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# PAPERBOARD MARKET AND WASTE MANAGEMENT SYSTEM IN CHINA AND INDIA

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| <b>Abstract</b>  |  |               |
| <p>The goal of the thesis was to offer an overview of the Chinese and Indian paperboard markets and waste management scenarios. From this thesis, potential investors and future partners would be informed about opportunities and obstacles that China and India have within the field of product recycling and waste management, especially focusing on the paperboard market.</p>  |  |               |
| <p>Literature review and market research on secondary sources were employed to deliver the most holistic review on the current scenarios of paperboard markets and waste management in China and India. Evaluation and discussion are based on information and data from various sources including researches of reliable institutes/publishers, policies and recommendations of authorities, organizations and verified data banks. Conclusion will focus most on available technical application in treating potential investors and future partners' paperboard products in each country.</p> |  |               |
| <p>The study concluded that China would be a more potential paperboard market to be invested in, as the country had been working on its waste management towards a more sustainable circular economy. Meanwhile, it was shown to the study that India still had a lot more to work on in order to become a more promising and sustainable paperboard market due to the country's current inadequate waste management infrastructure and regulations.</p>   |  |               |
| <b>Keywords</b>  |  |               |
| Waste management, paper waste, papermaking, circular economy   |  |               |

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## 1 INTRODUCTION

When it comes to potential markets for any type of investment, China and India, the two countries with the biggest populations in the world, are the two common names. With their extremely large population of over one billion people in each country, both China and India open many possibilities for investors to consider, including a wide variety of fields and functions, especially in terms of trading. Regarding the environmental aspects, the recycling and waste management industry is a popular business in the world, including China and India. The two countries' huge populations open many opportunities and possibly certain obstacles to investors to take into consideration when it comes to the field of recycling products and waste management.

According to The World Bank (2019), China has the biggest population in the world with about 1.398 billion people and namely 7 megacities of over 10 million people, including Shanghai, Beijing, Guangzhou, Shenzhen, Tianjin, and Chengdu. With this huge population, it was reported in 2017 that China generated about 215 million tons of waste, which was equal to the municipal solid waste value of 0.72 kg per person per day (Han 2019). The total amount of municipal waste in China is forecasted to increase up to 480 tons in 2030, which will become a significant burden to the currently existing waste management system in China (Zhang 2017).

According to Xie et al. (2012), there are four common waste treatment systems for paperboard and packaging waste in China, including landfill, incineration, paper recycling, and material recovery. However, Xie et al. (2012) notes that in China, since most of the paper waste was composite packaging (which contained paper and other materials), it is difficult to recycle composite packaging due to the material's characteristic of being costly to recycle but returning a low resale value. This type of waste appeared not appealing to recycling processors as China's packaging waste recycling system and reuse technologies were not very developed (Xie et al. 2012, 627). Moreover, the composition percentage of paper within composite packing is very high (up to 75%), meaning that it is a potential source for paper recycling. However, the lack of technology in China makes it

hard to separate and reuse the remaining composition materials in composite packaging. This leads to the packaging waste in China usually ending up in landfills, which is still not a very economical and environmental-friendly option for handling this type of waste. (Xie et al. 2012, 628-629.)

Although the end-of-life options for handling packaging materials in China are relatively limited, a recent survey by China Resources Recycling Association (CRRRA) showed that paper-making companies in China have begun to establish their standard waste paper recycling and sorting centers (Liu et al. 2020). These recycled papers are either sold to paper mills or to regulated recycling centers. Moreover, there is also a trend that shows how recovered used paper in China is now converted into recycled paper and board, demonstrating a certain conversion ratio that corresponds to the improving progress of paper recycling in China. (Liu et al. 2020.)

Besides China, according to The World Bank (2019), India is also a potential market for trading due to its world second-largest population of 1.366 billion. India's population spreads over megacities like Mumbai, Delhi, Kolkata, Chennai, and Bangalore, which have high impacts on both India's economic growth and waste generation volume (Kumar et al. 2017, 2). As such, the amount of municipal solid waste in India, depending on factors like living standards, variety of commercial activity, lifestyle (especially eating habits), and even seasons, is calculated to be 133760 tonnes per day. This number includes about 91152 tonnes of collected and 25884 tonnes of treated waste. This amount of municipal solid waste is equivalent to the range of 0.17 kg per person per day to 0.62 kg per person per day, varying from the size of small towns to big cities. (Kumar et al. 2017, 2-3.)

Generally, in India, paper waste is either usually picked up by waste pickers and recycled through a process of material recovery (Mahajan 2017, 34) or being dumped into landfills due to the lack of scientific treatment options and methods (Sharma and Jain 2019, Naveen et al. 2018). Yet, the recycling trend in India is rising as the municipal waste composition changes and this shows that the paper

waste percentage is also increasing. With the rising trend of recyclable waste like paper, formal material recovery and recycling facilities are now considered to be viable to the Indian economy (Mahajan 2017, 19). Another research suggests that recycling has become a big practice in India as it involves a large number of people who take up waste picking as their main livelihood (Srivastava et al. 2014, 329). Since the recyclable waste picking job provides monetary opportunities, people of the low income group in India, who make up the majority of the country's population, contribute to the trend and make it more visible to the country's economy.

Waste management and recycling situations of China and India have described the two countries as very potential targets for investors in the paperboard manufacturing industry to take into consideration. Huge populations bring about huge potentials in providing services and offering products, especially in the recycling industry that both countries are in the progress of accelerating together with their economies. As such, it is helpful for investors to explore more about China's and India's current paper waste management and recycling situations, including any advantages or obstacles in this field, before making the company's decisions to either partner up or investing in these two countries. The goal of this thesis is to explore these opportunities and obstacles that China and India have to offer investors and future partners within the field of product recycling and waste management, especially focusing on the paperboard market.

The thesis will provide a holistic background on China's and India's waste and recycling management by exploring the two countries' paperboard markets and waste management systems from several aspects, including the source of paper waste, the waste management legislation and regulation mechanism, the waste separation system, and the circular economy development for the paper manufacturing industry. These aspects will extensively cover the two countries' origins of paper waste, its existing managing systems, circular development potential for the industry, and of course, external law forces that regulate the industry. These sections will then ultimately serve the goal of this thesis, which is to propose to potential investors the most efficient treatment in the two countries.

## **2 MATERIALS AND METHODS**

The method used in this thesis mainly involved secondary sources evaluation, also known as literature review. After the literature review, the thesis provided discussion and analysis extracted from the extensive research, then come to the conclusion on the best paper waste treatment available in each country for the host company's paperboard products.

This research method mostly engaged in extracting and synthesizing information and data from sources like researches from reliable institutes/publishers, from policies or recommendations of authorized organizations regarding the thesis' topic, and from verified data banks. Keywords like "municipal solid waste," "solid waste management," "waste," "paper/paperboard," "corrugated fiberboard," and "corrugated paper," along with the name of the country (China and/or India) will be employed throughout the search for preliminary sources on the thesis topic.

As such, the literature review component of the thesis was divided into four main parts (after looking at the countries' profiles): the countries' source of paperboard waste, the countries' waste management legislation and regulation mechanism, the countries' waste separation system, and the countries' circular economy development for the paper manufacturing industry. These four sections gave a thorough view of the two countries' existing (paper waste) recycling practices. Under each part of the literature review section in the thesis, different keywords for search would be employed. For example, in the first section of the countries' source of paper waste, keywords like "waste generation," "waste composition," "material recovery," and "imported waste" will be used along with the countries' names; in the second section of the countries' waste management legislation and regulation mechanism, keywords like "pilot regulations," "waste management measurements," and "waste management strategies" will be employed.

## **3 RESULTS OF LITERATURE STUDY**

Below are the findings of the paper after an extensive literature review on China's and India's source of paper waste, waste separation system, waste management

legislation and regulation mechanism, and circular development for paper manufacturing industry.

### **3.1 THE SOURCE OF PAPER WASTE**

In order to have a better understanding of the paperboard markets and their waste management systems in both China and India, first, this thesis is going to provide information about the source of paper waste in both countries, which includes data and statistics about the two countries' volumes of waste generation over the past 5-10 years, and the composition of their waste generation with regard to the percentage of paper waste. This section of the thesis will also explore the material recovery potential of paper waste in China and India, and further provide information on how the amount of imported waste affects on both countries' economies.

#### **3.1.1 China**

Table 1 provides the production and consumption quantity of different paper-based products in China from 2014 to 2018. These statistics show that paper and paperboard products and packaging are the largest types of paper-based grades that are produced and consumed in China. The amounts of production and consumption of paper and paperboard products and packaging consistently stay on top throughout the years, with little to no discrepancy between the amounts of production and consumption. This demonstrates that the paper and paperboard market in China is very developed and potential, corresponding with the quantity of consumption. Besides, Table 1 indicates that the quantity of recovered papers that are produced and consumed in China is also promising in the sense that both the quantities of production and consumption are relatively great. It is worth to note that the discrepancy between the amount of recovered paper consumption over the quantity of production suggests that there is a need for more recovered paper to be produced, meaning that there is a need for paper waste in China to be recycled and recovered more in order to meet the demand of paper consumption produced from recovered paper (waste).



