

EFFECTIVE PLASTIC WASTE MANAGEMENT IN SRI LANKA

December 2020

IGES
Institute for Global
Environmental Strategies

CCET
IGES Centre Collaborating with
UNEP on Environmental Technologies

This case study report examines the establishment and evolution of plastic recycling under two different operational modalities in urban areas of Sri Lanka; 1) single municipal operation, and 2) PPP (Public Private Partnership) based operation. This report provides an analysis of each modality in terms of effectiveness, technical feasibility, environmental impact, financial sustainability and sense of ownership in view of learning lessons and replicability of successful implementation in other cities.

The case studies in this report identified the following critical factors for replication:

- ❖ Understanding the factors that influence on the plastic waste value such as volume, polymer, chemical homogeneousness, and contamination level of collected plastic waste as well as operational efficiency of the Plastic Recycling Centre (PRC) is important to decide effective interventions of the Local Authorities (LAs).
- ❖ If a LA operates a PRC where plastic wastes are sorted, cleaned and processed for recycling, the LA could stabilise the plastic recycling market by introducing a fixed rate agreement to plastic waste buyers for a certain period of time. This incentivises the buyers to make profit when the fixed price is higher than the market price.
- ❖ On the other hand, if a private company operates a PRC, the private operator can focus on extended collection even outside the concerned LA, proper and efficient operation of the PRC, development of value-added products and marketing, whereas LA can more focus on the reinforcement of segregated waste collection and awareness-raising to support the private operation. However, due to the profit-seeking and market-based operation, the low-value plastic items tend to be uncollected.
- ❖ Setting centres like PRC at school with a responsible group of children motivates not only school students to perceive waste as a valuable resource, but also their families get motivated through dissemination of messages from the children.
- ❖ Formalising or empowering the informal waste collectors who are the main players of recyclable waste collection in the cities would contribute not only to the improvement of municipal solid waste management but also to the alleviation of poverty in the community.

1 INTRODUCTION

1.1 OBJECTIVE

Due to the growth, particularly in urban areas, of plastic waste generation in Sri Lanka alongside the rise in population and changes in consumption patterns brought about by urbanisation and globalisation, together with growing demands of recycled plastic from foreign markets, the number of plastic waste collectors and recyclers in the recycling business sector has steadily increased, from 37 in 2007 to 210 in 2015 (CEA, 2015). Consequently, in parallel with the growth of small and medium-sized recycling businesses, a few large-scale recycling businesses were established between 2010 and 2019. One of these has recently established a network of 125 collection points across the country, which ensures nearly 200-250 MT of PET waste is delivered to a factory every month¹. Most large-scale businesses were established as Board of Investment (BOI) industries, which receive investment capital to cater for demand for high quality recycled plastic materials such as yarn and high-grade pellets from international markets (BOI, 2017).

The demand for plastic waste from processing factories continue to grow because their capacity is larger than the current supply of plastic waste (SACEP, 2020). In addition, according to a market survey carried out on medium- to large-scale plastic manufacturing industries by an NGO (Intermediate Technology Development Group (ITDG), 2000), most industries other than those using powdered plastic raw materials indicated a willingness to use locally recycled waste plastics as secondary raw materials, provided they are of high quality and graded correctly (Ratnakara, 2000).

Furthermore, a new type of plastic recycling businesses known as “upcycling” has emerged, which produces value added plastic products made from post-consumer plastics, such as flower pots, mats, and containers, as opposed to the conventional small-scale (1-10 MT/month) plastic recycling businesses that produce low quality plastic flakes, granules and pellets. For example, in 2007, Mr. Kumarasinghe, owner of Katana

Upcycling, installed two crusher machines and an extruder at his home to start a recycling business, and developed value added products from plastic waste for niche markets to ensure financial and environmental sustainability. He collects clean polythene from LAs such as Negombo MC, Gamapaha MC, Diwlapitiya PS and Minuwangoda PS and produces file covers, ceiling sheets, floor tiles, wallets and many other innovative products that other recyclers do not produce. He makes effective use of social media such as Facebook for advertising, marketing, and promotion and also approaches shopping malls and hotels for direct sales of his products. He eventually succeeded in marketing his products in Colombo.

It can therefore be summarised that there is still much room for growth in the plastic recycling and recovery business. Such growth in these sectors will eventually contribute to lowering the negative impact on the environment by reducing greenhouse gases emissions through reduction of use of raw materials and fossil fuels. Further, it will reduce the amounts of waste going to landfills which are nearly at capacity as well as help mitigate the challenge of sourcing alternative land for waste disposal.

Hence, at the early stage of plastic recycling business development (1980s to 2000s), LAs played a role of facilitating individual collectors, middlemen and private recycling businesses by providing municipal tax concessions, support for establishing recycling businesses, and permission for direct access to waste generators. However, continued growth of the plastic recycling industry is not guaranteed due to a wide range of factors, such as financial and technical constraints surrounding installation and handling of processing machines, unstable or insufficient quantities and contamination of collected plastic waste, which affects the quality and quantity of final products, development of biodegradable plastics that cannot be easily recycled, price fluctuations of virgin plastic materials, linked with international prices of fossil fuels, as well as the law enforcement of the government.

