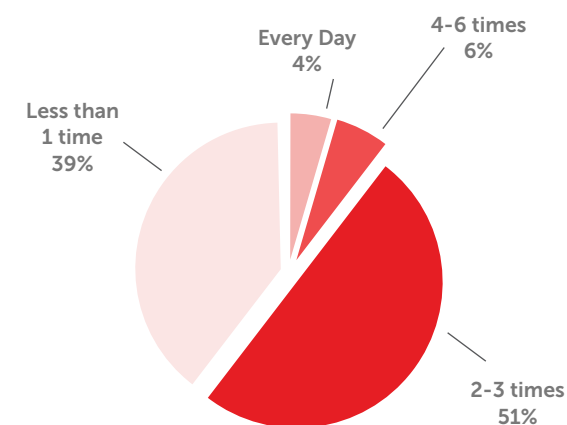
## Dietary Changes

Other dietary shifts have followed, from a diet based on a staple carbohydrates and vegetables to an increasingly diversified diet featuring increased consumption of meat, poultry, and dairy products.

Data from the National Bureau of Statistics shows that pork consumption in China reached 55,465 tons in 2015, almost twice the consumption in 1995. Similarly, beef and veal consumption has doubled in the past 20 years (Figure 2).



**Figure 2.** China's pork and beef/veal consumption from 1995 to 2015  
Source: OECD- FAO Agricultural Outlook



**Figure 3.** Frequency which Chinese nationals report weekly dining out excluding for work related reasons  
Source: China Cuisine Association, 2015

## Dining Out

Increased disposable income, busier lifestyle, and greater variety of choices have made dining out commonplace in the Chinese urban lifestyle. As shown in Figure 3, approximately 51% of Chinese nationals claim to eat out two to three times a week (China Cuisine Association, 2015), while the number of restaurants in China has grown eightfold between 1999 and 2016, with overall business turnover exceeding 500 billion RMB.



# FOOD WASTE IS A PROBLEM

Whether from a long history of agricultural practice, an abundance of fresh foods bought daily at wet markets, or from going through periods of food scarcity, historically the Chinese would rarely waste food because the value of food was known by farmers and consumers alike.

But new developments in the food market and in consumer behavior have created a waste problem in China, and most Chinese cities are still struggling to manage the build-up of food waste. Several tier-1 and -2 cities have developed policies and technical roadmaps for waste recycling and resource recovery, but the overall treatment capacity can hardly keep up with the vast volume of waste produced and collected. This gap has pushed municipalities to dispose of food waste through landfills and incineration; both approaches are highly inefficient in managing these wastes. Smaller cities have even less waste-management infrastructure.

The proliferating food waste has already had a negative impact on environmental and food safety, and if left unaddressed, will have disastrous consequences for the environment and agricultural system.

## Impact to Landfills

With more than 640 landfills in operation, nearly two-thirds of urban municipal solid waste in China is buried (National Bureau of Statistics, 2016). In many cities landfills are reaching maximum capacity and are not engineered properly to meet pollution-control standards.

The latter is an issue because when organic matter decomposes in an oxygen-free environment, it releases landfill gases such as methane, which can cause environmental, hygiene, and safety problems.

Additionally, because of surging land prices, public protests, and policy shifts in favor of waste-to-energy incineration, Chinese cities are running out of good places for landfills and facing mounting pressure to shut down existing ones.

## Food Safety Risks

Seeing the potential for economic gain, informal collectors and traders have been taking advantage of the capacity gap between waste generation and treatment in Chinese cities, in ways that have proven dangerous. They collect leftovers from restaurants by illegal trading, then sell them to pig farms as feed or to small workshops that reprocess the secondhand oils and sell them back into the market.

These workshops have been the focus of numerous “gutter oil” scandals, which have pushed various government agencies to introduce new regulations, kitchen-transparency programs, and overhauls of enforcement mechanisms. These actions have resulted in large numbers of restaurants being publicly shamed, fined, and closed.

## Waste Resources

While this report focuses on the impact of post-consumer food waste, the even greater impact is the waste that accumulates across the entire value chain.