Table 1. The production and consumption quantity of different paper-based grades from 2014 – 2018 in China (Forest Products Statistics 2018).

| PAPER-BASED GRADES                         | PRODUCTION (1000 TONNES) |        |        |        |        | CONSUMPTION (1000 TONNES) |        |        |        |        |
|--|--------------------------|--------|--------|--------|--------|---------------------------|--------|--------|--------|--------|
|  | 2014                     | 2015   | 2016   | 2017   | 2018   | 2014                      | 2015   | 2016   | 2017   | 2018   |
| Paper and paper board                      | 104700                   | 107100 | 108550 | 111300 | 104350 | 1014571                   | 104296 | 104987 | 109871 | 105317 |
| Other graphic papers, uncoated, mechanical | 17150                    | 17450  | 17700  | 17900  | 17500  | 17155                     | 17469  | 17722  | 17926  | 17626  |
| Other coated graphic papers                | 7750                     | 7700   | 7550   | 7650   | 7050   | 6136                      | 6312   | 5968   | 6213   | 5921   |
| Other paper and paperboard                 | 76550                    | 7900   | 80700  | 83400  | 77900  | 75820                     | 78181  | 79481  | 83489  | 79500  |
| Packaging paper and paperboard             | 63800                    | 65350  | 66500  | 68450  | 62750  | 63256                     | 64695  | 65483  | 69634  | 64397  |
| Carton board                               | 13950                    | 14000  | 14050  | 14300  | 13350  | 12921                     | 12914  | 12532  | 12886  | 12196  |
| Recovered paper                            | 48412                    | 48318  | 49635  | 52852  | 49392  | 75930                     | 77601  | 78131  | 78570  | 66417  |

Among the waste generated in China, the percentage of paper waste among other type of wastes is about 9% as shown in Figure 1. Much as organic waste or food waste still accounts for a large amount of waste generation in China, other recyclable wastes including paper are increasing in the municipal solid stream (Liu 2017, 10).

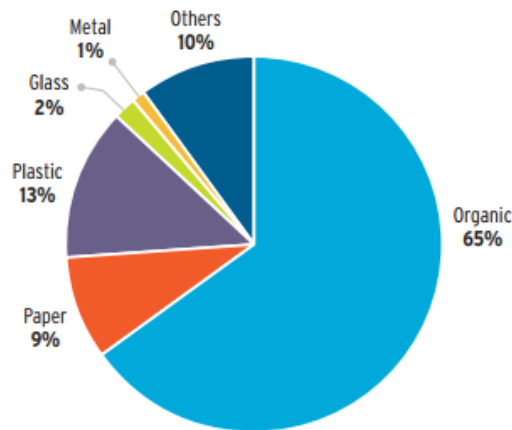


Figure 1. Waste composition in China. Adapted from Hoornweg and Bhada-Tata (2012).

Figure 2 also demonstrates that like plastics, paper waste is equivalent to about one-sixth of the amount of organic waste in China, which shows that paper waste is a relatively great quantity of recyclable waste in China.

| Composition (%)               | Organic garbage | Paper | Plastic | Glass | Metal | Textile | Others |
|-------------------------------|-----------------|-------|---------|-------|-------|---------|--------|
| Beijing (2006) <sup>a</sup>   | 63.39           | 11.07 | 12.07   | 1.76  | 0.27  | 2.46    | 8.98   |
| Shanghai (2004) <sup>b</sup>  | 66.70           | 4.46  | 19.98   | 2.72  | 0.27  | 1.80    | 4.07   |
| Tianjin (2006) <sup>c</sup>   | 56.88           | 8.67  | 12.12   | 1.30  | 0.42  | 2.47    | 18.14  |
| Chongqing (2006) <sup>d</sup> | 59.20           | 10.10 | 15.70   | 3.40  | 1.10  | 6.10    | 4.40   |
| Average                       | 61.54           | 8.58  | 14.97   | 2.30  | 0.52  | 3.21    | 8.90   |

Figure 2. Municipal solid waste composition in four big cities in China. Adapted from Mian et al. (2016).

According to Statista (2019), the recycling rates for paper waste in China have always been in the range of 40% to almost 50% during the past 10 years as shown in Figure 3.

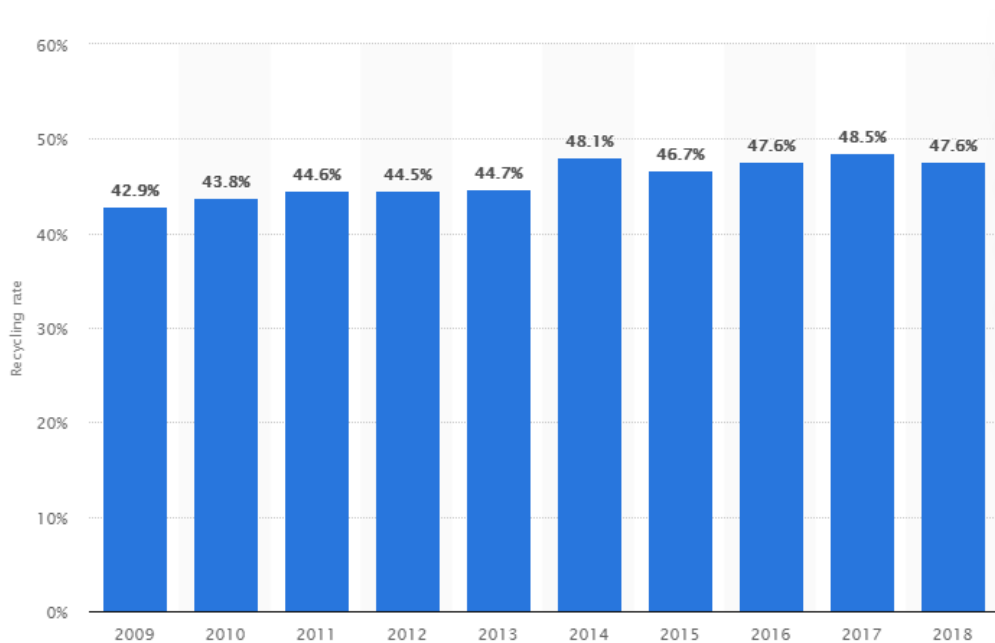


Figure 3. Paper and cardboard recycling rate in China 2009 – 2018. Adapted from Statista (2019). Available online at: <https://www.statista.com/statistics/1076772/china-paper-recycling-rate/> [Accessed 4 October 2020].

Meanwhile, Figure 4 shows the potential in recovering paper waste among other recyclable wastes. Paper waste is shown to be on the increasing trend, whose recycling rate and potential have been improving every year. The recovery potential of paper waste is also relatively higher than that of other recyclable wastes like plastic waste (Xiao et al. 2018, 114). This shows that paper waste is not just one of the most common recyclable waste but also one of the most potential sources for material recovery and recycling in China that can potentially contribute to the country's economy. According to Liu et al. (2020), "when the recovery rate of China's waste paper was from 50% to 70%, the economic benefit per ton of waste paper recycled increased by 351 yuan compared with the original." This means that as the standard recovery rate of paper waste in China rises from 9.7% to 31.2%, the paper waste's economic benefit also increases by 84.9%, resulting in the recovery of paper waste bringing a huge economic benefit to the Chinese economy (Liu et al. 2020).

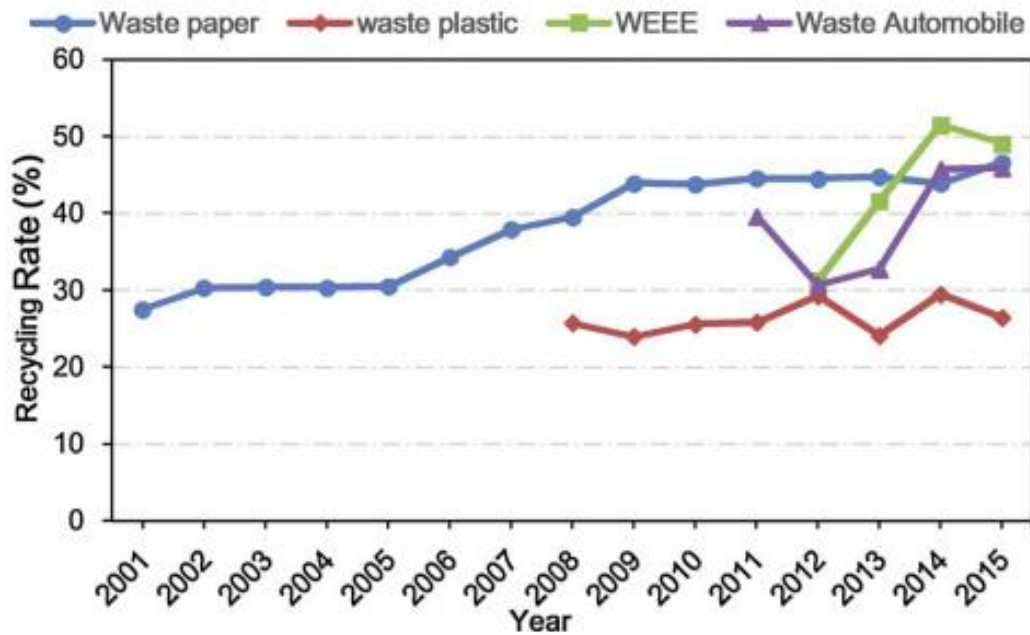


Figure 4. The recycling rates of four main recyclable wastes in China. Adapted from Xiao et al. (2018).

According to a report by the WWF (2018), in 2016, there were 28.5 million tons of foreign waste imported into China. Even though the domestic waste paper recycling rate of China is not at all low, there is still a very high demand and practice of importing foreign paper waste in order to become a material for the

Chinese paper manufacturing industry as China has now become the world's biggest paper and paper products' producer. WWF (2018) points out that "due to limited capital and production capacity and lack of domestic recycled fibrous materials, China had no choice but to import foreign waste paper as the raw material for papermaking in the early stages of the reform and opening-up... With the fast development of the paper industry, inadequate separation and recycling of domestic waste paper have led to the underutilization of large amounts of recycled waste paper, which in turn results in far lower quality and pulp yield than those of imported waste paper. Many enterprises are forced to turn to and rely on imported recycled paper." This scenario demonstrates the lack of recycling practice and treatment for paper waste in China. Also according to the same report by WWF (2018), imported foreign waste is shown to certainly have many advantages in terms of fibrous material and cost, which contribute a lot to the rapid growth of China's paper manufacturing industry. However, as there is a huge difference in the amount of imported and exported waste paper in China (28.5 million tons of imported versus only 2,300 tons of exported waste paper – according to the statistics provided by WWF in 2018), the continuation of the Chinese paper manufacturing industry depending on a large amount of imported foreign waste can create some sort of imbalance in the economy and also can create a burden in the Chinese paper waste management and recycling system.

