SUSTAINABILITY INSIGHTS:

SHANGHAI'S INFORMAL WASTE MANAGEMENT

COLLECTIVE RESPONSIBILITY

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Collective Responsibility
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INTRODUCTION

Over the past decade, China's cities have grown at an unprecedented rate. More than half of Chinese people now live in cities, and urban GDP per capita has risen almost 10% every year (World Bank, 2016).

As China's commercial capital, over the last two decades, Shanghai has experienced high economic and population growth. The city's GDP has increased at an average of 7.2% over the last five years, to reach 2.75 trillion RMB in 2016, and its population topped 25.2 million people. As part of this economic, a boom in Shanghai's consumption and building activity has taken place (CNBS, 2016).

As in other Chinese cities, with rapid increases in economic development, higher levels of consumption have led to per capita, and gross, increases in the amount and varieties of waste entering the system. With the production of such large amounts of waste, the city is struggling to process it efficiently, economically, and safely.

In particular, increased individual consumption and construction have produced tons of waste and strained government resources. Cardboard packaging, Styrofoam, construction sediment, plastic bags, and other material waste have flooded China's waste stream and forced cities to take a closer look at how they handle waste.

China's current waste management system has two parts. The first is formal and government-run, with contracted companies that manage collection, incineration, landfill disposal, and composting. The second part of the system is entirely private and involves millions of "informal" workers who collect, store, and sell waste.

China's government-run system currently faces a resource crunch, and without help from private collectors, will soon run out of landfill space. Under the current system, city governments own few recycling facilities, rely mostly on landfills, and have only recently begun building more incinerators.

This is where "informal" collectors help. They specialize in recycling and reuse – selling waste to recycling plants, factories, and reprocessing centres, diverting from landfill in the process. Despite their potential, however, they rarely work with the formal sector. In fact, informal actors face increasing pressure to close private facilities as the system formalizes and environmental regulations tighten.

Their potential decline presents an urgent challenge – not only for first-tier cities like Shanghai and Beijing, but also for second- and third-tier cities like Chongqing and Changsha, whose municipal waste levels have risen 80% and 167% respectively over the last 10 years.

Taking a closer look at the data, Shanghai waste production has steadily increased since 2005, with the amount of waste transported and collected peaking in 2015 at 7.9 million tons (Shanghai City Appearance and Greening Bureau, 2015). Of this three million tons went to landfill, and 2.5 million tons was incinerated. The remaining material was either composted, recycled, lost in transit, or subjected to hazardous or comprehensive waste treatment (Figure 2).

This report will look at one city, Shanghai. We will outline current trends, key stakeholders, challenges, and opportunities in waste management, focusing mostly on the informal sector and its role within the wider waste management ecosystem.

In particular, we argue that Shanghai's better-regulated and environmentally friendly system must incorporate the informal sector, combining efficiencies from both the current formal and informal models of collection. The following analysis will not only pertain to Shanghai and first-tier cities, but also to cities like Chongqing and Changsha that could experience similar challenges and patterns of development over the coming decade.

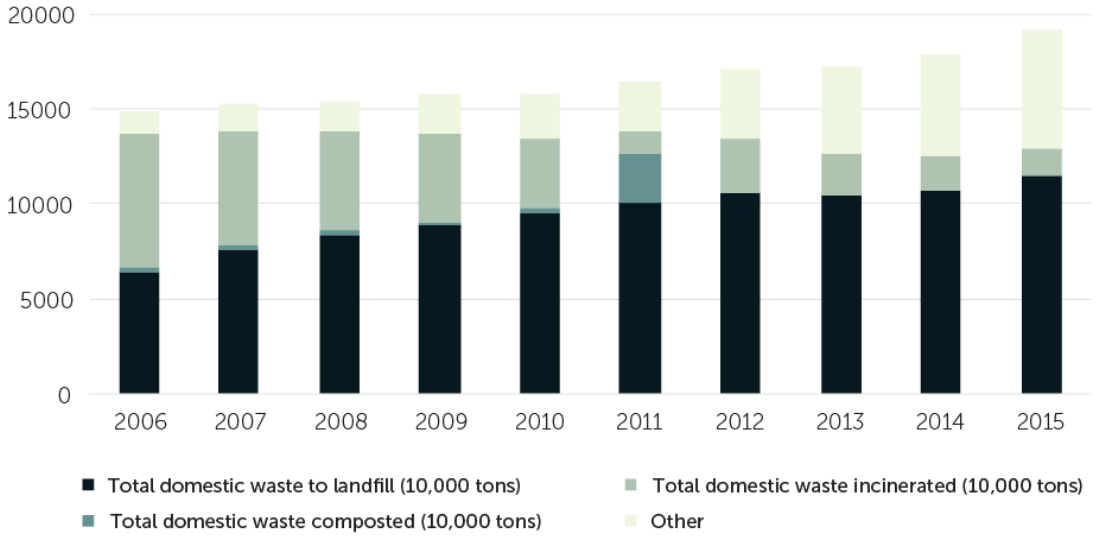


Figure 1: Domestic Waste and Treatment in China. Source: CNBS, 2016

FORMAL SECTOR

Shanghai's formal sector is a government associated system in which contracts are won by waste management providers for each district. In reality the system is more complex with private contractors present within the system taking responsibility for certain waste streams. This part of the waste system is outside the scope of this study but below the common formal treatment methods are outlined.

Shanghai's formal treatment primarily involves large-scale landfills and incinerators, but it is supplemented by a number of small-scale alternatives, like landscaping and backfilling.

Landfill

Landfilling is Shanghai's most common form of waste treatment, handling nearly 40% of officially recorded waste (CNBS, 2016).