China throws away about 200 billion RMB worth of food annually. This represents a wasted investment that reduces the economic well-being of actors in the food supply chain and undermines the economic viability of hundreds of millions of Chinese small farmers.

This tremendous food waste also equates to a loss of resources such as water, seed, and labor, each of which is already considered scarce in China. This scarcity contributes to China becoming the largest importer of foodstuffs worldwide.



# GOVERNMENT ACTIONS

Facing mounting pressures and challenges to manage food waste, in 2007 the Chinese government started to regulate food waste management and introduce regulations meant to encourage nonhazardous treatments and resource recovery processes to replace landfill and incineration. Since these initial regulations, a process of formalizing the food waste management systems was laid out in the 12th and 13th Five-Year Plans.

These efforts have resulted in a number of programs, including the launch of nationwide campaigns to reduce food waste at the consumer level and to require local businesses to sort food waste from general waste prior to collection (Figure 4).

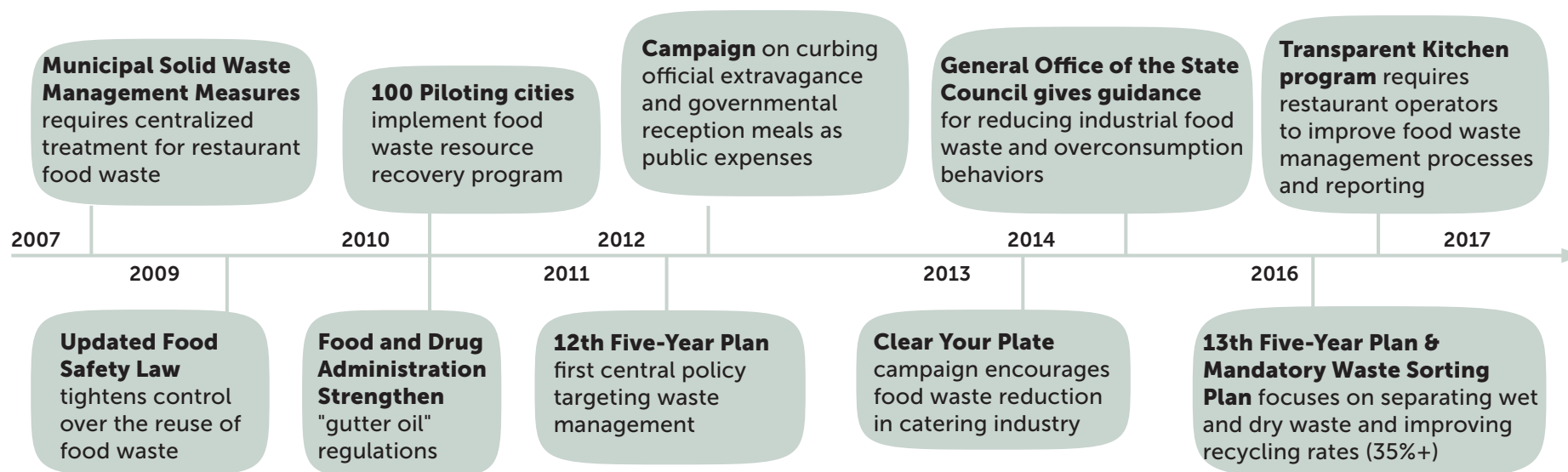


Figure 4. Milestones of Food Waste Management in China



## "Producer Pays" Principle

To ensure that management of food waste is economically viable, and to alleviate the financial burdens of waste management on government, municipal governments often charge business operators fees for food waste disposal to subsidize the operation of municipal food waste treatment plants.

There are no national standards on the collection and disposal fees of food waste. However, 15 Chinese cities, including Shanghai, do have their own waste collection pricing schemes. Some charging restaurants by property size, while other cities base the fee on the volume of food scraps.

In Shanghai, in addition to reporting their daily waste volumes, businesses must report their total food waste production once a year and pay a disposal fee based on the average waste volume as part of the process to renew their catering permit.

However, the introduction of a producer-pays principle has faced opposition from the business community, which currently enjoys free disposal services or benefits from the illegal trading of food waste. These objections have largely obstructed the execution of the principle and have likely propelled participation in the informal waste sector.