### **3.1.2 India**

Table 2 provides the production and consumption quantities of different paper-based products in India from 2014 to 2018. Like in China, the amounts of paper and paperboard products and packaging are still the largest types of paper-based grades that are produced and consumed in India. However, the quantity of paper and paperboard products, and packaging produced and consumed in India throughout the years is very small when compared to those numbers in China. Despite the fact that the two countries have similarly large numbers of the population, it seems like the paper and paperboard industry of India is not that attractive when compared to that of China. The amount of paper production from recovered papers is also relatively low, demonstrating that this practice is not very developed in India. Yet, the consumption demand for this type of paper

products from recovered papers is two to three times higher than the production ability, showing the need for this type of products within the country.

Table 2. The production and consumption quantity of different paper-based grades from 2014 – 2018 in India (Forest Products Statistics 2018).

| PAPER-BASED GRADES                         | PRODUCTION (1000 TONNES) |       |       |       |       | CONSUMPTION (1000 TONNES) |       |       |       |       |
|--|--------------------------|-------|-------|-------|-------|---------------------------|-------|-------|-------|-------|
|  | 2014                     | 2015  | 2016  | 2017  | 2018  | 2014                      | 2015  | 2016  | 2017  | 2018  |
| Paper and paper board                      | 14490                    | 15435 | 15540 | 16227 | 17284 | 16259                     | 17415 | 17782 | 18807 | 18645 |
| Other graphic papers, uncoated, mechanical | 1590                     | 1735  | 1455  | 1220  | 1025  | 1481                      | 1631  | 1341  | 1154  | 925   |
| Other graphic papers, uncoated, wood-free  | 2053                     | 2240  | 2688  | 3225  | 3870  | 1964                      | 2197  | 1580  | 3306  | 3726  |
| Other graphic papers, coated               | 756                      | 825   | 535   | 347   | 225   | 1257                      | 1307  | 1169  | 1167  | 793   |
| Other paper and paperboard                 | 8711                     | 9255  | 9772  | 10335 | 10964 | 8877                      | 9472  | 10026 | 10501 | 10696 |
| Packaging paper and paperboard             | 7603                     | 8143  | 8721  | 9342  | 10005 | 7768                      | 8359  | 8970  | 9513  | 9751  |
| Carton board                               | 2155                     | 2308  | 2472  | 2647  | 2835  | 2188                      | 2341  | 2502  | 2634  | 2775  |
| Other papers mainly for packaging          | N/A                      | N/A   | N/A   | N/A   | N/A   | 9                         | 11    | 15    | 9     | 3     |
| Recovered paper                            | 3600                     | 3700  | 3700  | 3700  | 3700  | 6669                      | 6789  | 6885  | 6985  | 10116 |

According to Chand Malav et al. (2020), among the total amount of municipal solid waste generated in China, paper waste usually accounts for about 7% as shown in Figure 5.

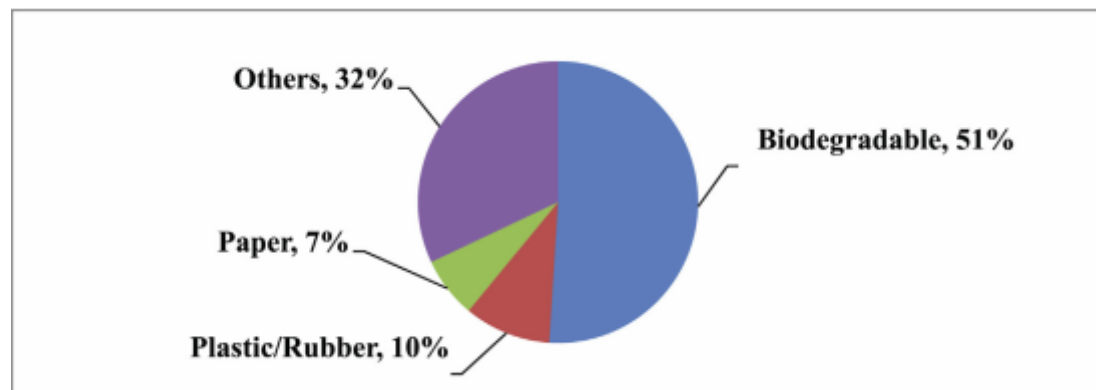


Figure 5. Typical municipal solid waste composition in India. Adapted from Chand Malav et al. (2020).

A discussion paper released by the Department for Promotion of Industry and Internal Trade (2011), paper waste amount in India is equivalent to 50% of the recyclable waste amount, which is about 13 million tons a year as shown in Table 3. This demonstrates the importance of paper waste among other wastes in India.

Table 3. Percentage of different recyclable wastes in India. Adapted from a discussion paper by the Department for Promotion of Industry and Internal Trade (2011). Available online at: [https://dipp.gov.in/sites/default/files/DiscussionPaper\\_Recycling\\_WastePaper\\_21October2011%20%208.pdf](https://dipp.gov.in/sites/default/files/DiscussionPaper_Recycling_WastePaper_21October2011%20%208.pdf) [Accessed 4 October 2020].

| Component                          | Fraction | Quantity<br>(million tonne) |
|------------------------------------|----------|-----------------------------|
| Paper                              | 50%      | 13.0                        |
| Plastic                            | 14%      | 3.6                         |
| Metal                              | 1.5%     | 0.4                         |
| Glass                              | 6%       | 1.6                         |
| Wood                               | 3%       | 0.8                         |
| Textile                            | 5%       | 1.3                         |
| <b>Total Recyclables per annum</b> |          | <b>20.7</b>                 |

The aforementioned discussion paper released by the Department for Promotion of Industry and Internal Trade (2011) addresses that “the present recovery and utilization of waste paper by paper mills in India is 3.0 million tonnes annually, which translates to a recovery of 27% of the total paper and paperboard consumed.” These numbers are broken down into material recovery percentage of different kinds of paper waste as shown in Figure 6. Moreover, Mahajan (2017) points out that informal waste pickers account for a large amount of paper waste recovery as “they are able to recover 2.4- 3.7 million tonnes of mixed paper and cardboard.” This shows great potential in the material recovery field from paper waste in India.

## Recovery Potential

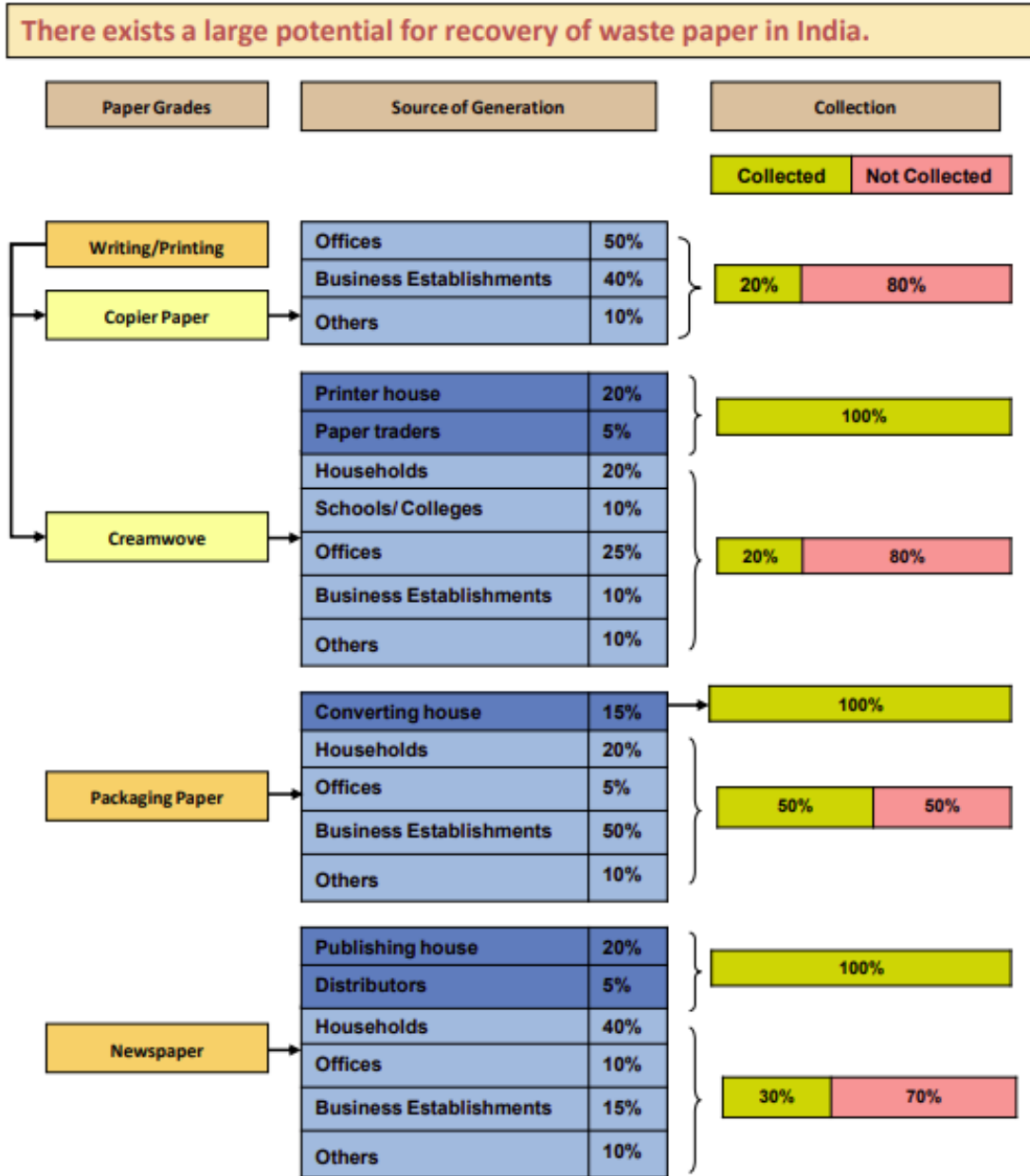


Figure 6. The considerable potential for recovery of waste paper in India. Adapted from a discussion paper by the Department for Promotion of Industry and Internal Trade (2011). Available online at: [https://dipp.gov.in/sites/default/files/DiscussionPaper\\_Recycling\\_WastePaper\\_21October2011%20%208.pdf](https://dipp.gov.in/sites/default/files/DiscussionPaper_Recycling_WastePaper_21October2011%20%208.pdf) [Accessed 4 October 2020]