Under this treatment method, waste management companies essentially bury waste in the ground, periodically covering it with soil or inert material. While landfills are often highly-effective and easy to maintain, they do carry some environmental risks. The protective membranes – however effective in the short term – can erode over time. If improperly maintained, they can degrade, cause unnoticed leaks, and ultimately contaminate the surrounding soil and groundwater.

Likewise, when left unaddressed, anoxic environments and the degradation of organic material can result in a buildup of methane. This gas is highly flammable and can cause explosions with significant buildup. If managed well, however, landfill managers can isolate the gas and even use it for renewable energy production. The Laogang Phase 4 landfill, for instance, generates biogas on site and accumulates roughly 10,000 MW/hour in electric power every year.

The city currently operates five landfills – two of which will be closed by the end of 2017 (Shanghai City Appearance and Greening Bureau, 2015). Once decommissioned, the city will lose an average daily storage capacity of 15,500 tons.

There is a central push to reduce waste sent to landfill and in the city's 12th and 13th Five-Year Plans it states that Shanghai must substantially decrease its waste to landfill over the next five years. Rather than build new landfills, Shanghai officials have begun building five new incinerators, which will increase daily capacity levels by 11,000 tons and align with the city's goal of zero waste to landfill by 2020 (Shanghai Municipal Government, 2015).

A GROWING CHALLENGE

Incineration

Incinerators are a common form of treatment through which waste is disposed of by burning and in the case of waste to energy used to turn a turbine and produce electricity. There has been a recent push by central government to increase the use of incineration as a waste treatment as it is a high efficient way of diverting waste from landfill. Shanghai currently has 5 official incinerators operating a combined daily capacity of 8,300 tons, and large scale plans to increase the number of incinerators and daily capacity are in place.

While incinerators are a mature and effective technology if operated correctly, if not they can cause considerable environmental and medical harm through the release of toxic chemical such as dioxins. Around the world, considerable opposition to them exist and in 2015 thousands of Shanghai residents protested a new paraxylene (PX) petrochemical plant in Jinshan, afraid that the plant would emit toxic compounds, impact air quality, and prove to be a eyesore (Reuters, 2015). Like the PX plant, some of Shanghai's future incinerators will be built near residential communities on Chongming Island and in Qingpu district – and may face similar opposition from local residents.

Recycling and Recovery

Formal recycling and recovery are virtually non-existent in Shanghai's formal sector, and the informal sector does much of the collection and treatment of valuable material. However, recently, government movements are occurring to account for the sector. The "Provision of Shanghai Municipality on the Administration of Construction Waste Treatment"（上海市建筑垃圾处理管理规定（草案）, 2016) looks to enhance capabilities to recycle deconstruction and decoration waste and build recycling sites in Taopu Putuo, Jiefang Island, and Minhang. This will add an additonal treatment capacity to the formal system and further divert waste streams away from landfill.

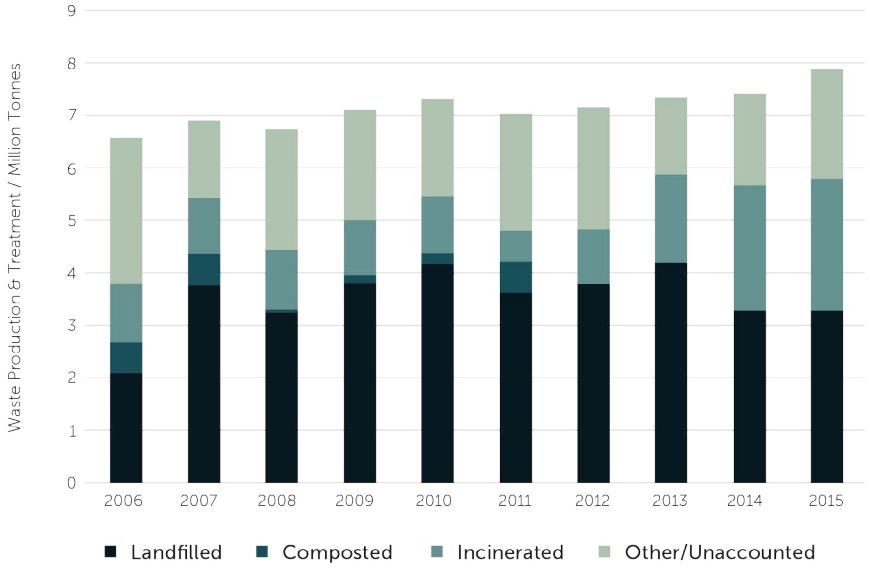


Figure 2: Shanghai's Waste Production and Treatment. Source: CNBS, 2016

INFORMAL OVERVIEW

"This is such an interesting time to be in the informal industry. The supply of waste in China has never been higher. Tons of waste from other countries is being sent to China, and kuaidi [delivery] is becoming increasingly popular."

- Truck driver from Huai'an, Jiangsu province

With the ever increasing amount of waste created in Shanghai, and in the absence of a formal system that can capture, sort and divert recyclable materials, an informal ecosystem of private waste collectors has come to play an essential role in diverting large amounts waste from landfills and put them back into the economy.

Well-connected, hierarchical, and at scale, the informal ecosystem involves individuals who collect materials on tricycles, to entire companies that buy, sort, and store material before selling it to larger players within the system.

The sector is self-reliant and efficient, with private collectors using their own storefronts, large collection centres, and tricycles to collect, separate, and transport material.

Figure 3: Informal Road Recyclers in Shanghai

The informal sector owes its existence to two key aspects of the formal system:

1. The formal sector predominantly does not sort, recycle or reuse material, even though there is plenty in the waste stream.

2. The formal sector charges businesses and construction sites for waste collection based on weight, not waste type. As a result, if informal collectors remove recyclable material from the waste stream, companies do not need to pay as much for collection.