Taking these factors into consideration, individual LAs have taken the initiative to integrate collection with processing of recyclable plastics into their waste

¹ Eco Spindles (Pvt) Ltd., <https://ecospindles.com/beira-Recycling.php>

management plans, with the support from the national government. This case study report examines the establishment and evolution of plastic recycling under two different operational modalities in urban areas of Sri Lanka; 1) single municipal operation, and 2) PPP (Public Private Partnership) based operation. This report provides an analysis of each modality in terms of effectiveness, technical feasibility, environmental impact, financial sustainability and sense of ownership in view of learning lessons and replicability of successful implementation in other cities.

1.2 POLICY AND REGULATIONS ON SOLID WASTE MANAGEMENT

Sri Lanka, a lower middle-income country with a GDP per capita of 4,079 USD and total population of 21.8 million, has achieved steady economic growth and infrastructure development in urban and rural areas (Central Bank of Sri Lanka, 2019). At the same time, however, rapid economic expansion and urban development has brought with it many challenges for Municipal Solid Waste (MSW) management to protect the environment and to maintain urban sanitation.

Solid waste management policies in Sri Lanka have been established with the goal of guaranteeing environmental and social responsibility. Up until the time national waste reduction and reuse policies were formulated in Sri Lanka as part of *National Strategy for Solid Waste Management* (NSSWM) in 2000, recycling had not featured strongly as an important subject of national debate or in the public consciousness. While the advent of NSSWM provided a set of actions to combine fragmented issues in different sectors of MSW, such as waste collection, composting, recycling, and final disposal, it lacked strategic national action plans that would be needed to show the way forward. Instead, the core content of NSSWM introduced appropriate technologies and management systems to the MSW sector. In acknowledging that the fragmented approaches of NSSWM would not be sufficient to tackle the myriad MSW issues in the country, the government determined there was a need for a strong policy to support LA initiatives. This led to development of the *National Policy on Solid Waste Management* by Ministry of Environment and Natural Resources (ME&NR) in 2007,

which was aimed at encouraging implementation of the 3Rs and emphasised financial allocation by the government for solid waste management. Under this policy, ME&NR launched a national programme, PILISARU (meaning re-enrich) under the Chairmanship of Ministry of Environment and Central Environmental Authority (CEA). The aim of PILISARU was to solve the country's MSW issues within five years through promoting 3Rs and resource recovery prior to final disposal, starting in 2008. It was funded by the central government with capital of 5.675 billion LKR (43.6 million USD) for the first three years, and the project eventually ran until 2015.

This Policy was amended in 2018 upon the realisation that different agencies practiced different waste management activities - with varying degrees of success. The chief underlying factor that came to light was the absence of adequate infrastructure, including conflict-free final disposal facilities in the integrated waste management system throughout the country. The amendment incorporated novel financing mechanisms such as the reinforced polluter pays principle which imposes waste collection fee on households that used to be excluded and received cabinet approval in 2019.

1.3 MUNICIPAL SOLID WASTE MANAGEMENT

The basic legal framework for MSW management is provided by Local Authorities (LA) which follow the laws and regulations made by the Central Government and the Provincial Council. LAs are divided into three categories - Municipal Councils (MC) (there are 24), Urban Councils (UC) (41) and Pradeshiya Sabha (PS) (276) - depending on population density, urban infrastructure and revenue status, and are mandated to remove and dispose of waste without causing nuisance to the public. As of 2018, of the 341 LAs, 306 provide regular MSW collection services to the public. The remaining 35 dispatch workers and collection vehicles for certain places or public events on an occasional basis.

To assist local governments in improving MSW management, the National Solid Waste Management Support Centre (NSWMC), established by the Ministry of Local Government and Provincial Councils, is responsible for producing various manuals, guidelines,

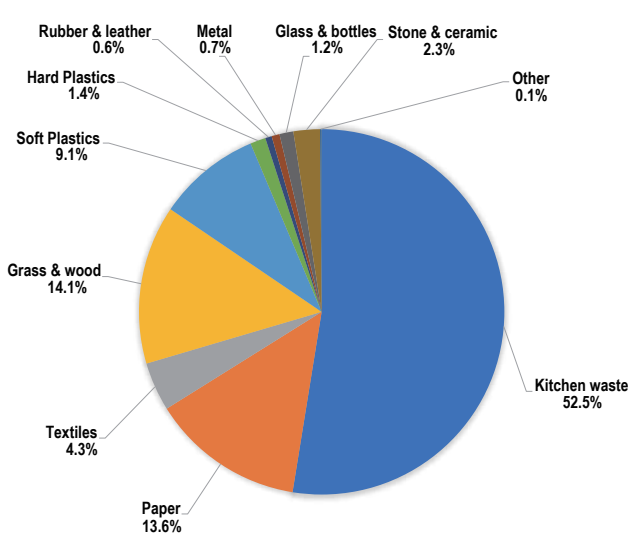
and technical assistance. To increase plastic recycling, reinforcement of source segregation and collection was emphasised by several LAs in the early 2000s. Some LAs and other organisations initiated waste reduction and reuse programmes at the local level independently, with a focus on home composting of biodegradable waste, reduction of plastics/polythene usage through promoting use of cane bags instead of polythene bags for shopping, and public awareness-raising programmes. Several large retail shops and department stores promote plastic waste collection by establishing plastic waste collection points at their stores. This outreach activity has been acknowledged by customers and is popular, with the model now being replicated by many other individual retail stores in the country, leading to the collection of substantial amounts of post-consumer plastics, especially PET bottles. This plastic waste is then sold on to recyclers on a regular basis. The conventional door-to-door visits conducted by individual collectors has evolved in such a way that collectors now use small trucks and cover larger collection areas within a day. The exchange of plastic waste in addition to other recyclables for goods such as kitchen utilities is also gaining popularity across the country.