As mentioned above, there are 3 million tons of paper waste recovered every year, which is equivalent to 27% of the recovery rate; however, this rate is considered to be very low by Department for Promotion of Industry and Internal Trade (2011), when compared to other developed countries like Japan (60%) and

US (49%). The discussion by Department for Promotion of Industry and Internal Trade (2011) addresses that “due to inadequate availability of indigenous waste paper, Indian mills rely heavily on imported waste paper to meet the raw material demand.” Indian paper manufacturing companies prefer importing waste for usage because of the foreign paper waste’s stronger fiber quality and also because there is a lack in domestic supply due to the non-systematic collection of paper waste in India (Gupta et al. 1998).

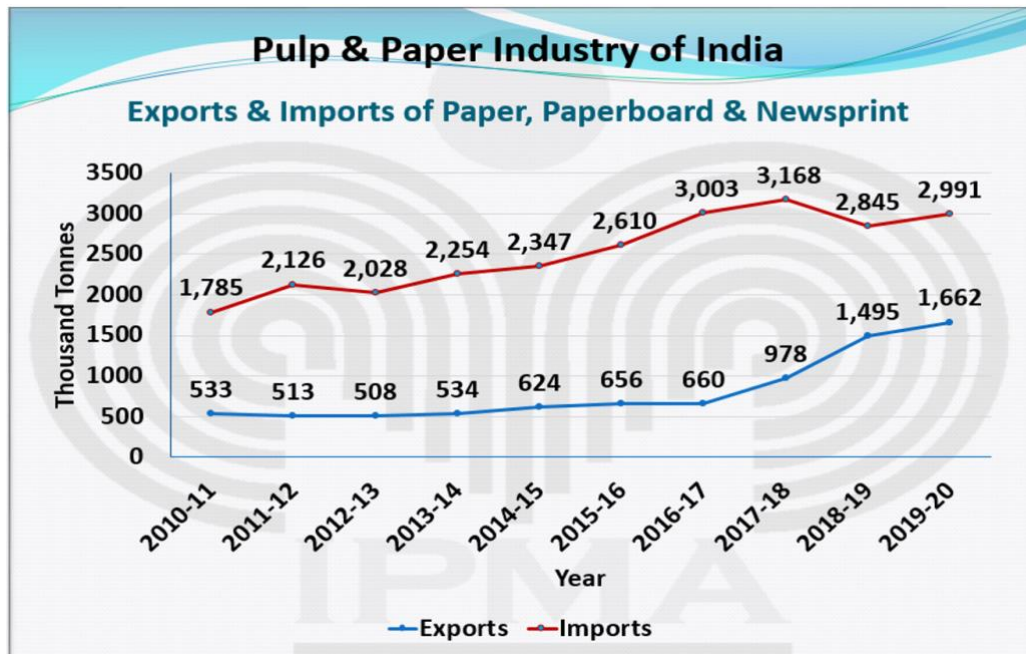


Figure 7. Total exported and imported paperboard amount in India throughout the current decade. Adapted from a graphical presentation by the Indian Paper Manufacturers Association (2018). Available online at: <http://ipma.co.in/statistics/> [Accessed 4 October 2020].

As such, there is a trend in importing foreign paper waste into India in recent years, which is shown in Figure 7. The discussion paper by the Department for Promotion of Industry and Internal Trade (2011) reports that “India imports around 4.0 million tonnes of waste paper annually, which is about 57% of its requirements.”

### 3.2 WASTE SEPARATION SYSTEM

To continue to understand the waste management scenario in both China and India, the thesis is going to explore further the structure of the waste separation systems in the two countries, covering the whole process of managing waste



from waste collection, waste segregation/sorting, to waste treatment, especially focusing on the recycling aspect of paper waste.

### 3.2.1 China

According to Mian et al. (2016), the local Sanitary Bureau is responsible for collecting and transporting municipal solid waste in China. Mian et al. (2016) notes that there are two types of municipal solid waste management systems in China that are the formal and informal ones; and the informal collection system involves a much larger number of people than the formal one. Mian et al. (2016) describes the process of waste management system in China with two steps: “firstly wastes are collected by local individuals and stored at a specific point and secondly stored wastes are collected by large waste car and transferred to the treatment point; treated wastes are transferred to the disposal point.” Mian et al. (2016) also addresses that municipalities are in charge of this overall municipal solid waste management collection and treatment but the facility and system may differ from cities to cities or even within the same city. This point is noted by Mian et al. (2016), who say that it is difficult in China to regulate and execute a more standardized waste management system due to the informal sectors and a variety of facilities.

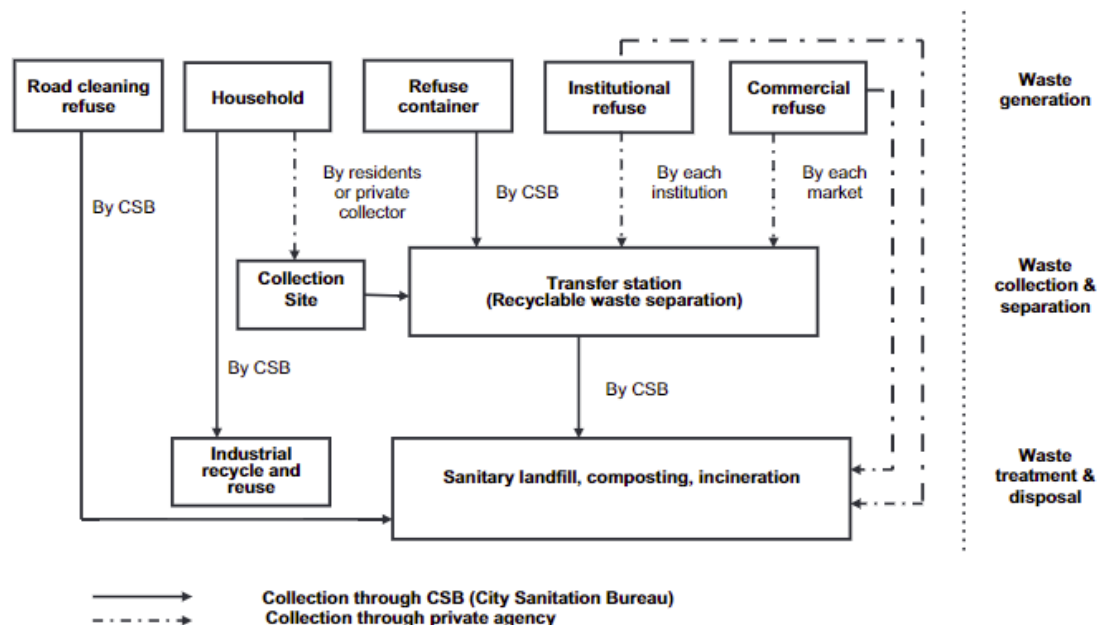


Figure 8. General diagram of municipal solid waste management system in China. Adapted from Zhang et al. (2010).

Figure 8 describes the Chinese waste management system in more detail, with the involvement of CSB (City Sanitation Bureau). According to Zhang et al. (2010), there are three steps in the Chinese waste management system: waste generation, waste collection/separation, and waste treatment/disposal. There are two flows of waste management: the formal one by the local Sanitary Bureau and the informal one by the private agencies like informal collectors.

WWF (2018) summarizes and lists out the types of papers that can be recycled and those that cannot be. According to WWF (2018), non-recyclable papers that are not accepted in the recycling process include: “Paper with paint or oil soiling, plastic glossed waste paper, carbon paper, waxed paper, paper-interlayered laminated wood, label stickers, thermal paper (e-invoice, fax or electrocardiogram paper), oil-proof paper, sand paper, transfer paper, used sanitary paper, paper diaper, etc.” These types of papers are marked as “Other garbage” and then treated with subsequent processes other than being recycled.

According to Mian et al. (2016), as the municipal solid waste collection system in China is a mixed collection model, in which people usually just sell recyclable materials to informal sectors or waste buyers, there appear some complications for waste generation from multiple sources. Zhang et al. (2010) also addresses that despite part of this segregation has already been sold during works of the waste pickers, sorting waste right at the first steps of collection is a rare procedure in China so the waste separation in China is still difficult. Mian et al. (2016) addresses that the waste sorting efficiency of the municipalities’ facilities is quite low – just about 20% of the waste is recovered and recycled through the informal waste picking process, which is excluded from the formal waste collecting and separating system. This informal characteristic of the separation process with China’s waste segregation system affects the overall efficiency of the system as there are no formal and rigid regulations over this informal sector (Mian et al. 2016). However, Mian et al. (2016) also points out there have been pilot programs initiated in big cities of China like Beijing, Shanghai, and Guangzhou, which focus on improving the source separation in the municipal solid waste collection system. Meanwhile, Liu et al. (2020) indicates that “many

large paper- producers in China have gradually started to upgrade waste paper recycling and sorting workshops. They even directly joint hands with downstream packaging enterprises and users to directly recycle waste corrugated boxes and industrial waste paper. This trend shows an effort of Chinese enterprises' active way of overcoming the obstacles within the Chinese municipal solid waste separation system.