From initial collection to final treatment (which is most often recycling), informal workers play a role in every step of the process. Individual collectors sell to small storage and sorting centres, the small centres sell to larger centres, and the larger centres sell to factories and reprocessing plants.

Workers within the informal system are hundreds of thousands of individual actors who are motivated by material price and availability. Looking to maximize profit, collectors keep close track of international commodity prices and macroeconomic factors that might influence prices, including a rise in e-commerce, higher construction activity, or new government regulations.

THE COLLECTION ECOSYSTEM

Given the large-scale nature of informal collection, sites are distributed across the city, with multiple small collection sites and only one to two large sites per district. The informal system relies on the interaction of these sites and stakeholders to run efficiently.

Figure 5 maps important waste collection sites that exist in Shanghai's central districts. In the following sections, we outline key sites and individuals within this sector.

Legend

- Floating large consolidation centres
- Static large consolidation centres
- Small collection centres
- Incinerators
- Unofficial landfills

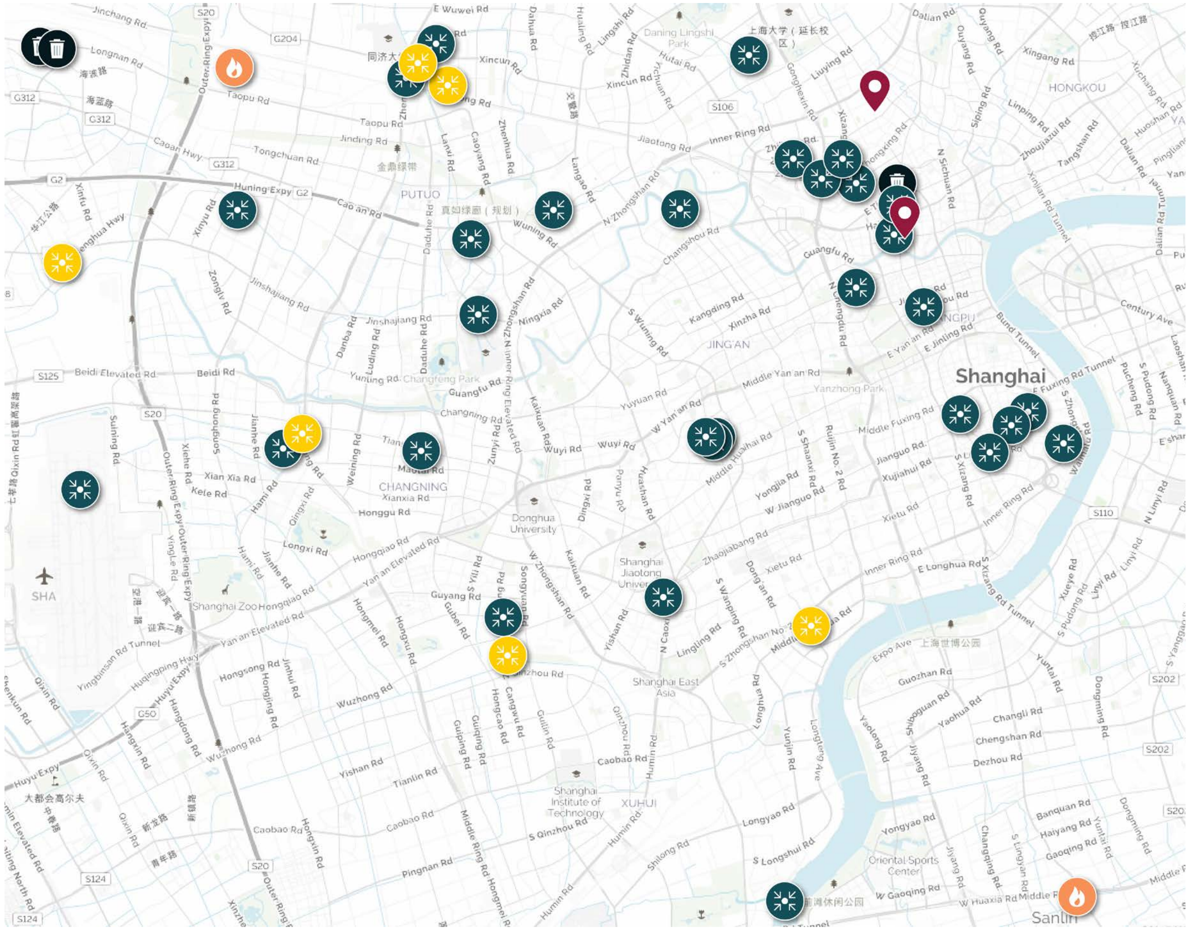


Figure 4: Shanghai's Informal Collection Network

Swapping Points

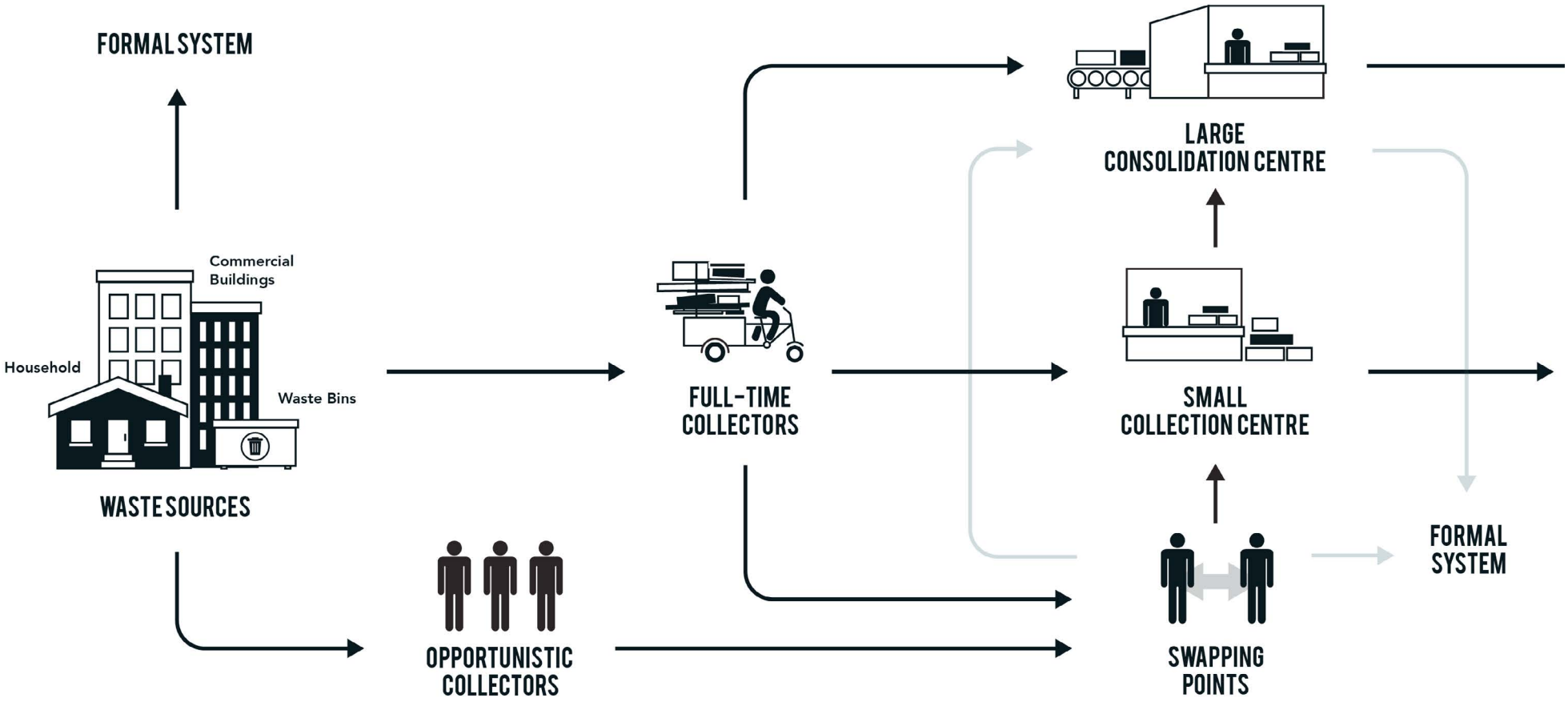
Swapping points are non-licensed areas on the street where informal recyclers and individuals gather to buy and sell material to other informal recyclers.

These points are either managed by a single informal recycler or multiple informal recycling companies that each handle different materials (plastic, cardboard, wood, etc.). Because many of these swapping points are non-licensed, collectors who operate them must be careful about attracting official attention.

Small Collection Centres

These collection centres are consolidation points for waste that is collected throughout the city. These sites pay informal and opportunistic collectors by weight for the waste collected.

They categorize materials by type and subtype before preparing for transportation to processing centres. In some cases, these centres sell to larger waste collection points if the amount of material does not warrant loading onto an individual truck.



Large Consolidation Centre

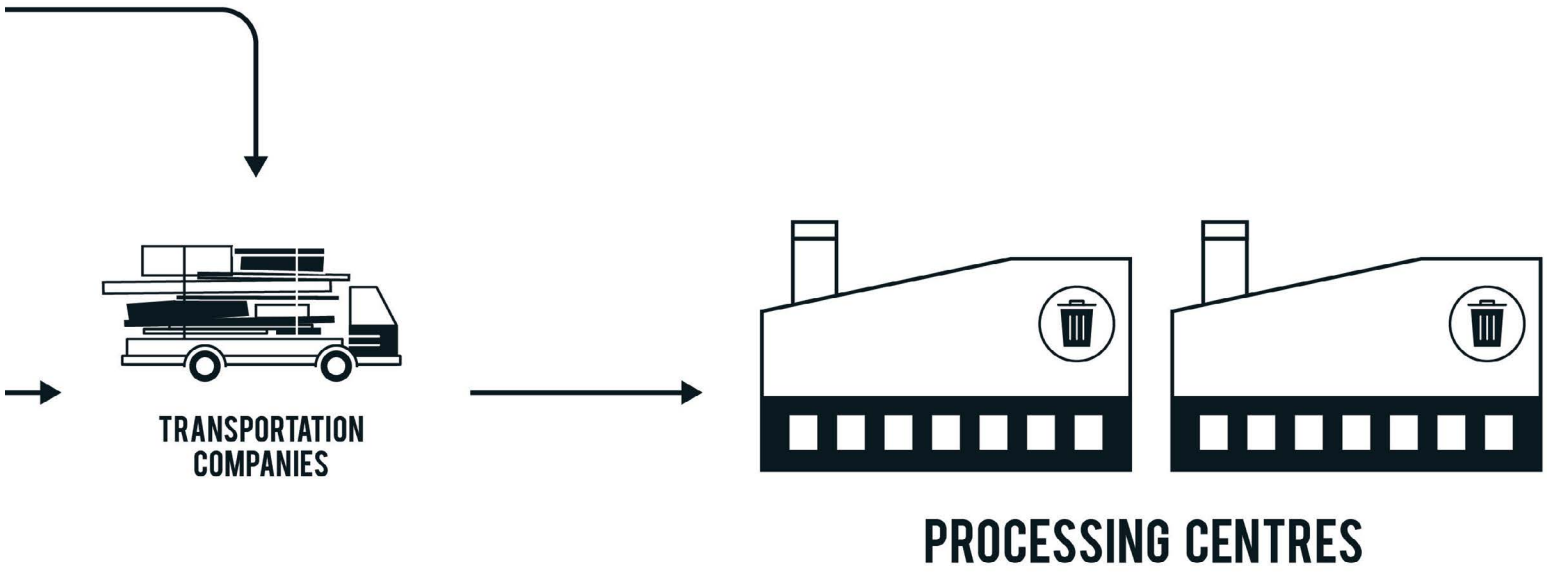
Operated like small collection centres, these larger-scale centres process high volumes of a wider range of materials every day.