## Mandatory Waste Sorting

In March 2017, China's central government selected 46 cities, including Beijing, Shanghai, and Shenzhen, to pilot a mandatory garbage classification system aimed at upgrading waste disposal, collection, transportation, and treatment practices (National Development and Reform Commission, 2017).

As part of these pilot projects, restaurant managers are required to separate food waste from other general waste (such as plastic scraps, paper, and chopsticks) and to record the waste type and weight and the disposal methods daily.

As a result of the mandate, the recovery utilization rate of domestic garbage is projected to increase to 35% by 2020.

However, for cities such as Shanghai, with high percentages of organic waste, it is expected that garbage classification will increase the burden on the local disposal capacity and that some waste will need to be temporarily stockpiled at storage facilities before being properly disposed of.

## Resource Recovery Pilot Projects

To find alternatives for landfill and incineration and to maximize the resource recovery from urban food waste, from 2011 to 2014, China identified 100 first- to third-tier cities to carry out pilot projects.

Each pilot city can design its own waste management programs based on their food waste components and volume, and localized regulations for better enforcement (National Development and Reform Commission, 2016).

To support local efforts, China invested 10.9 billion RMB and 18.35 billion RMB in food waste sorting and treatment facilities during the 12th Five-Year Plan and the 13th Five-Year Plan, respectively. Cities are encouraged to identify and pilot technology innovations that will convert food waste to useful resources such as heat, composter and soil conditioner.

Targeting projects in these areas has proven beneficial to many cities. By the end of 2017, approximately 87 food waste processing facilities were in operation, with a total treatment capacity of 18,700 tons per day (E20 Research Institute, 2018). The main technologies they are using are anaerobic digestion and aerobic composting.

# SHANGHAI WASTE ECOSYSTEM OVERVIEW

While the city has looked to formalize food waste management since 2000, and has ambitions to build a robust management system to handle the city's MSW production, the current waste management ecosystem continues to comprise a wide range of formal and informal stakeholders who are involved in the collection, transportation, and processing of the city's food waste.

As shown in the adjacent map, in the formal food waste system, waste producers pay licensed collection companies to send the waste to official treatment plants, incinerators, and landfills.

However, in an effort to turn food waste into a resource, a number of innovative treatments and processes are being deployed as part of the formal system.

At the same time, a significant portion of food waste is diverted through an informal waste stream from restaurants to who sell the food waste illegally to pig farms and oil shops.

It is a system that we have detailed in the diagram and in the pages that follow.