According to Xie et al. (2012), there are four common waste treatment systems for paperboard and packaging waste in China, including landfill, incineration, paper recycling, and material recovery. For the first type of treatment, packaging and paper waste will just be "delivered to the landfill with no further treatment" (Xie et al. 2012). For the second type of treatment, paper and packaging waste will be transported to incineration plants and be converted into energy through combustion so as to produce electricity (Xie et al. 2012). For the treatment of paper recycling, paper and aseptic packaging waste becomes "an excellent source of raw material for producing recycled paper," as "the cellulose material from the post-consumption aseptic packaging gives high quality fibers (around 90 % of the total fiber content)" (Xie et al. 2012). During the paper recycling process, materials are mostly recovered by paperboard companies and then are reused to produce kraft papers. The last treatment of material recovery from paper and packaging waste is able to generate polyethylene and aluminum through recovering the cellulose "from the post-consumption aseptic packages." This process happens in sanitary landfills (Xie et al. 2012).

Liu et al. (2020) points out that despite some distinctiveness in the intermediate stages between the nonstandard recovered waste paper directly entering paper enterprises and the nonstandard recovered waste paper entering paper enterprises after going through sorting centers, their acceptance rate is the same with the same starting point. Standard sorted and nonstandard recycled waste paper enter the waste pulp production process after their impurities are removed. From only this recycling process, it already accounts for 67.3% of the total recycled waste paper. (Liu et al. 2020.) Figures 3 and 4 in section 2.1.3 of the thesis demonstrate that the recovery rate of paper waste in China was around

50% every year in the past decades and paper waste is certainly the most potential waste among other recyclable wastes. However, Liu et al. (2020) points out that this recovery rate of paper waste in China is not higher than any other developed countries. Liu et al. (2020) explains this is due to the fact that paper waste is mostly recycled by informal vendors in China, who have limited technical conditions and a non-standardized method of recycling that leads to the low quality of recovered papers. Hence, Liu et al. (2020) urges for “a standardized waste paper recycling industry in China” that will yield a inclusive growth and vast economic benefits to the country.

### **3.2.2 India**

According to Priti and Mandal (2019), in India, the Municipal Corporation is responsible for the waste collection process, and there are two types of waste collection services: the house-to-house services for those who can pay, and communal collection service for those of low income. Swaminathan (2018) clarifies the Indian waste collection process saying that it starts with the government contractors who run the door-to-door collection services for local households to search for any recyclables that may be sold in the market. The waste is transported by trucks which wait in line for two and three hours for its turn to weigh and dump the amount of waste collected that day into the landfill. Priti and Mandal (2019) also note that no separate collection system is available for municipal solid waste in India.

The waste management infrastructure of India includes mostly landfills as indicated in Table 4. Specifically for paper waste, the discussion paper by the Department for Promotion of Industry and Internal Trade (2011) addresses that the waste collection process is mostly carried out by informal sectors like rag pickers or door-to-door vendors. In order for the paper waste to be accepted into recycling, they must be separated from other household waste and not be contaminated (JC 2018).

Table 4. The overall infrastructure of the municipal waste management system in India. Adapted from Priti and Mandal (2019).

|  |                        |
|--|------------------------|
| <b>Total states</b>                                | <b>29</b>              |
| Union territory                                    | 7                      |
| House-to-house collection (done partially)         | 18 states              |
| Segregation (done partially)                       | 5 states               |
| <b>Landfill</b>                                    |                        |
| Landfill sites identified                          | 1035                   |
| Landfill constructed                               | 95                     |
| Landfill under construction                        | 59                     |
| Landfill in operation                              | 175                    |
| Landfill exhausted                                 | 5                      |
| Landfill capped                                    | 5                      |
| <b>Compost/vermicompost facilities operational</b> | <b>553 ULBS</b>        |
| <b>Processing facility setup</b>                   |                        |
| Composting   | 209                    |
| Vermicomposting                                    | 208                    |
| Biogas plants                                      | 82                     |
| RDF/pelletization                                  | 45                     |
| <b>Processing facility operational</b>             |                        |
| Composting   | 168                    |
| Vermicomposting                                    | 141                    |
| Biogas   | 67                     |
| RDF/pelletization                                  | 26                     |
| Pipe composting                                    | Adopted only in Kerala |
| Waste to energy plants                             | 30                     |

About India's way of waste segregation, Priti and Mandal (2019) note that rag pickers are segregating large part of the waste but there is very minimal effective segregation happening, which causes most of the waste in India ending up in landfills. Srivastava et al. (2014) addresses the same point that in Indian cities, waste collectors and rag pickers are the main force in sorting waste while residents rarely do the segregation. Mahajan (2017) expands on this point that much as the non-standardized way of sorting waste yields a low quality of recyclable waste material in India, informal sectors like waste/rag pickers can do well the waste segregating works by collecting plastic, paper, glass and metal, which can be recycled. This helps reduce the ultimate burden on waste disposal thus to a great extent, waste segregation is done before the actual waste is disposed in landfills or other dump sites (Mahajan 2017). Mahajan (2017) also believes that in India, as waste separation is not carried out right at the source point, "the job of waste pickers gets crucial from segregation aspect." Indian people has a tendency embedded in their mind that the mixed waste, including organic waste, recyclable waste, metal and even battery, is supposed to be tossed out on any spare space they can find, usually under a tree or on the side

walk. After that, the waste pickers will do the work of separating those and exchange them for money from either formal or informal waste dealers. (Mahajan 2017.)

In India, among the solid waste, paper is one of the most recycled products that is usually picked up by waste pickers and recycled through the carrying out the process of material recovery (Mahajan 2017, 34). After being collected, paper waste in India is sorted and processed into new materials then sold as new products (Singh 2016). The new materials are usually recycled by drop-off centers or other programs like the buy-back or deposit systems in India (Singh 2016). Besides material recovery, which happens as paper waste is repulped and remanufactured into paper/cardboard and other paper products, in India, this type of waste is directly used to produce energy, which is known as a process called refuse-derived fuel (RDF). This energy source from paper waste is considered a great alternative to coal and is widely employed in the papermaking industry in India as a very good renewable energy source (Chand Malav et al. 2020, 6). Another end-of-life option for paper waste in India is paper waste being shredded and used in insulation mulch manufacturing (Singh 2016).

However, Sharma and Jain (2019) address that there is a lack of scientific treatment options and methods, counting choices for reprocessing, treatment accessibility, and removal limit, which prompts natural debasement and low quality of life. According to Sharma and Jain (2019), only five states are engaging in carrying out proper waste sorting at the source point while others are yet releasing combined waste at the junkyards. Kumar et al. (2017) reveals that over 90% of waste in India is assumed to be dumped in an inadmissible manner. Moreover, solid waste which is often abandoned in low-lying or open areas without avoiding potential risks and with none operational control, are mainly handled by Pourakarmikas (road sweeping) with no legitimately preventative tools thus are susceptible to endanger to their wellbeing (Naveen et al. 2018). Another waste treatment option in India is incineration and Naveen et al. (2018) rates this technique as unsuccessful, "due to the very low calorific value of the municipal solid waste."

Naveen et al. (2018) describes the waste treatment scenario in India as “unscientific as the disposal of MSW is accepted in every city, town and villages. MSW is usually discharged directly on low lying areas. Almost no local urban bodies have been installed with adequate engineering landfilling facilities and MSW is often piled up along the roads in the outskirts region. Unscientific disposal of MSW is prone to flooding resulting in water contamination. The surface or underground water source during monsoon around the dump sites are seriously contaminated due to percolation of leachate.” Chand Malav et al. (2020) also adds on that man-originated practices of discarding waste being open dump sites, unsanitary landfill and incineration in India have caused serious environmental pollution and health issues.

### **3.3 WASTE MANAGEMENT LEGISLATION AND REGULATION MECHANISM**

After exploring various information regarding the sources of paper waste in China and India, the thesis will cover the external law forces that regulate the waste management in China and India, especially with the focus on policies that concern with managing paper waste. This section of the thesis will continue exploring China’s and India’s waste management measurements and strategies in order to have a full overview of the current waste management scenarios in the two countries.

#### **3.3.1 China**

Qing et al. (2020) outlines six key pieces of legislation that relate to the environmental part in corporate operations, which include Environmental Protection Law, Cleaner Production Promotion Law, Circular Economy Promotion Law, Law on Environmental Impact Assessment (EIA Law), Administrative Measures for Pollutant Emission Permitting (for trial implementation), and Emergency Response Law. Xiao et al. (2018) also points out that in recent decades, the Chinese government has issued some national regulations and policies promoting the recycling of recyclable waste, as shown in Figure 9; and

among these regulations, the National Circular Economy Promotion Law released in 2009, and the National Cleaner Production Promotion Law released in 2003 are the vital laws “in the field of [recyclable wastes recycling].” These laws have contributed to reinforce a legal framework to guide the recycling practices in the country (Xiao et al. 2018). Within this section of the thesis, the first three legislations outlined by Qing et al. (2020) will be further explained.

| Effective Time | Laws or Policies  |
|----------------|---|
| 1991/12/26     | Notice on Strengthening Administration of Recyclable Resources Recycling  |
| 2003/01/01     | Clean Production Promotion Law  |
| 2007/05/01     | Measures for the Administration of Recyclable Resources Recycling   |
| 2009/01/01     | Law on Promoting the Development of Circular Economy  |
| 2010/05/28     | Guideline on Further Advance in Development of Recyclable Resources Recycling Industry                                  |
| 2011/10/31     | Opinion on Construction of Complete and Advanced Waste Recycling System   |
| 2013/01/23     | Development Strategy of Circular Economy and Recent Action Plan   |
| 2014/12/31     | Implementation Plan of Important Resources Recycling Engineering (Technology Promotion and Equipment Industrialization) |
| 2015/01/21     | Construction of Recyclable Resources Recycling System in Mid-long Term Planning (2015–2020)                             |
| 2016/05/05     | Opinion on Promoting Transformation and Upgrading in Recyclable Resources Industry                                      |

Figure 9. Law and policies referring to the practice of recyclable wastes recycling in China. Adapted from Xiao et al. (2018).