These centres are the last points in the collection chain before transportation to processing centres, and because many are licensed, they are able to remain in the same location for long periods of time.

Processing Centres

These are the end point in the material lifetime with many present in nearby provinces of Jiangsu and Zhejiang. Trucks arrive here and sell material on for processing and reentry back into the economy.

This is the side of the informal sector that is the least transparent and in many cases little is known about the quality of the treatment.



MATERIALS COLLECTED

At its core, a material economy, the informal sector divides waste into a few essential categories – with different subtypes, prices, and end-of-life treatments. The informal sector relies on accurate pricing set by material processing factories, which rely on international and domestic material commodity prices. Once set by factories, actors relay price adjustments and information all the way down the chain to informal collectors.

At each stage, prices are altered based on the size, capacity, and profit-making ambitions of key actors in the system.

Impacted by a number of factors, including domestic stockpiling and investments, seasonal manufacturing activity, and scarcity of virgin materials, upward pricing pressure on informal prices will catalyze demand for recycled material, and incentivize collectors to capture these wastes for processing.

As collectors often develop a preference for certain materials based on price and market demand, these prices have a direct impact on the activity of collectors within the informal system. For example, collectors will ask for payment for the removal of iron, yet pay actors for paper and cardboard – materials in high demand due to the rise of e-commerce and growing need for packaging.

In times of recession, such as in 2008, activity of collectors is impacted considerably as material prices decrease to the point that they are not even worth collecting. While this is a rare occurrence within the waste market, it is proof of the clear impact that global and domestic commodity markets have on "on-street" activity.

Paper and Cardboard

Paper and cardboard are presently the informal system's materials of highest volume. Cardboard is divided into multiple subtypes, but two of the most common are patterned and yellow cardboard, the former has color print on the surface, while the latter is plain with no print.

Informal collectors remove tape and other adhesive material from the edges, package the material into bundles, and then send it to large collection centres, recycling facilities, and paper-making factories. These processing centres sort cardboard by paper grade, shred the material, and immerse it in a chemical mixture to reduce it to pulp. After five days, it is considered a finished product.

Plastics

Plastic bottles, bags, and containers are collected frequently in the informal sector and like paper and cardboard, plastics are one of the materials of highest value to the informal sector.

Unlike paper and cardboard, Informal collectors will only take a material if it is clean and deemed valuable. After being sent to a collection centre, small or large, a waste transportation company will send sorted materials to a waste compression facility, which will then flatten the plastic bails into manageable cubes to be processed.

Following this step, the cubes will then be sent to factories and recycling centres, where the plastics will be ground and melted. The process requires five to 10 days from beginning to end for materials in the Shanghai region.

Aluminum and Copper

These are two of the most valuable materials in the informal sector, with red copper the most expensive subtype.

Copper and aluminum are mainly recovered from construction, demolition, and renovation sites. Here informal collectors separate and sell the metal to collection centres, who will in turn sell directly to factories that clean and reprocessthe material.

In China, many factories that sell aluminum or copper products will also have secondary recycling and reprocessing facilities, so they purchase aluminum and copper with the knowledge that it is relatively easy and non-energy-intensive to recycle. Both materials require an average of 10 days to melt down, remove potential impurities, and reshape to make cans, wires, piping, or other metal products.

Steel and Iron

Not as valuable as copper, these materials are mainly recovered from construction and demolition sites as crews tear down metal support structures, frames, and shelving units in apartment and office buildings.

Small and large collection centres separate the materials on-site and ship both to metal factories and manufacturers. Many of the reprocessing and manufacturing companies specialize in materials for furniture-making, building foundations, and general construction because the construction and renovation sectors are in constant need of raw material.

Both ferrous metals require about three to five days to collect, crush, smelt, purify, and enter back into the manufacturing.

Wood

Incentives for collecting wood are much lower than those for other materials within the ecosystem, due to low demand. It is heavy and difficult to transport, its price is relatively low (0.06 to 0.1 RMB per kilo), and it is relatively expensive to reprocess and reuse. However, in some cases, informal collectors will take wood for free and sell the material to either a small collection centre or a wood processing factory. If the wood has an outer layer of varnish or paint, informal collectors will still retrieve it, but charge a transportation fee because it is more expensive to process.

Most materials will be delivered to a furniture or construction material factory that will sort material into different types, strip or chemically remove any varnish, and reuse the wood in new products.

Styrofoam

Unlike other materials, Styrofoam is unique in that it is collected both for reuse and recycling.

At the point of collection, Styrofoam packaging is assessed for quality and reuse, and if in good condition, informal collectors will simply wash and take it back to markets to resell to traders. Particularly for container used for food, fruit and seafood storage.

If the material is too worn for direct reuse, then it is broken up and stacked high on tricycles before being taken for reprocessing in areas and districts out of the city where the material is broken up and process for re-entry into the material economy.

KEY ACTORS

Thousands of individuals, many migrant workers from Jiangsu and Anhui provinces, are engaged in Shanghai's informal waste system. Some are individual sellers who consider waste collection a part-time job, while others consider it their occupation to collect and separate materials for resale or manage team of collectors and collection centres.