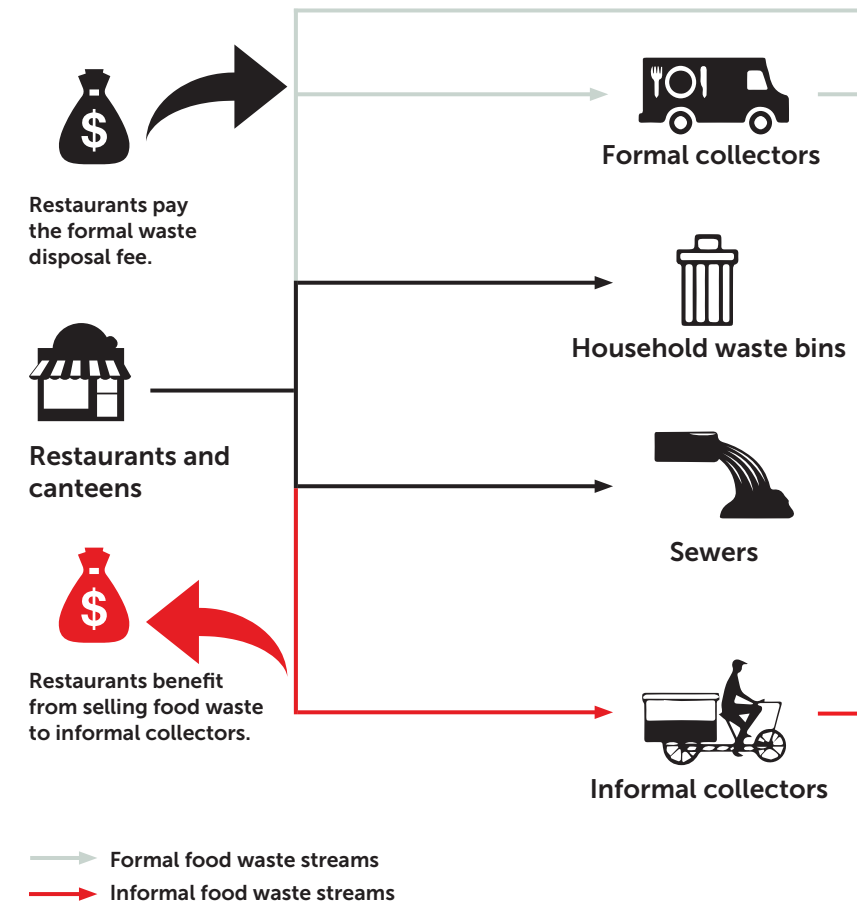
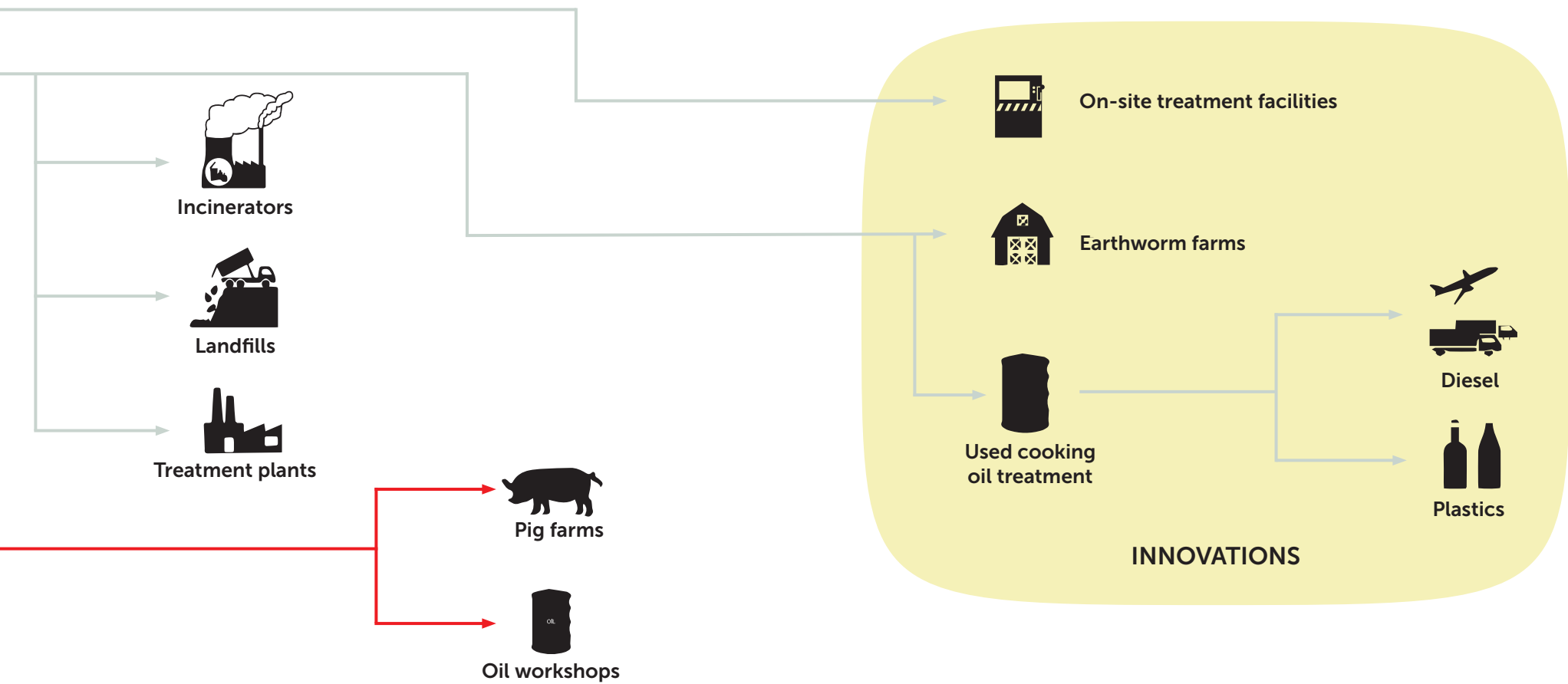


Figure 5. Shanghai Waste System Ecosystem Overview.