First of all, according to Mu et al. (2014), the Environmental Protection Law is regarded as the most unyielding law for environmental preservation in China. This law amendment is very strong as it deals with matters like air pollution,



which has extensively aroused the public's awareness on environmental problems (Mu et al. 2014). This law's enforcement regulates "sustainable development concepts and ecologically conscious construction," while emphasizing the coordination between China's economic development and environmental protection (Mu et al. 2014). Its administrative mechanism also promotes multiple governance, which involves not only the government but also enterprises and citizens in being responsible for environmental protection (Mu et al. 2014). Benjamin et al. (2014) also points out that the Environmental Protection Law sets more pressure and assigns responsibility for urban waste management authorities as "Article 51 emphasizes the responsibility of municipal governments to properly manage collection, transport and disposal of wastes so as to improve overall environmental sustainability."

Secondly, Article 27 and Article 39 of Cleaner Production Law deal with individuals and enterprises recycling packaging products. Article 27 released by the People's Republic of China's Ministry of Commerce (2007) states that enterprises have to recycle products or packaging items that are listed in the compulsory recycling directory provided by the State Council, and these items are recycled according to the guideline also provided by the state. Meanwhile, Article 29 addresses that if enterprises or individuals violate Article 27, they will bear a fine. Therefore, Cleaner Production Law clearly highlights the importance of recycling packaging products.

Thirdly, Li and Yu (2011) summarize Circular Economy Promotion Law as a guideline of "ideology, basic principles, main objectives, priorities and policy measures for the development of a circular economy" that aims to promote "the development of a circular economy, improving resource utilization efficiency, protecting and improving the environment and achieving sustainable development" in China. Overall, Benjamin et al. (2014) sums up that waste management policies and regulations in China help in making the Chinese economy become greener (sustainable and environmentally friendly).

According to Wang and Jiang (2020), waste management policies in China are implemented on both national and local levels according to laws and regulations made by the State Council. Table 5 shows that the national laws like the Environmental Protection Law and the Circular Economy Promotion Law introduced above are the basis of several following regulations that specifically tackle different parts of the waste management systems in China. These laws and regulations together establish a legal framework for the Chinese waste management system (Wang and Jiang 2020).

Table 5. Laws, administrative regulations, and rules in China that are responsible for waste management (sorting). Adapted from Wang and Jiang (2020).

| Name  | Effective Date | Level of Authority        |
|---|----------------|---------------------------|
| Environmental Protection Law  | 01-01-2015     | Law                       |
| Circular Economy Promotion Law  | 26-10-2018     | Law                       |
| Law on the Prevention and Control of Environment Pollution Caused by Solid Wastes | 07-11-2016     | Law                       |
| Regulation on the Administration of City Appearance and Environmental Sanitation  | 01-03-2017     | Administrative regulation |
| Administrative Measures for Urban HSW   | 04-05-2015     | Departmental Rules        |

On the waste management measurements, specifically with regard to recyclable products like paperboard or packing, Xiao et al. (2018) notes that there are two notable regulations: the Provisional Management Measures on Packaging Resources and the Measures for the Administration of Recyclable Resources Recycling. The former one was issued in 1999, which describes the “recovery channels, principles for sorting, and requirements for the treatment of different

kinds of packaging materials, including paper, wood, plastic, metal and glass” (Xiao et al. 2018). The latter is a national regulation that gives a general direction for recycling recyclable resources, which was released in 2007 (Xiao et al. 2018).

There have been several waste management plans and pilot programs especially focusing on municipal solid waste sorting and recycling in China. For instance, according to Wang and Jiang (2020), in 2017, as China wanted to promote the “ecological civilization” concept, local legislation issued by the National Development and Reform Commission and Ministry of Housing and Urban-Rural Development was created as a plan for compulsory municipal waste sorting. This plan was piloted in 46 cities by 2020 and is aimed to become a national system by 2025 (Wang and Jiang 2020). Moreover, according to Xiao et al. (2018) the local establishments of bureaus such as the Bureau of Commerce, the Bureau of Urban-Rural Planning, and the Bureau of Environmental Protection, are responsible for promoting the waste recycling system at the local level. For example, the Bureau of Commerce is in charge of “preparing a recycling development plan and supervising recycling activities at the county level,” “the Bureau of Urban-Rural Planning is responsible for integrating the plan for recycling sites into the urban rural plan,” and “the Bureau of Environmental Protection is responsible for controlling pollution generated from processing recyclable wastes (including collection, sorting and final treatment)” (Xiao et al. 2018).

### **3.3.2 India**

According to Vaish et al. (2017), Environment Protection Act, issued in 1986, is a crucial legislation that build up the framework for “studying, planning and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations that threaten the environment.” This law “is an umbrella legislation designed to provide a framework for the coordination of central and state authorities” (Vaish et al. 2017). The same source points out that under this legislation, “the Central Government is empowered to take measures necessary to protect and improve the quality of environment” (Vaish et al. 2017). Galea (2010) also addresses that

under the Environment Protection Act, the central government are given the right to supervise all issues related to waste and “tackle specific problems that may present themselves in different regions of India.” Environment Protection Act “is the primary legislation that must be considered and contains important provisions concerning the Environment” (Galea 2010).

Besides Environment Protection Act issued in 1986, Municipal Solid Waste (Management and Handling) Rules released in 2000 is also important driving forces in this field of municipal solid waste management in India. According to Zhu et al. (2008), this legislation provides measurements for all municipal authorities to control solid waste. Ray and Rahman (2016) summarize that this law settle[s] all the problems of solid waste collection, discarding and helps leading the municipal authorities in India “manage solid waste in their respective jurisdiction according to the rules.” There was also an updated version of this law in 2016.

In India, there are three main stakeholders responsible for setting up environmental regulations in the legislative system for waste management: Ministry of Environment and Forests, Central Pollution Control Board, and State Pollution Control Board, as demonstrated in Figure 10.

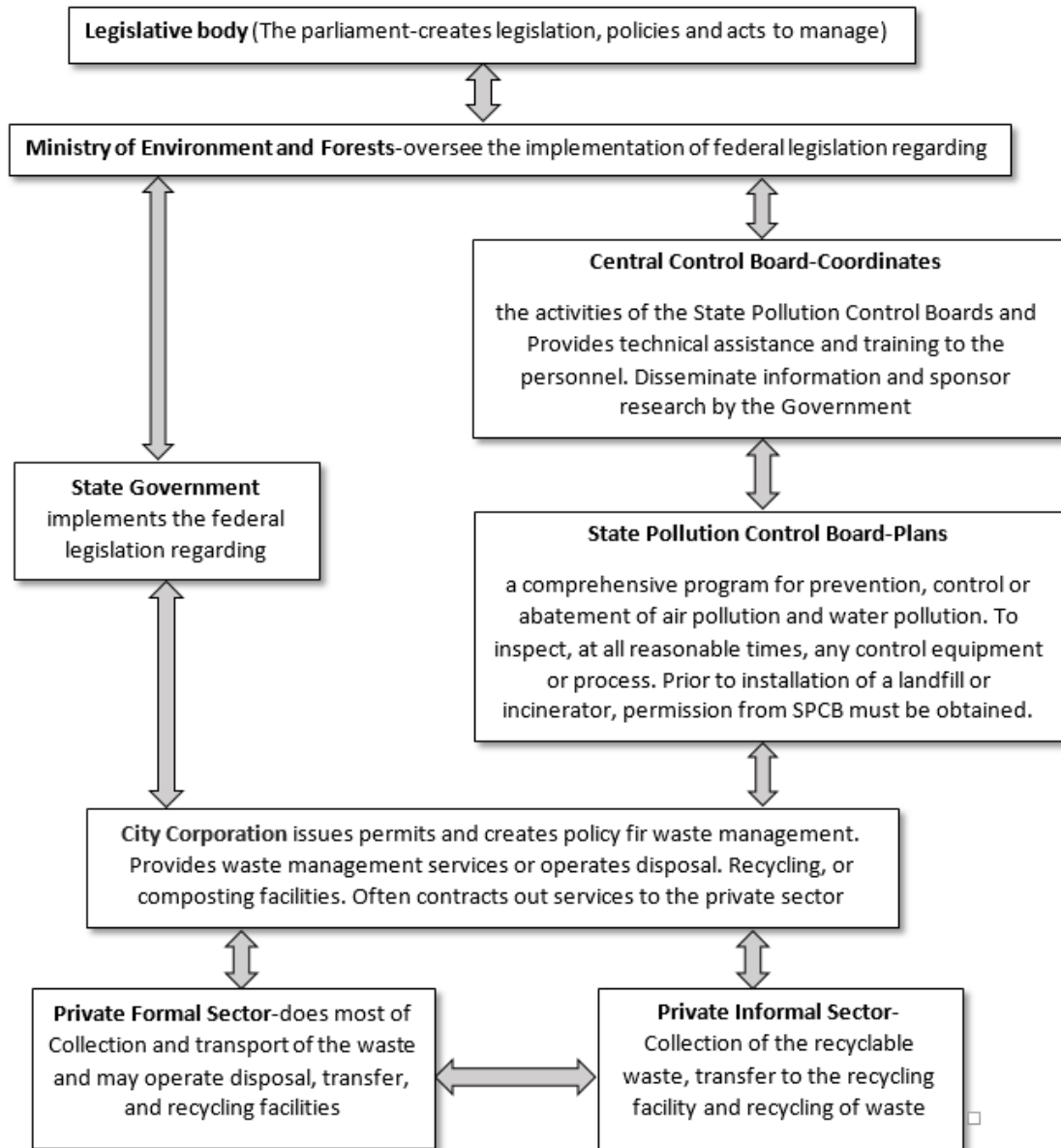


Figure 10. Municipal solid waste management system in India. Adapted from Ray and Rahman (2016).