Over the last two decades the collection and processing of plastic waste for recycling has received special attention by LAs as well as private recyclers. Plastic waste collection in Sri Lanka is currently a combined

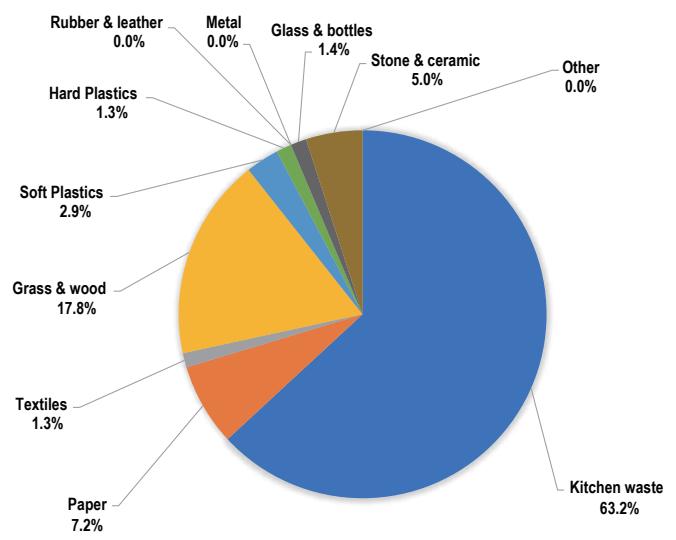
effort of its citizens, municipalities and private sector collectors.

1.4 HISTORY OF PLASTIC RECYCLING IN SRI LANKA

In Sri Lanka, manufacturing of plastic products, packages and industrial polymers has been growing as an industry over the last 45 years and currently comprises about 400 companies. Significant numbers of plastic products are also imported, and according to CEA statistics (2019) Sri Lanka annually imports about 500,000 metric tonnes of virgin plastic for manufacturing plastic products. On the other hand it was estimated that Sri Lanka dumped one million sachet packets, e.g., sauce, jam and shampoo every month, as well as 20 million yoghurt cups, 15 million lunch sheets and 20 million grocery bags every day (Dangalla et al., 2013). Plastic consumption per capita is about 6 kg per annum (Basnayake et al., 2020), and in urban areas plastic waste, comprising both hard and soft plastics (films) accounts for 10% of total waste. In contrast, a nationwide study conducted by JICA in 2016 revealed that the rural waste stream consists mainly of biodegradable waste and that residual plastic waste accounts for only 5% but is difficult to recycle using the simple mechanical shredding, pelletising and extruding technologies available (Figure 1).



Urban Municipal Solid Waste (Bulk density $365 \pm 60 \text{ kg/m}^3$)



Rural Municipal Solid Waste (Bulk density $600 \pm 100 \text{ kg/m}^3$)

Figure 1 Composition of municipal solid waste in urban and rural areas of Sri Lanka (JICA 2016)

Historically, in Sri Lanka, like many other developing countries, the conventional plastic recycling industry was mainly driven by entrepreneurs. Collection of plastic waste from industries and commercial sectors by small and medium-sized entrepreneurs has been commonly practiced since the late 1980s. Individual collectors collect recyclable materials from households and institutes and then sell them on to junk shops where they are cleaned and resold to local industries or for export. In the past, the plastic recycling industry in Sri Lanka mainly targeted export markets such as China and India in the form of granules, chips and flakes. Small businesses and individuals often purchased high-value plastic waste (e.g., damaged furniture, household items) from households and other establishments directly, which meant that despite the presence of the recycling business since the 80s, non-degradable waste, mainly composed of low value plastics such as packaging film and shopping bags, tended to be overlooked and ended up in dumpsites.

As part of the policy and regulations on plastic waste management, in 2006, ME&NR banned the manufacturing and distribution of polythene and any polythene product of 20 microns or less owing to the heavy pollution generated by the burning or burying of these post-consumer products. ME&NR then executed the National Post Consumer Plastic Recycling Project (NPCPRP), which had three main objectives: 1) address the behavior change necessary among consumers to ensure the proper disposal of plastic waste in such a manner that will not harm the environment and natural resources, 2) establish the necessary logistics to enable the collection and recycling of post-consumer plastic waste, and 3) reduce the foreign exchange loss by enhancing recycling of post-consumer plastic waste. The project was initially funded via a 1% tax imposed on imports of all plastic raw materials and finished goods in 2007. With the technical inputs from NPCPRP and financial support through the tax and the PILISARU project, this led to a rapid increase in the number of waste plastic collection facilities established in different parts of the country. By 2018 NPCPRP had established 12 plastic waste recycling facilities in Sri Lanka and LAs were equipped with collection vehicles either dedicated to non-degradable waste collection or partitioned tractor trailers for source segregated waste collection. The implementation of mandatory source separation policies and regulations by LAs compelled citizens to separate waste into degradable and non-degradable

types. Currently, however, not all recycling facilities are fully operational owing to in-house management issues such as shortages of skilled labour, lack of market for low quality recycled plastics, and higher production costs.