# FORMAL FOOD WASTE MANAGEMENT

## Waste Producers

In the formal system, before restaurants apply for catering service permits they are required to declare their annual catering waste tonnage and pay collection fees to the district's Appearance Management Bureau.

For large shopping malls and commercial centers, the property management is responsible for collecting and sorting food waste generated by tenants before handing it over to formal food waste collection companies.

While the collection fee may vary for different commercial facilities, the standard collection fee in Shanghai is 54 RMB per 240-L bucket (Shanghai Municipal Pricing Bureau, 2013), or about 225 RMB per ton.

However, to avoid these costs, many businesses dump their food waste into standard municipal streams, or sell it for up to 1,000 RMB per ton to the informal waste management system.

## Formal Collectors

About 90 collection companies in Shanghai are currently responsible for district-specific collection and transportation of food waste.

Obtained through a competitive bidding process, the primary sources of revenue for formal waste collectors is usually a combination of government grants and stipends from waste disposal companies.

Operating with thin profit margins, formal collectors at times face the dilemma of also competing with informal collectors, who get to restaurants earlier than they do and collect the higher-quality waste.

Consequently, formal collectors are often left with food scraps of less quantity and poorer quality, resulting in huge gaps between waste production quantities and collection volume.

## Resource Recovery Plants

In suburban Shanghai, there are seven official food waste treatment plants that convert a total of 575 to 625 tons of food waste into soil conditioner and compost every day.

These treatment plants are either state owned or contracted to private enterprises through a bidding process, but like the formal collectors, they are forced to rely heavily on government grants to remain in operation.

This is a result of the prevailing challenge faced by plant operators — the lack of a well-established market and regulatory framework for the secondary products they are creating. Because of food safety concerns, which are among the most sensitive issues in China, questions exist over what risks may be involved in using food waste as agricultural compost or fertilizer, and correspondingly, no regulations exist to support commercial use.

As a result, most fertilizers sourced from food waste are being purchased by the government for urban landscaping, which creates a significant economic challenge for their producers.

## Landfill and Incineration

In Shanghai, when existing resource recovery facilities are at capacity, there remains 600 to 800 tons of collected food waste that cannot be properly disposed of. Instead, after undergoing a dehydration process, this waste is mixed with household waste and discarded at landfills or incinerators.

Shanghai currently has five incineration plants in operation, with a total treatment capacity of 8,300 tons per day. However, there are challenges associated with incineration, including higher incineration costs — especially for food waste, with its high water content (80–95%) and low heat value, and emissions of air pollutants such as fly ash and dioxins.

As the city is looking to invest into more environmental friendly methods or resource recovery technologies, all the landfills in Shanghai are scheduled to close by 2020 (National Development and Reform Commission, 2016).



# INFORMAL FOOD WASTE MANAGEMENT



**Figure 6.** Cooking Oil, Informal Waste Collection and Formal Waste Collection

## Informal Collectors

Informal collectors are often individuals who cycle through the main streets of the city, pouring food waste into bins attached to their bicycles or tricycles. They have established strong networks with dozens of restaurants, particularly those vendors at popular night food markets.

These informal collectors walk into the restaurant kitchens before the formal collectors arrive and collect the most valuable food scraps, which are then sold to consolidators that transport the waste to farms or workshops in the surrounding provinces.

## Informal Buyers and End Users

Often scattered in villages or suburban areas of Shanghai, pig farms or illegal oil workshops purchase food waste from informal collectors to feed hogs or reprocess it into oil products that can be sold back to the cities.

Faced with the pressure of intense competition with large industrialized pig farms, skyrocketing prices of the pig feedstock, and the government's resolution to formalize the pig industry, for many of these farmers the decision is purely one of economic survival. Which is why many pig farmers continue the practice despite clear regulations banning it.