Naveen et al. (2018) further expands on the Indian waste management system with the legislation-making hierarchy below: first, the National Waste Management Committee (established in 1990) identifies the recyclable solid waste content; then, the Ministry of Environment and Forests prepares policy paper on solid waste treatment and develop a master plan for municipal waste treatment. After that, implementation of the plan takes place under the help of the High Powered Committed (established in 1995), which guides the waste management system in a long-term position through using proper technology (Naveen et al. 2018).

Kulshrestha (2018) outlines a few strategies and plans that have been implemented in India on different levels in order to improve its waste management. On the national level, the Swachh Bharat Mission was launched with the basic goal of eliminating defecation and manual scavenging while introducing solid waste management in a more scientific way, which includes an aim to transform the Indian social behaviors and awareness regarding sanitation. On the state level, the State Schemes for Redevelopment take place to renew slum areas. Last but not least, on the city level, the Smart City Mission, launched in June 2017, has the goal of creating “futuristic cities that provide clean and sustainable urban spaces and a decent quality of life to all its citizens using smart solutions for provision, use and maintenance of utilities facilities and services” (Kulshrestha 2018).

At the same time, Joelsson and Lord 2016 points out that “decentralized models such as ALM and the Parisar Vikas Program have lately become more widely practiced in Mumbai.” Decentralized models are those that involve municipal solid waste management through many local waste management centers. The decentralized models allow the segregation process to be taken more extensively at the localities, thus help reducing the waste going to be discharged to the landfills or open dumpsites (Joelsson and Lord 2016). Together with the abovementioned strategies and plans from the state and on various levels, India is currently promoting the practice of decentralized models in order to redevelop and improve the quality of municipal solid waste sorting.

#### **3.4 CIRCULAR ECONOMY DEVELOPMENT FOR PAPER MANUFACTURING INDUSTRY**

The next section will provide key findings on how China and India are doing in moving towards a circular economy development for their paper manufacturing industries.

### 3.4.1 China

Pesce et al. (2020) describes the notion of circular economy in the Chinese context as “a generic term for the reducing, reusing and recycling activities conducted in the process of production, circulation, and consumption.” Pesce et al. (2020) address that China considers promoting circular economy as a national strategy, especially after releasing Circular Economy Promotion Law in 2018 as aforementioned. Many socio-economic policies like parts of the Eleventh Five-Year Plan (2006–2010) and the Thirteenth Five-Year Plan (2016–2020) that focus on circular economy, have helped set up a key principle “for the introduction and enhancement of [circular economy] in China, validating “the importance of CE both as a national policy and a fundamental pillar of the economy” (Pesce et al. 2020). The Chinese government seems to really recognize the core of a clean surrounding which will create benefits for the country. This is reflected in how the nation has been pushing its companies to emerge in eco-friendly merchandising, the purpose being acquiring and maintaining the perquisites within the global trading market (Pesce et al. 2020). According to (Pesce et al. (2020), China’s recognition of a market-based outlook is undeniably providing the Chinese enterprises an incentive to lean forward to sustainability business model.

The Chinese government seems to push a consistent effort in making policies in regulating the four following categories in managing the environment and promoting circular economy: “generation of more valuable resource flows, production efficiency and environmental performance, prevention of waste disposal and associated pollution, and sustainable consumption and life cycle considerations” (Pesce et al. 2020). Qi et al. (2018) further elaborates on these plans, which have components that can directly impact the paper industry in China. Qi et al. (2018) list out four goals of the Chinese plans on promoting a circular economy in the paper industry as followed: first, to promote paper waste recovery that completes the production cycle; second, to promote resource recycling through material recovery undergone multiple channels in the process of production; third, to promote environmental friendliness through the use of

forest-paper; and fourth, to promote social environment through enhancing the deduction of pollution.

| NO | Item  | Content  | Goal  | Standard   |
|----|---|--|---|--|
| 1  | Upgrading process for chemical pulp                                   | Using low-energy consumption cooking, oxygen delignification, and free chlorine bleaching process                                    | Reducing 80% emission of AOX, 30 m <sup>3</sup> water/ton pulp, and altering annual 2 million tons pulp                         | <ul style="list-style-type: none"> <li>Each wood pulp process can generate over 0.1 million tons</li> <li>Each bamboo pulp process can annually yield over 51,000 tons</li> <li>Non-wood pulp can annually yield over 34,000 tons</li> </ul> |
| 2  | Comprehensive utilization of non-bleaching straw pulp and its product | Using low-energy consumption cooking, oxygen delignification, and residue water recycling process                                    | 5% increase of achieved pulp, saving water of 30 m <sup>3</sup> /ton pulp   | <ul style="list-style-type: none"> <li>Each newly-built line can yield over 0.1 million tons.</li> <li>Each altered line can annually yield over 34,000 tons</li> </ul>  |
| 3  | Altered process of alkali recovery                                    | Using evaporation and combustion process of high solid content black liquor, and new filter process of green liquor and white liquor | 30 tons alkali recovery from 50,000 tons of annual yield of pulp, generating 570 tons steam, and reducing 70% of pollution load | The chemical pulp system can annually yield 50,000 tons  |
| 4  | Anaerobic digestion and its gas utilization                           | Anaerobic digestion for high content waste water, and biogas power generation  | One kg BOD generates 1 m <sup>3</sup> biogas, and reducing 70% of pollution load  | Waste pulp can yield over 0.1 million tons for each line   |
| 5  | Combined heat and power   | Improve energy efficiency using combined heat and power  | The combined heat and power project with over 6 million watt can save 15,000 standard coal                                      | Over 1.5 million watt  |

Figure 11. Typical circular economy practices for cleaner production and resource recycling in China. Adapted from Li (2018).

Specifically, Li (2018) points out that the paper and paper board industry is directly influenced by the Cleaner Production Promotion Law and the Circular Economy Law, which regulate the life cycle management of paper (waste). As such, many companies in the Chinese paper and paperboard industries have been developing technological solutions to accomplish cleaner production and circular economy. These cleaner technology adoptions include the alkali recovery system, forestry-pulp-paper integration project, and straw pulp waste liquor



hazard-free treatment (Li 2018). Li (2018) also indicates that with many more laws and regulations, the circular economy in China regarding the paper and paper board industry is now measured by the two main indicators of resource efficiency and recycling rate. These indicators are then transferred to formal practices and other developed processes of manufacturing and waste recycling technology, as demonstrated in Figure 11. Once again, this demonstrates the Chinese government's consistent effort in strengthening the cleaner production and resources recycling in the paper and paperboard industry in order to move towards a circular economy.

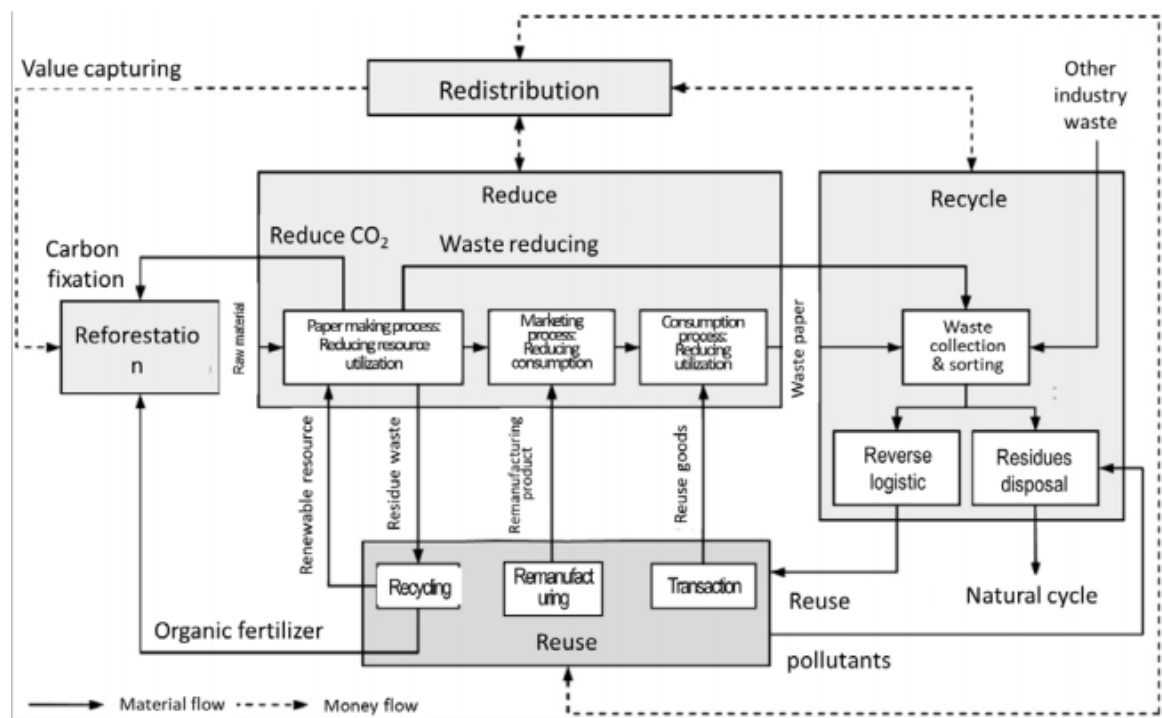


Figure 12. The ideal circular economy model in the paper and paper board industry. Adapted from Li (2018).