In 2011, WMA-WP introduced a new recycling concept, termed “Sampath Piyasa” (recyclables collection centre) to several LAs in Western Province, where recyclables are traded according to the type of material, weight, and market value. Sampath Piyasa was acknowledged by many other LAs outside the Western Province as an effective way of collecting recyclables from citizens as well as raising awareness as it demonstrates recyclables have a market value. PILISARU financially supported these LAs to establish Sampath Piyasa during 2008-2015. In addition, several non-governmental and international donor agencies operated in the MSW management sector at different scales, such as the Ampara Environmental Remediation Programme (2006-2011) funded by the European Union. This programme implemented several MSW management projects, including six centralised plastic recycling facilities in Eastern Province, with a projected total expenditure of 12.3 million USD.

2 CASE STUDIES

Two cases of successful plastic recycling have been selected based on their operational modality: 1) single municipal operation, and 2) PPP (Public Private Partnership) based operation (Figure 2 and Table 1). The cases were then analysed in aspects of efficacy, technical feasibility, financial sustainability, environmental impact and sense of ownership in terms of their collection, processing, finance and supportive activities.

Figure 2 shows their locations and Table 1 gives an overview of their facilities and operations.

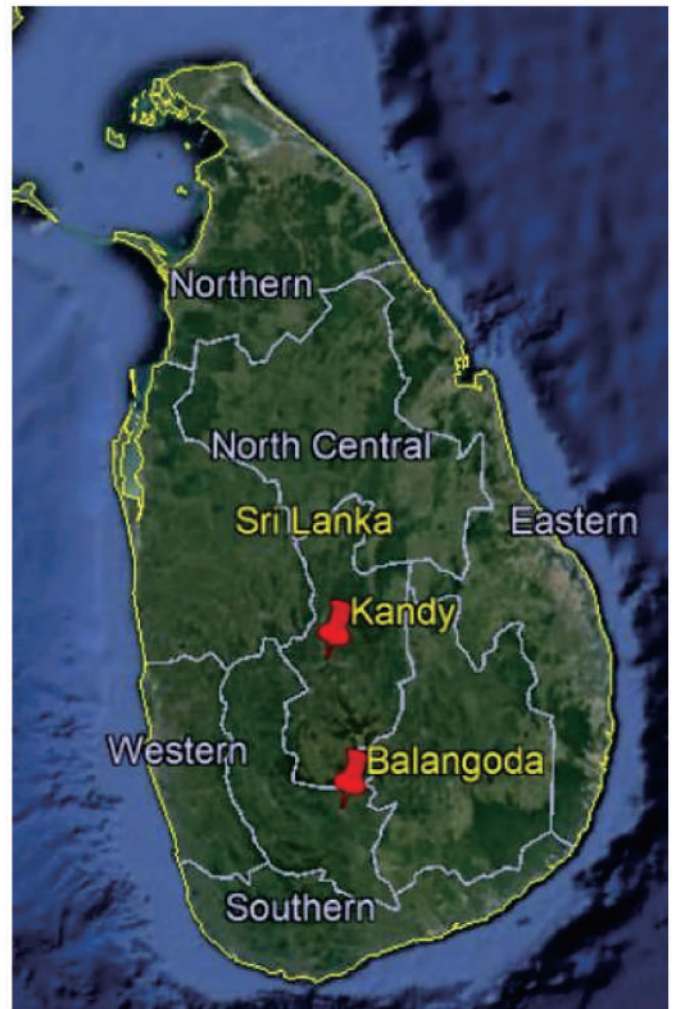


Figure 2 Case study locations (google maps)

Table 1 Overview of the two case studies

Case	Single municipal operation	PPP-based operation
Description	Kandy Municipal Council (KMC) is a large-scale waste generation municipality that introduced successful waste source separation, collection services and a recycling facility under different stages of a master plan.	Balangoda Urban Council (BUC) contracts a private company for the operation of a PRC, which was installed and equipped with public funding.
Operational modality	Single municipality: Kandy Municipal Council (KMC)	Balangoda Urban Council (BUC) and private company
Type of technology used	Crushing, compacting and bailing for plastic recyclables	Crushing, compacting and bailing for plastic recyclables
Waste generation / collection	175 MTPD (estimated) / 140 MTPD	25 TPD (estimated) / 15-20 MTPD
Processing capacity	500 kg/day	500 kg/day

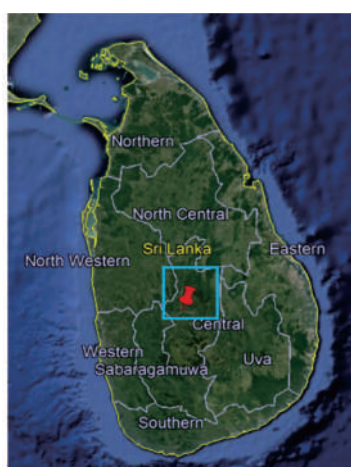
2.1 SINGLE MUNICIPAL OPERATION (KANDY MUNICIPAL COUNCIL)

2.1.1 BACKGROUND

Kandy Municipal Council (KMC), with 28.53 km² of land area, is the largest township in Kandy district, and is located 110 km north-east of Colombo with a population of 102,500 as of 2018. Being a passenger transit hub, public service centre, tourist destination, world heritage city and main commercial centre in Central Province, Kandy is also known as the second capital of Sri Lanka. Its floating daily population consisting of workers, tourists and visitors swells to around 400,000, which has increased the burden on KMC for managing the increasing volumes of municipal waste (Figure 3).