# CHALLENGES TO FORMALIZATION

Shanghai's food waste management system is facing challenges during the transition from an informal to a formal system. Some key challenges lie in moving from traditional methods of disposal at landfills and incinerators to comprehensive resource utilization, and in increasing resource recovery rates at disposal plants by adopting technological innovations.

## Enforcement

*"I collect tofu dregs and rice and sell them to pig farms. That's what traditional farmers always do and there is nothing bad. By mixing a small amount [of food waste] with feed, pigs can grow faster without any harm."*

— Informal collector

Whether out of a belief that feeding post-consumer food waste to pigs is safe, or to derive profit, the individual actors in the informal system are currently undeterred by the risks of being involved.

Thus, key steps for the government to take during this transition to modernization are improving supervision and monitoring of the waste collection process, and providing solutions to help these traditional pig farmers adapt.

However, as we have seen in other areas of China's informal waste economy, it is clearly only a matter of time before the risks and costs of getting caught are realized and informal actors no longer view the trading of food scraps as viable.

## Economics

*"I give up the huge profit of selling food waste to the informal industry because I know it is unhealthy for people to consume. But I have to say, the disposal fee is quite a big expenditure for me."*

— Restaurant owner, Shanghai

The huge differences in the economics of formal and informal waste handling makes it hard to manage restaurant workers' and pig farmers' behavior without proper awareness training.

The key step to balance the economics for the government will be to increase enforcement, thus increasing the costs for the informal system. Catalyzing the formal sector to improve its capacity to capture and process food waste economically will also help shift the balance away from improper and illegal handling.

## Capacity

*"We encourage resource utilization of food waste, but the current capacity (580–630 tons/day) still can't meet with the generation (2000+ tons/day). We don't have places to store all the extra waste."*

— Shanghai Afforestation and City's Appearance Management Bureau

Increasing disposal capacity has never been easy. At the same time, existing landfills in Shanghai are closing, which will further reduce disposal capacity. Even with government subsidies and policy support, many programs have been delayed or are still under development. Some programs are grappling with land ownership and certification issues, while others are being met with strong public pushback from environmental groups and residents who are unwilling to have a disposal site built in their backyard.

Thus, it becomes a challenge for Shanghai to increase its disposal capacity to catch up with the actual food waste production rate. More innovative and efficient waste management technologies are expected to emerge, which will maximize resource utilization while reducing the energy consumption and environmental impact. Some exciting innovations can already be found in Shanghai.



# OPPORTUNITIES FOR INNOVATION

An increasing number of enterprises and investors are now beginning to recognize the growth of innovation in food waste recycling. With significant difference in local needs, regulations, and formalization activities, it is important for potential solutions providers and investors to identify technologies and processes that can scale to the needs of China's growing cities.



Figure 7: Five Stages of Earthworm Composting Process

## Earthworm Composting

Through earthworm composting, food waste is utilized as earthworm feed for worm cultivation. Both the worms and worm castings being used as the soil conditioners or organic compost in agricultural activities.

Both economic and regulatory challenges exist for the adoption and scale-up of this process. The process of earthworm composting is slow, but more importantly, legal standards for worm compost for agriculture do not exist, meaning that earthworm farmers cannot sell their compost to the agricultural market legally.

In Shanghai, one earthworm cultivation farm in the Baoshan district has a daily treatment capacity of 50 to 60 tons of food waste. While the farm's primary purpose is to develop and scale the worm composting process, a wide range of fruits and vegetables are also being grown on site. If both process and produce are proven safe, and are supported by a change in regulation to allow for the sale of compost materials, the facility will see opportunity for scale in China.

## Microorganism Composting

Through microorganism composting, food waste is decomposed and converted into microbial fertilizers rich in diverse nutrients that can improve soil quality and productivity.

At Shanghai Technology University, one on-site composting facility could turn one ton of food waste into 100 kg of organic fertilizer within six to eight hours, with a sales price of 1,300 to 1,500 RMB/ton to landscaping companies.

Similar to earthworm composting, microorganism compost materials cannot be sold on the market as an agricultural fertilizer or soil conditioner because of a lack of regulation. Consequently, many of these businesses try to survive by selling to urban landscaping or land remediation markets.