Finally, Li (2018) suggests a technology-based mechanism for evaluating different measurements on water contamination decrease in the paper and paperboard sector as presented in Figure 12. From this model, Li (2018) breaks down the circular economy system of the paper and paper board industry in China into three components of “resource flow, money flow, and ecological flow in supply chain.” Controlling the above-mentioned components through the model presented in Figure 12 can help alleviate “the negative impact of resource, environment, and ecology imposed by [the paper and paper board industry],

enhance the forest resource and ecological environment system, and then realize the sustainable development of green supply chain for forestry and paper” (Li 2018). As such, Li (2018) sums up that “the successful green supply chain of [the paper and paper board industry] is characterized with green symbiosis of circular economy, the core of enterprises, and the coalition of forestry industry and [the paper and paper board industry].”

### **3.4.2 India**

Overall, Priyadarshini and Abhilash (2020) address that in India’s circular economy, a weakness and insufficiency particularly at the “processing and recycling stages” have been recorded in the implementation of policies and regulations on solid, plastic and e-waste management. Rani Yaduvanshi et al. (2016) expand further on this notion by pointing out that there is a lack of awareness among the Indian population that prevents recycling programs to be implemented successfully. According to Rani Yaduvanshi et al. (2016), the issue of sustainable development is “a complex charting process” for India, thus the country “needs to gain clarity on current practices. The difference in felt vs. assessed impacts of green consumerism, relevant social welfare and [waste management would be useful results for future [circular economy] policy development to influence India’s sustainable development in a planned manner.”

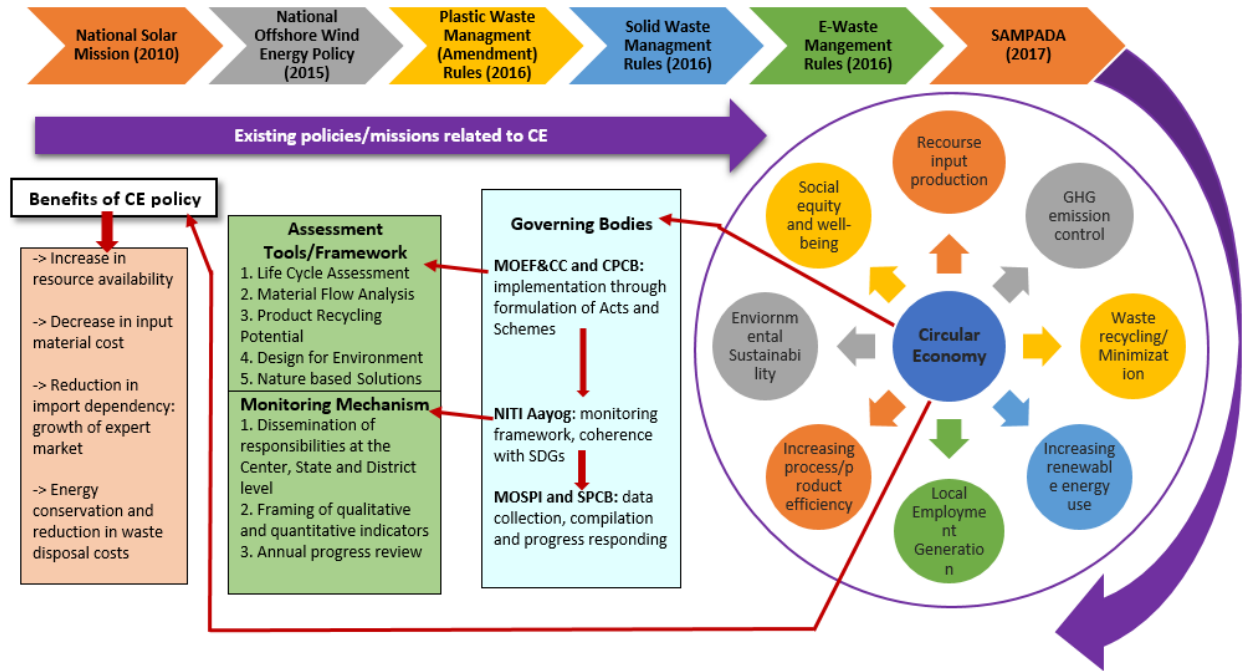


Figure 13. A proposed framework for a circular economy policy for India. Adapted from Priyadarshini and Abhilash (2020).

Priyadarshini and Abhilash (2020) provide a legislative framework for a circular economy in India as shown in Figure 13, which will benefit the renewable energy and sustainable development goals of the country. Priyadarshini and Abhilash (2020) also points out that there is a need for a better connection between circular economy and waste to energy conversion practices, in which paper waste can be utilized through the processes of composting for biomass generation, biorefinery systems, and biomethanation for biogas production. In addition, Rani Yaduvanshi et al. (2016) comments that “overall industry shift towards [circular economy] practices may be slow, but need to be initiated today. Educating and increasing awareness levels of people of India for effective methods of [waste management] goes a long way towards accepting new sustainability policies and practices.”

#### 4 CONCLUSION AND SUGGESTIONS

The last section will conclude the whole thesis based on the above findings and analysis, then provide suggestions for potential investors on what can be in China and India in order to contribute to more sustainable paper manufacturing industries in these two countries.

## 4.1 China

For China, the country with the world's biggest population, the quantity of paper consumption and waste production is certainly worth for papermaking companies to look at and consider for investment. Paper and paperboard products are the most produced and consumed products among different paper-based grades in China, demonstrating a huge potential for papermaking companies to invest in and export their paper products to China. Although the amount of paper waste is considerably great in China as a potential source for material recovery and recycling as addressed in the thesis, the recovery rate of paper waste is still low and the demand for quality imported waste as the papermaking industry's materials is still high, which can create a negative impact on the Chinese economy. This suggests a potential in maximizing the Chinese domestic paper waste recycling system in order to meet the demand of supply for the Chinese papermaking industry, which is now the world's biggest paper and paper products producer. This aspect of the paperboard market in China may appear attractive for papermaking companies to consider investing in developing and promoting a more sustainable recycling system for their own paper products in China.

As in China, the mixed waste collection model still exists and imposes certain problems for the sorting and recycling processes, it is important for papermaking companies to raise awareness about the recycling potential of their paper products, from the authoritative level (the City Sanitation Bureau) to the urban population level (citizens and informal waste collectors). The active movement of raising awareness about the recycling potential of paper products since the collecting and sorting step in the Chinese waste management process can prove a benefit in moving towards a more sustainable scenario of managing waste in China, as there has been a trend in Chinese enterprises even to establish their own paper waste recycling and sorting centers (Liu et al. 2020).

As there is an increasing trend in producing and recycling paper waste in China (Liu et al. 2020), China seems to put a lot of effort into regulating its waste management through various legislative mechanisms, measurements, and

strategies. This means that papermaking companies are welcomed and may be supported by the Chinese authorities and government in carrying out their own recycling (promotion) program and so on. As clearly presented in the thesis, the Chinese government acknowledges the importance of the need to protect their environment and promote a circular economy within the country through various sets of regulations and measurements. There have been many initiatives and plans for recycling at a more local level by the Chinese government, so it is worth for papermaking companies to note and collaborate with the local administrative authority to promote their paper products and their recycling potential to the City Sanitary Bureau and the citizens. This entire aspect of promoting paper waste recycling totally fits into the Chinese circular economy developing direction, as presented by the four categories according to Qi et al. (2018). The papermaking companies can certainly take advantage of and adopt the material recovery, recycling practices that already exist in China (demonstrated in Figure 11) in order to have their paper products best treated and recycled.

## **4.2 India**

For India, the country with the world's second-largest population, the amounts of paper and paperboard consumption are relatively low (only one-tenth the amounts of that in China). Regardless of paper waste is considered to be an important source for recycling, the recovery potential of paper waste is also low (only half of that rate in China) due to the informal characteristic of the India waste collection and recycling process, which is handled mostly by waste pickers. Although there is a need for recovered papers to be produced to meet the demand for consumption, which is shown through the current scenario of importing paper waste in large quantities into India, the problem of paper waste management in India seems to rely on the country's seemingly poor waste collection and segregation system and process. The Indian current waste management system is not strictly regulated and does not have enough infrastructure and facilities for paper waste to be sorted and recycled fully. This aspect of the Indian waste management results in, potentially, all the paper products of papermaking companies being dumped in open landfills without further treatment. This makes the paper and paperboard industry appear less

attractive to papermaking companies to consider investments, especially in terms of investment with sustainable goals.

Even though there is a trend in decentralizing the waste management system and process that can help improve the waste management at a local level, the overall waste management system and its legislative authorities are not effective and helpful for papermaking companies to benefit from carrying out the promotion for sorting and recycling paper products. Unless papermaking companies want to invest in initiating a social movement that has the ability to raise awareness and educate the majority of the Indian population about the importance of paper waste sorting and recycling, it seems that India still has a lot more to catch up in order to achieve more sustainable development for its waste management and recycling system. There should be a lot more effort from the Indian authorities to work on the country's current waste management regulations and infrastructure for India to develop towards its own circular economy and sustainable goals.

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