From the 1980s to 2002, owing to the lack of a proper MSW management plan, all solid and liquid waste was

openly disposed of at Gohagoda dumpsite, which is situated next to a residential area along the Mahaweli River (the longest river in Sri Lanka). In 2003, KMC converted this dumpsite into a semi-engineered landfill in accordance with the MSW management master plan, with financial and technical assistance from Japan International Cooperation Agency (JICA). However, since KMC lacked sufficient human and financial resources to fully implement the plan, it eventually returned to a dumpsite by 2011. The absence of source segregated collection, burning and illegal dumping of waste caused many health and environment problems for the public. KMC was also unable to find a suitable site as an alternative final disposal site. Although the Gohagoda dumpsite was partially rehabilitated once again by KMC with the involvement of the private sector, the remaining disposal capacity decreased drastically due to the rapid increase in waste generation. Since then the city's strategy has shifted from one based on city cleaning to that based on waste minimisation, recycling, and recovery.



Country	Sri Lanka
Province	Central
District	Kandy
Size	28.53 km ²
Land use	Residential, cash crops, sanctuary Home gardens & built up lands
Population	Residential 102,500 (2012) Floating 400,000
Dwellings	26,722 (2012)
Waste generation	175 MTPD (estimated)
Waste collection	140 MTPD (estimated)

Figure 3 Location and basic information of Kandy Municipal Council (google maps, Kandy Municipal Council, 2013)

2.1.2 INITIATIVE

Promotion of waste separation started in 2011 by KMC. At that time, most recyclables were collected by municipal collectors during the regular waste collection and informally by individuals through door-to-door visits. Several private entrepreneurs, or "middlemen shops" also operated, and purchased recyclables (paper, cardboards, plastics, metal, glass, etc.) from collectors and resold them to recycling companies and exporters. However, due to variability in the recycling

business owing to frequent market price fluctuations, such middlemen tended to seek other labour jobs in times of low recyclable prices. Further, collectors often only collected high-value recyclables, meaning low-value recyclables were left uncollected. Taking such limitations of the recycling business into consideration, KMC took a decision to remedy the situation by means of waste minimisation through the establishment of Sampath Piyasa Centres (SPC), where recyclables are bought, sorted and sold.

SPCs are a publicly-owned entities introduced by the CEA. The first one in Kandy was established in 2012 at the city centre for the purpose of formalising recyclables collection through involvement of a municipality that guarantees collection of recyclable waste, especially plastic waste throughout the year, regardless of market price. With the rising demand from waste generators, two more SPCs were installed; one at Gohagoda disposal site and another at Katugasthota area in 2014 under the short-term targets (2014-2015) of KMC's 10-year master plan. Each SPC employed two dedicated staff who had been trained on identification of recyclables, grading, sorting and bulk packaging. Once it was recognised that waste was as a valuable resource, residents also started to take part in the collection activity.

Later, in 2014, a single story building (600 m²) was installed at the Gohagoda disposal site to house a Plastic Recycling Centre (PRC). This was then equipped with plastic and polythene crusher machines with 500 kg/day processing capacity, with financial support of 5.5 million LKR (about 42,308 USD) from the NPCPRP. In 2015, KMC invested 10 million LKR (about 74,074 USD) to upgrade the centre with a second floor, which is used as an auditorium for solid waste management training programmes.

Thereafter, one Public Health Inspector (PHI) from KMC's waste management section was employed for overall management of the PRC and Gohagoda final disposal site. Two technical officers, one at the PRC and another at the final disposal site were employed by KMC to supervise activities. There are (as of writing) six female and four male labourers grading recyclables at the PRC, of whom five are permanent and the others are contract staff. Labourers are supplied with personal

protective gear to ensure occupational health and safety, and regular training programmes are conducted by a KMC engineer and PHI staff. All labourers at the PRC were recruited from communities nearby, which aids their livelihoods.

2.1.3 COLLECTION ACTIVITY

Recyclable items such as paper, coconut shells, cardboard, newspapers, plastics, glass, metals (iron, copper, aluminum and tin), batteries and e-waste are collected by various types of vehicles - by handcarts for narrow lanes in residential and commercial areas, by tractor and compactors in main streets and the city centre, and by small trucks in more distant peripheral residential areas. The collected segregated wastes other than plastics are further sorted manually by KMC labourers at the SPCs and stored for sale. Figure 5 shows that among the three SPCs, Gohagoda disposal site receives more and lower-value recyclables than the others as it is the final destination of all waste collection vehicles. The low-value recyclables, including plastic waste are mainly sorted, cleaned, and processed at the PRC. On the other hand, the SPC at Kandy is located in the densely populated city centre, thus receives considerable amounts of high-value recyclables such as cardboard, paper and metal (Figure 4), whereas the lowest amounts of recyclables are handled at Katugasthota SPC, located in a relatively small town with few commercial establishments and households.