# OPPORTUNITIES FOR INNOVATION



Figure 8: Shanghai Technology University Microorganism Composting

## Integrated Waste Digestion

Aerobic composting (AC) produces compost or soil conditioner by degrading organic material in the presence of oxygen; Anaerobic digestion (AD) is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen and release chemical energy in the form of methane.

Through the integration of AC and AD processes, solid food waste components can be converted to compost under the AC process while the methane and waste heat produced from the AD process is captured as energy for the AC process. Moreover, the oil components extracted from food waste can be processed into biodiesel.

In this way, the processor is able to maximize the potential outputs from food waste, including compost, biodiesel, and methane, while significantly lowering the operational costs.

In Shanghai, Jiabowen Co., Ltd., has an integrated process that is able to process approximately 200 tons of food waste per day.

## Comprehensive Industrial Park

In a comprehensive industrial park, companies specializing in different types or stages of waste management are located together on a common property and operate as a collective system.

They share information, infrastructure, natural resources, and utilities while leveraging their respective strengths to maximize the economic gains and environmental benefits.

Unlike stand-alone treatment facilities, such industrial parks are capable of handling all kinds of waste, including household waste, kitchen waste, electronic waste, construction waste, etc.

At present, China Everbright International Ltd. runs nine such parks across Suzhou, Nanjing, and Lianyungang. In Shanghai, China Tianying Incorporated has developed a cloud-based platform that allows tenants and operators of parks to monitor in real time the wastes available.





# CONCLUSIONS

Since China started streamlining food waste management processes in 2011, the system has undergone a rapid transition toward formalization and a continued exploration of the marketability of end products. Under the current Five-Year Plan, Shanghai has built several food waste disposal plants that employ resource utilization technologies such as aerobic and anaerobic technologies, as well as made investments to encourage worm composting.

It is an evolving system that is adapting to the rising challenges. With food waste treatments moving toward integrating multiple methods to maximize resource recovery and economic benefits while reducing potential labor and environmental costs, a more efficient, circular economic model of food waste management is coming into being. However, even with beneficial long-term prospects, each new technology faces regulatory and market challenges that inhibit growth in the short term.

In conclusion, we identify four challenging areas that represent opportunities for stakeholders to look into:

- Put in place suitable economic incentives to encourage restaurants to get more involved in the formal system and stop food waste from flowing into the informal market;
- Create a comprehensive regulation and monitoring system to benefit all relevant stakeholders by clearly defining their respective roles and responsibilities, which is necessary for the proper functioning of the whole system;
- Foster the development of companies specializing in different waste treatment technologies, which is a growing trend that will help achieve higher treatment efficiency at a lower cost;
- Support and incentivize the development of a market that closes the loop and redeploys these wastes as new resources.

With total estimated food waste generation in China having reached 97 million tons in 2016 and the entire food waste management market expected to reach 150 billion RMB in 2020, it will take leadership from all sectors — private, public, academic, and nonprofit sectors — to come together and find ways to scale up innovative solutions to these challenges.

# REFERENCES

- China Cuisine Association. (2015). Report on Chinese Food Service Industry Development (in Chinese).
- E2o Research Institute. (2018). Report on 2017 Food Waste Treatment Market (in Chinese).
- National Bureau of Statistics of China. (2016). Collection, Transport, and Disposal of Consumption Wastes in Cities by Region.
- National Development and Reform Commission. (2016). China 13th Five-Year Plan on Harmless Household Waste Treatment (in Chinese).
- National Development and Reform Commission. (2017). Implementation plan of household garbage classification system (in Chinese).
- Shanghai Municipal Pricing Bureau. (2013). Notice on Shanghai waste disposal fee (in Chinese).
- Sina News. (2017). Suggestion of real time monitoring system on food waste in Shanghai (in Chinese).
- World Economic Forum. (2016). Three Great Forces Changing China's Consumer Market.





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121 Jiangsu Road, Suite 18/F  
Shanghai, P.R.C. 200050

[www.coresponsibility.com](http://www.coresponsibility.com)  
[insights@coresponsibility.com](mailto:insights@coresponsibility.com)