"It's a hard life, but we are doing good for now. We usually process 300-400 Jin (500g) of cardboard per day, and we earn 100-200 kuai [RMB] from that. There are a lot of new apps and online platforms trying to encourage people to recycle, You have to operate at the street level and have fast turnovers to get work done." – Tricycle Collector, Anhui Province

Between collectors, waste management companies, and site workers, the informal industry employs an estimated 3.3 to 5.6 million people in China, and in spite of their dirty and often tiring work, many informal collectors are satisfied with their industry choice (Linzner and Salhofer, 2014).

The industry has considerable earning potential, even for those at the bottom of the chain. An average collector earns roughly 100 RMB per cart of cardboard (the most frequently collected material) and sends about two carts per day to collection points. This means that a collector earns about 200 RMB per day and around 67,200 RMB per year.

"Most people can make money from this… They start work at five in the morning and get off at 10 at night; they never rest and don't spend much money. In one year, [they can earn] about 72,000 RMB. After a little over a year, you can really make that much money. 10 years down the road, you can save quite a lot." – Owner, Large Collection Centre

Small-Scale Collectors

These collectors can include anyone from Environment and Sanitation Department workers who collect potentially valuable waste in their free time, to cleaning ladies, to those who consider waste to be their primary source of income.

These individuals often have set collection routes, working on a few city blocks, and have strong relationships with local residents.

So long as someone is willing to buy the material they find – including wood scraps and waste paper – they are willing to collect and cart it to the nearest swapping point, small storefront, or large collection centre.

"I basically collect from everywhere – hotels, markets, residential buildings... It's hard, you know, I face great risks every day, and the government is trying hard to shut us down. Cycling on major roads has become very dangerous now. The price of Styrofoam has also dropped a lot over the past few years."

"There's really not another site as big as ours in the area. The people here know us, and they've worked with us now for 16 years, so we're the most familiar business here."

– Mr. Chen

"I collect 24/7. Except for between 12 and 2, when I work part-time as a cleaning lady. Then I take everything to the closest large centre outside the district."

– Ms. Liu

Tricycle Collectors

These are the industry's full-time collectors and the most important part of the informal hierarchy.

Typically coming from the surrounding provinces of Anhui and Jiangsu, they often work long hours, collecting material off the street or at residences when they're called. During the day, they trade to other informal collectors at swapping points and carry tons of material to large collection centres, crossing district lines.

Neighborhood Collection Centre Owners

To efficiently manage their own waste, and extract profit from the recycling of household waste, some residential housing complexes have established their own waste collectors.

These centres are then managed and operated by individual collectors who strike informal contracts with building management for the "rights" to a building's waste.

In doing so, they can collect all valuable waste within the compound, and their only obligation is to take wet waste to a government site.

Consolidation Centre Owners

Large consolidation centres often work in a single area for a long period of time, hire over 100 employees, and deal with multiple businesses on site.

Many managers began as single collectors and worked their way up the supply chain from riding a tricycle to developing their own network of collectors and centres during the first phase of their careers in waste management.

Owners are responsible for hiring businesses and managers to handle and sort each material type, including cardboard, steel, iron, plastic, and glass.

Truckers and Waste Transport Workers

As middlemen between large collection centres and reprocessing centres outside of Shanghai, truckers work with large collection centres and load material onto their trucks when they are called.

They often specialize in a specific material and are owned and operated by families who have worked in waste transportation for their entire careers.

These workers normally load trucks at night and drive them out of the city to surrounding provinces.

WHERE IT GOES

One of the most important aspects of this research was to understand where the waste went. To understand who was on the buy side of the market, and to know how these commodities were being processed. This was of particular interest as a formal recycling system does not exist, but also given the scale of supply, and the thousands of actors who are involved with the collection, sorting, and transport of recyclable goods,

Through research, more than 50 shipments of materials (plastic, metal, wood, cardboard, and Styrofoam) were followed and it became clear that (1) a well established net of buyers exists well within the Shanghai city limits (2) within under 24 hours most materials are sent to a factory where the goods would be reprocessed.

This was particularly true in the case of cardboard, plastic, and metals, where we were able to establish through interviews that many of the materials were being recycled into new goods well within 10-15 days of their being thrown away. A testament to how truly efficient this process is.

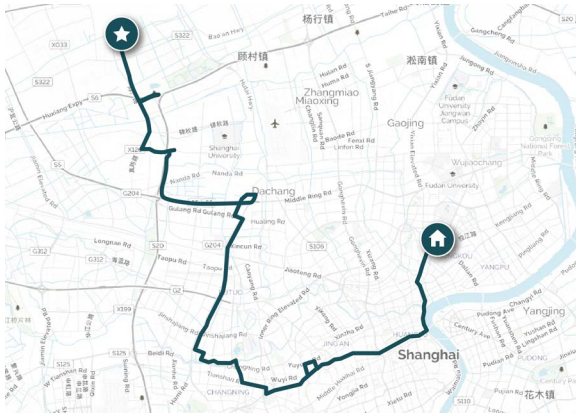
To illustrate this process, we have included sample shipments showing how each of these materials move through the city and how close their final destinations are to the city.

Figure 5: Start, End Points and Routes of informal Collection

Plastic

Metal

Wood



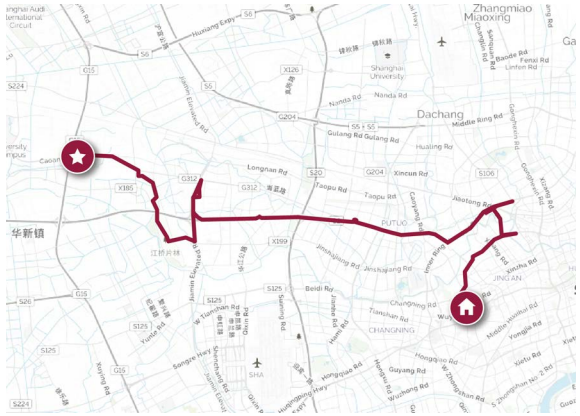


Figure 6: Routes for Specific Materials Collected in the Informal Sector.