Recognising that recyclables have value and can be sold at the SPCs, they are also brought in by individuals outside KMC as well as municipal collectors, who have become motivated to pick them up during domestic and commercial waste rounds to supplement incomes. Municipal collectors encourage citizens to segregate



Figure 4 Waste at the Sampath Piyasa Centre (SPC) at the city centre (source: author)

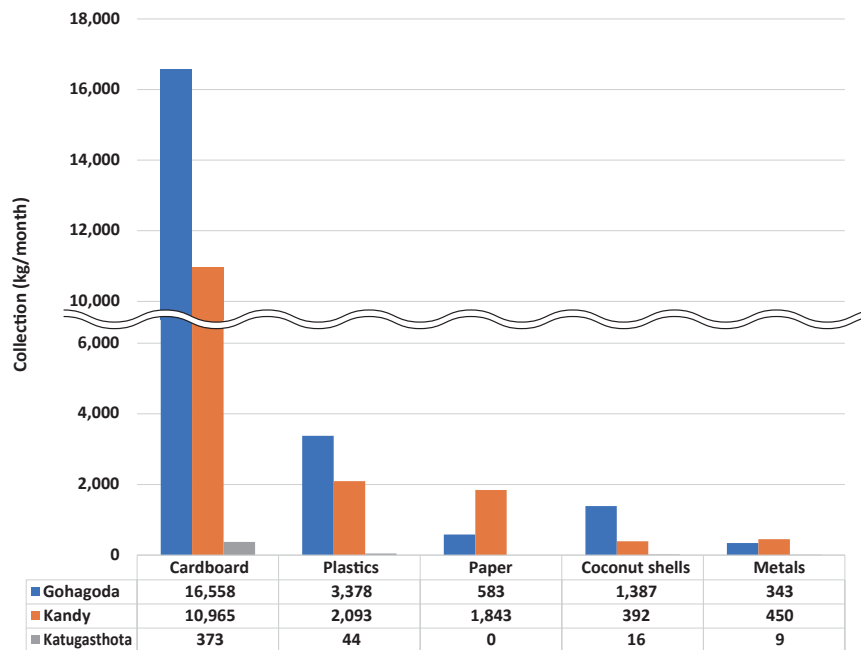


Figure 5 Monthly average amount of recyclables received at the three SPCs in 2019²

waste at source as cleaner items attract higher prices. While the quality of recyclable plastic is a big concern in KMC, citizens are advised that non-segregated waste is not collected.

A recent study of KMC conducted by Ilesinghe (2017) shows that approximately 54% of plastic waste generated from households is uncontaminated plastics, which can be sold or processed after grading without the need for extensive cleaning. It also shows that the amount of clean recyclable plastics in source separated inorganic waste from trade and the business sector is very high (83% uncontaminated plastics), compared to approximately 54% contaminated plastic waste from hotels and restaurants, which requires washing, cleaning and drying prior to sale or processing. Thus, it became crucial for KMC to encourage residents, hotels and restaurants to minimise plastic contamination from particularly food waste during discharge, storage, and handling. As a result, KMC initiated in early 2020 a new scheme of waste separation involving three categories - biodegradable, recyclables, and non-recyclables (contaminated) - in which bins for recyclable

waste can only be filled with uncontaminated paper, plastic and metal waste, which can be either sold at the SPCs or collected by KMC recyclable waste collection vehicles. However, the waste segregation activity has been suspended since the outbreak of infectious novel corona virus. The citizens accepted and adhered to this new source segregation rule based on the fact that KMC has maintained a proper MSW collection service, which implies that the quality and punctuality of waste collection together with ongoing, closely monitored awareness-raising activities (by field supervisors and PHIs in respective zones) are key strategies to reinforcing implementation of waste segregation at source. Hotels and restaurants in the city is the only sector displaying reluctance to follow suit, which cite limitations of time, space, and manpower as reasons not to take part.

Another study, by Alahakoon et al. (2020), shows that the amount of plastic waste generation in KMC is about 12 MT/day (or about 360 MT/month), of which only approximately 6% is collected for recycling by municipal workers and private collectors at different

² Data extracted from reports from the 3SCPs.

stages. Of this 6%, KMC collects 1.5%, or 5.5-7.0 MT, and the remaining 4.5% is assumed to be collected by various private collectors, who prefer high-value plastic waste generated from the commercial and small business sector. KMC continues to encourage citizens and plastic waste collectors to bring plastic waste to the SPCs to the extent possible, as another purpose of the SPCs is to reduce amounts of plastic waste going to the final disposal site.

2.1.4 PROCESSING ACTIVITY

Clean hard plastics from all sources and uncontaminated soft plastics from commercial enterprises and shopping malls in particular, are directly stored and sold at the SPCs by grade and type after minimum cleaning. About 60% of the plastic items are sold at the SPCs (Figure 6). On the other hand, contaminated plastics are transferred to the PRC for cleaning, sorting and processing to pellets or flakes using one plastic crusher, one polythene crusher, and one compactor (hydraulic bailing machine) which have been in operation by KMC since 2015. The PRC's processing capacity is around 0.5 MTPD, which is negligible compared to the total generation of plastic waste in KMC - about 12 MTPD. Amounts of processed plastic sold by KMC fluctuate according to market prices, and if prices are lower than expected, recyclables are normally stored at the PRC and the SPCs until prices rise again.

The processing begins with the removal of inert materials, labels and stickers from the collected plastic and polythene materials by hands. While washing facilities are available at the PRC, they are only used if requested by the buyers. High Density Polyethylene (HDPE) and Polypropylene (PP) materials are sorted according to resin type and colour. Common colour categories are blue, green, brown, red, yellow, white, black, ash and purple. Polyethylene Terephthalate (PET) materials are simply compacted without crushing. Other types of plastics unsuitable for crushing are sold as-is without further processing. Although polythene used to be crushed at the PRC, KMC has recently diverted most low-value polythene to an adjacent landfill site for construction of a special clay-polythene-clay landfill liner as a first experience in Sri Lanka. This innovative technique which is applied in countries in Latin America and Africa, is a low-cost alternative as a liner material for use in landfill construction (Gunarathna et al., 2007).