PAPER & CARDBOARD

Over the past decade, with China's cities experiencing the highest rates of economic growth and urban consumption, the demand for paper and cardboard products has soared, and with it the demand for recycled cardboard.

This can mostly be explained by a rise in cardboard packaging, with e-commerce giants and delivery services shipping billions of packages per year in either cardboard boxes or plastic bags. Alibaba, Taobao, and kuaidi services promise fast shipping, and because of a growing customer base, require a constant supply of raw and recycled material. This need for material has had a clear impact on the market for recycled cardboard, encouraging faster reclamation of used cardboard, and led to both short- and long-term price spikes for domestic recycled cardboard.

However, in addition to e-commerce and delivery, other factors have played a role in cardboard pricing, including new regulations and environmental impact assessments.

The following case study explores each of these variables and track their influence on recycled cardboard prices during a two-week span in 2016.

1. Stricter Enforcement of Domestic Environmental Impact Assessment (EIA)

On October 20th, 2016, China's Ministry of Environmental Protection enhanced enforcement in 20 provinces. Many small- to medium-sized paper factories that failed to pass the EIA were forced to shut down, resulting in a major drop in domestic supply of reprocessed paper and cardboard.

2. Import Intervention

Between 2011 and 2015, China imported 27 to 30 billion kilograms of foreign waste paper per year (UN Comtrade, 2016). This heavy flow of imports increased China's supply of paper and cardboard, applying downward pressure to its price. In 2016, the Chinese government raised the regulatory bar on imports of foreign waste and over the course of a two-week period waste seizures contributed to the price of cardboard increasing from 1,210 RMB per ton to 1,610 RMB per ton.

In response to this initial price volatility, some large recycling centres and storage facilities began stockpiling cardboard, hoping to earn greater profits in the future as the price reached its peak. Which further reduced the volume of paper and cardboard on the market, driving prices even higher.

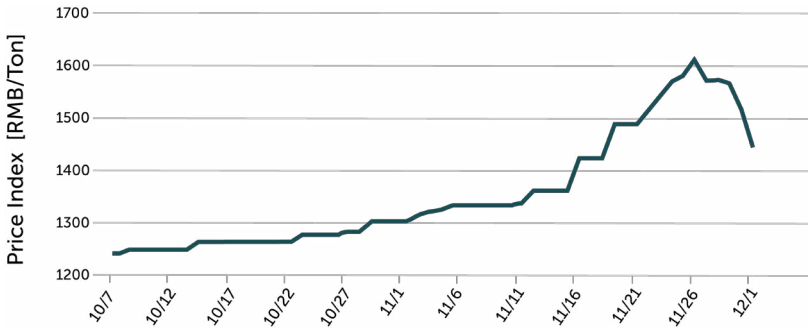


Figure 7: The Price of Cardboard. Source: Sublime China Information Group, 2016

3. E-Commerce: Singles' Day Boom

China's Singles' Day on November 11th every year is perhaps the biggest contributor to companies' packaging waste, and the event grows larger in scale every year. In 2016, in the weeks immediately following Singles' Day, the National Post Office delivered 350 million packages. This was an additional factor in triggering a large spike in demand for paper and cardboard – and a subsequent price rise (Beijing Evening News, 2016).

Figure 8: Start and Endpoint of Collected Cardboard.

The Journey of Cardboard

As part of our effort to better understand the recycling of this resource, we sent eight shipments of cardboard through the system, one of which follows the route in Figure 8.

Given to a recycler in the vicinity of Jing An Temple, within three hours he had already arrived at a large collection centre and loaded his cubes of cardboard onto a large truck, which was owned by a waste management and transportation company.

Once fully loaded, this truck then traveled to a large international cardboard and paper manufacturing company, Ji'an Group Corporation, that specializes in packaging material, paper, and logistics for delivery services, where it was loaded into a yard full of paper and cardboard waiting to be processed. A yard estimated to be nearly a half kilometer long.

Through discussions with multiple stakeholders, we were told that once there, the waste would have most likely completed processing after five days of factory treatment (i.e. shredding and reduction to pulp material), dried, then returned to circulation immediately afterwards.

This means that the entire process, from receiving a delivery to processing the packaging, occurred in less than a week.

FORMALIZATION

"This industry – compared to what it was a few years ago – is already much more formalized. The inner ring of the city doesn't really have large-scale, bigger businesses, and these might completely die out soon."

– Owner, Large Collection Site

The Formal Shift

Formalization refers to a transition in Shanghai's waste collection, in which the government is trying to create a modern, environmentally-responsible, and government-regulated system. Officials have encouraged this transition for a number of reasons as Shanghai looks to become more efficient, rise to meet global environmental standards, and increase oversight.

Perception of Waste

General attitudes toward waste are a growing challenge for the informal sector, intensifying in areas where housing prices and living standards are increasing rapidly. Although most informal collection centres handle non-hazardous material, their work is dirty and unsightly, and many residents are actively pushing back against the informal sector, forcing informal collection centres to close in areas where there is still an operational need.

Environmental Challenges

While the collection process itself does not pose major environmental risks, and is seen as a net positive as it diverts vast amounts of waste from landfill, the processing of these wastes are a subject of concern. Particularly following the illegal dumping scandals in 2016 and 2017, where it became clear the current system does not have firm control over all waste transport and logistics. Similarly, many of the reprocessing factories around Shanghai have little to no environmental certification, and as China government studies have better understood the environmental costs, these factories are targets for closure.