2.1.5 FINANCIAL ANALYSIS

All prospective buyers of recyclables and other plastics intending to purchase raw or processed plastics from the SPCs and the PRC are required to register at KMC as part of the open tender process, and contracts are handed to those offering the best prices every year by

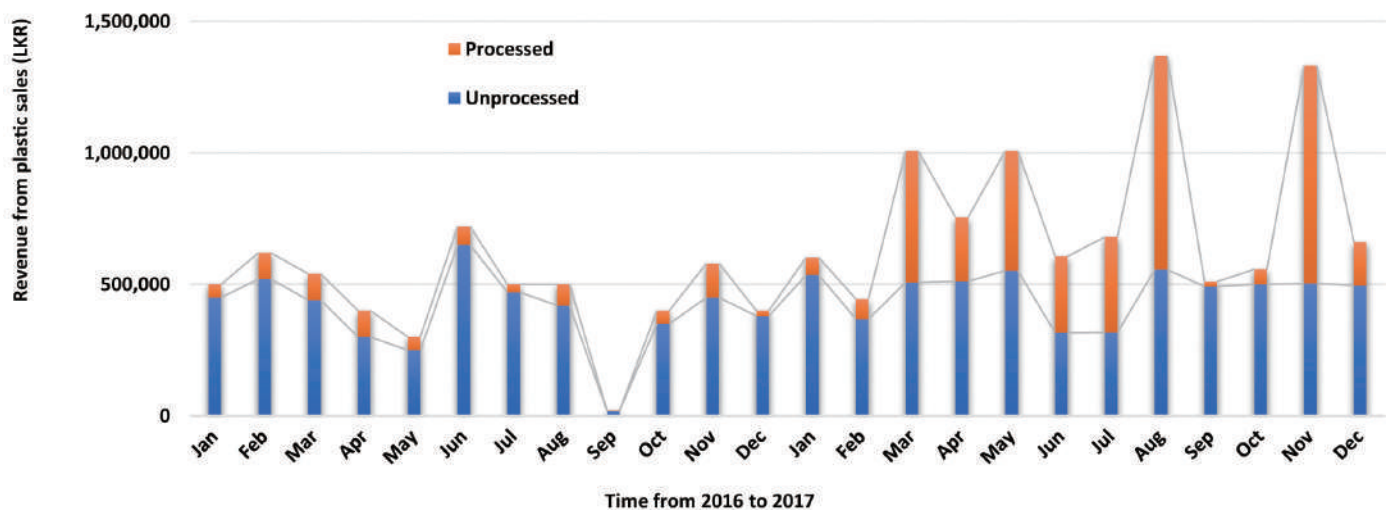


Figure 6 Income from sales of unprocessed and processed plastics at the SPCs and the PRC from 2016 to 2017³

³ Data extracted from reports at the 3SCPs and the PRC.



Figure 7 Activities at the PRC, Gohagoda (source: author)

KMC. Such prices cannot be changed throughout the year, which helps stabilise the plastic recycling market.

Table 2 shows the average cost and selling prices of different types of plastics in 2017. For example, soft uncleaned plastic is purchased at 3.5-15 LKR/kg, and after sorting and grading is sold at 5-20 LKR/kg. On the other hand, uncleaned PP and HDPE is purchased at 30-40 LKR/kg, and sold at more than double price after processed. It means that the establishment of the PRC to process the collected plastic waste has created an opportunity for KMC to increase its revenue compared to simply direct buying and selling of recyclables at

the SPCs. In general, between 6,000 and 8,000 kg of plastic is sorted and crushed per month (Figure 8). In 2017, total processed PP and HDPE at the PRC was 31,180 kg and 39,535 kg respectively. The average annual income from sales of total recyclables has risen by 72% from 5.5 million LKR (about 37,931 USD) in 2016 to 9.5 million LKR (about 63,333 USD) in 2017, 70% of which was generated from the sales of plastics. To secure a steady market for processed plastics, KMC has planned to install injection-moulding equipment to convert the pellets into finished products, such as nursery pots.

Table 2 Buying and selling price of plastic waste at KMC for year 2017⁴

Types of activity and plastic	Cost price (LKR/kg) [US¢/kg]	Selling price (LKR/kg) [US¢/kg]
Sorting, cleaning (at SPC)		
Soft Plastics	3.5-15 [2.3-10]	5-20 [3.3-13.3]
Hard plastics	7-25 [4.7-16.7]	10-45 [6.7-30]
Sorting, cleaning, grading (at SPC)		
PET	15-20 [10-13.3]	25-30 [16.7-20]
Other	30-40 [20-26.7]	35-45 [23.3-30]
Sorting, cleaning, grading, and palletising (at PRC)		
PP	30-40 [20-26.7]	80-100 [53.3-66.7]
HDPE	30-40 [20-26.7]	70-85 [46.7-56.7]
Other	20-30 [13.3-20]	45-55 [30-36.7]

⁴ Data extracted from reports in 2017.