Process Transparency

Linked to environmental issues is a lack of transparency within the informal system seen as a grey area of the economy. Individual actors are self-employed and are not required to report collection routes, sorting locations, or final treatment sites. As the industry looks to develop and formalize, the government will need to better monitor and understand each step of the collection process. This will allow for greater accountability throughout the waste value chain and will create a clear means to identify and punish actors responsible for environmental or social issues.

In response to these concerns, the government plans to better enforce regulations and introduce stricter ones to address recent scandals. In June 2016, the government drafted new legislation that placed additional responsibility on the producers of C & D waste to separate and categorize their waste.

While the legislation is still in draft form, it shows that the government is willing to target the industry and address major problems. Similarly, in late 2016, the government suspended production at paper and pulp factories outside of Shanghai because they failed to meet environmental standards.

Many large collection centres and swapping points have closed in recent years, with at least four informal collection centres in Shanghai's Huangpu District, shut down over the past five years. Leaving only small storefronts, solitary collectors, and swapping points behind, which must now deliver to points outside the city.

Not limited to Huangpu District, very few long-term, large-scale collection centres can be found inside the city centre, and with stricter regulations and enforcement coming, remaining centres are under threat. Of the six large collection centres found during this study, two exist within heavy construction sites that will shut down as soon as construction is complete.

Shanghai's government has a difficult path ahead. The city needs to create a new collection system, develop recycling plants, and build eight more incinerators, all while managing a higher volume of waste. At the same time, they must also figure out how to incorporate informal collectors into the formalized system, maintain their incentives, and keep up with their everyday collection efficiency – or risk a massive build-up of waste on the street.

Informal collectors and their network will need to have some role in the new system. The informal sector includes thousands of street-level collectors and hundreds of sorting facilities that divert waste from landfill. In comparison, the formal sector has fewer sorting incentives, a more limited presence on the streets, and less experience with reuse and recycling. If the government wants to control waste management, it will need to incorporate informal workers' sorting and collection efficiency, as well as existing relationships between local collectors, large collection centres, and recycling facilities.

To ensure the success of the transition into a cleaner formal system, solution providers from the private sector are already being encouraged to offer their expertise, investment, and recycling infrastructure to help the government transition.

For actors wishing to enter the waste system we see three areas of investment opportunity:

FORMALIZE

Informal Collection Centres

Centres struggle to pass the EIA and will face closure if they do not modernize. In order to pass, large centres will require significant investment to upgrade existing facilities with new equipment, and better on-site conditions that minimize air, odor, and sound pollution being required.

Private companies can target centres based on number of employees, location, and amount of material collected on a daily basis – showing preference to larger-scale facilities. After preserving and updating these centres, companies can help them apply for an EIA inspection and official license, as well as enable them to work within the city's formal collection scheme.

INVEST IN

Recycling and Incineration

Shanghai has announced that the city will build new recycling facilities and eight more incinerators by 2020. This is a pretty major shift in waste treatment, as Shanghai has relied mostly on landfills in the past, and incinerators have at times inspired protests among local residents (The Economist, 2015). In order to convince locals that new incinerators are environmentally friendly and have a minimal impact on surrounding air, soil, and water quality, the city will need to partner with reputable green businesses that have experience with waste-to-energy projects. In addition to this investment in and knowledge of formal recycling infrastructure is key, as the city is currently starting from close to ground zero.

TARGET

Second, Third, & Fourth-tier cities

Shanghai is only one of several cities that need investment in recycling, waste-to-energy, and EIA-approved collectors. As mentioned at the beginning of this report, Chongqing, Changsha, and a number of other second-, third-, and fourth-tier cities are experiencing similar trends: heavy reliance on landfills, stricter environmental regulations for local businesses, and rising levels of household waste. Landfill capacity issues and a need for greater regulatory oversight will force these cities to respond in the same manner as Shanghai, and proactive businesses should anticipate a demand for alternative waste treatments and green tech for waste collection centres.

CONCLUSION

Shanghai's waste management sector is reaching a point of significant transition, and as the city's supply of waste continues to rise, and official landfills reach capacity, the government will face pressure to invest into waste management systems that effectively and efficiency handle materials. As part of this process, they will need to formalize the informal waste system, which for many years has effectively helped reduce the pressure on existing infrastructure through the removal of significant volumes of recoverable materials.

To date, the government has been able to reap the benefits of the informal sector – efficient collection and free recycling. However, as Shanghai residents have begun to see the informal sector as dirty and polluted, associating them with air and water pollution, as well as odor and lower property values, the pressure to modernize has grown.

This places the government in a challenging position. They need informal workers to recycle and divert waste from landfill, but they also want to make Shanghai an example of a modern streamlined global city.

So long as this remains a priority, Shanghai's government will need to replicate the informal sector's efficiencies. Currently, thousands of collectors, hundreds of sorters, and dozens of centre managers all form an efficient network, collecting and processing most of the cities reusable waste. Without this informal sector, at best, thousands of tons of material will be lost to landfill, and at worst, more companies will resort to illegal dumping or accumulate waste on the sidewalk.

In spite of this potential, the challenge also represents a significant opportunity for firms. As Shanghai formalizes, innovative companies can develop solutions, helping drive new system and ease the transition of formalization. Shanghai could soon become a testing ground for new investment, as Shanghai officials try to replace the informal sector, build new recycling plants and incinerators, and bring waste collection up to EIA standards.

These are problems and challenges that will only increase as the next 300 million Chinese individuals move to the cities. But this ultimately represents a major opportunity for solution providers who can anticipate problems and deploy solutions at scale. With a drive for investment, governments in these cities will also become more willing to sponsor, approve, and partner with companies that have established strong reputations in waste management to drive the system towards a cleaner, more efficient future.

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