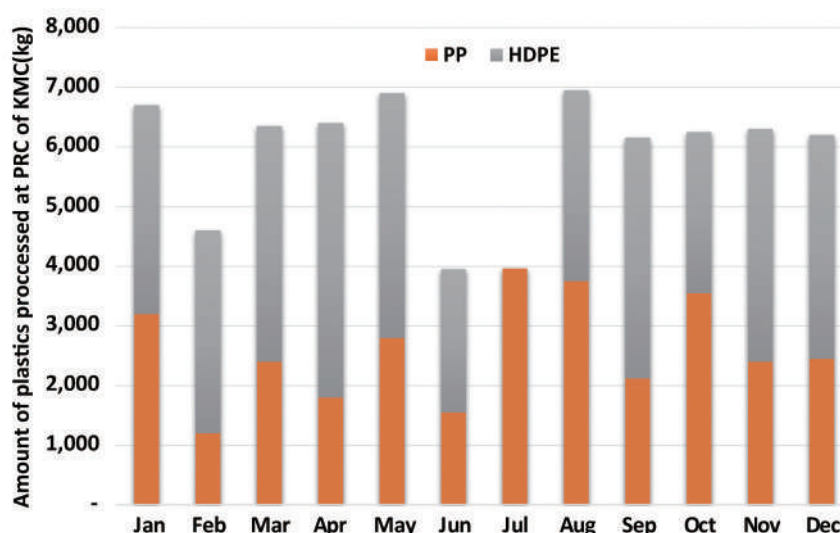


Figure 8 Production of pellets at the PRC in 2017⁵

2.1.6 SUPPORTIVE ACTIVITY

KMC waste management staff, particularly PHIs and their supervisors conduct annual public awareness activities by visiting households, institutes, and traders, and distribute leaflets, display billboards and posters in public places as well as conduct community meetings. In addition, KMC has established 45 environment committees in each village (Grama Niladhari Division) to promote waste management activities - such as “Shramadana” campaigns (voluntarily engagement in social works), roadside cleaning, and school programmes. While universities, local and international Non-government Organisations (NGO) conduct awareness-raising activities, the private sector has also gradually started taking part in such activities under the scope of Corporate Social Responsibility (CSR). The concept of source segregation and recycling has been disseminated to citizens through a series of awareness-raising activities.

KMC also attempts to change consumption patterns by introducing flea markets for trading second-hand materials. Enhanced attempts to collect e-waste are also a positive initiative. These activities help reduce waste generation and soil and groundwater contamination caused by the leaching of heavy metals from E-wastes, and has also helped create a new business model due to waste being viewed as a valuable material.

While establishing the SPCs and the PRC has formalised the recycling business in Kandy city, this has resulted in reduced amounts of readily marketable recycling materials at the disposal site in recent years. Prior to KMC restricting entry of rag pickers to the site, about 20 pickers had operated at Gohagoda disposal site, most of whom were family members living close to the site. In an attempt to ensure steady income for those who had lost income as a result, KMC employed eight former rag pickers at the SPCs and the PRC. KMC also relocated around 200 houses to safer locations due to the risk of waste dump collapse, and now prioritises the relocated families and the former rag pickers whenever opportunities in waste collection, cleaning work, and recycling activities arise at KMC. In addition to rag pickers at the disposal site, KMC continues to purchase recyclables from urban poor collectors who now make door to door visits to collect recyclables from households, businesses and pick at waste collection points in the city.

2.1.7 OUTCOME AND LESSONS LEARNED

While an established market now exists for high value plastic, low value plastic including soft plastic had been always problematic. One of the achievements of the recycling activity in Kandy was its ability to penetrate the plastic recycling market with low-value

⁵ Data extracted from reports in 2017

plastic waste by assuring a stable price throughout the year in cooperation with the private sector and waste generators. As the SPCs are open every day except for a few public holidays and receive both high- and low-value recyclables, citizens easily adapted to disposal of recyclables at the SPCs regardless of the frequency of municipal waste collection. Together with KMC's strict monitoring and inspection, waste burning on site and illegal dumping activities have also decreased. Another indirect achievement is the approximately 20% reduction in total waste generation from 150 TPD in 2015 to 130 TPD in 2017, which has been attained through expansion of source segregation of biodegradable waste for home composting and biogas use. The inclusion of informal waste pickers into the formal recycling activity is another positive outcome that needs to be highlighted.

In KMC, plastic waste is sold to selected buyers under a contractual agreement in which KMC is obligated to supply certain amounts of plastics. In other words, KMC is bound to collect and process agreed amounts of recyclable plastics through the SPCs and the PRC, which motivates KMC to improve its waste collection and recycling processes. Currently, source segregated recyclables collection secures a constant 5.5 - 7.0 MT of plastic waste every month; however, it represents only 1.5% of total plastic waste generation. Contamination of plastic waste at source by food waste and other contaminants needs to be solved in order to increase the both the quantity and quality of such waste.

The recycling activities practiced in KMC are

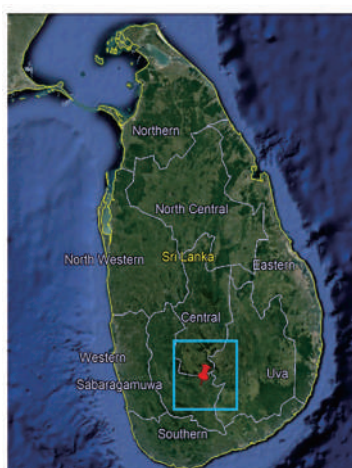
perceived as part of an integrated waste management model and have been well acknowledged by many large municipalities and the national government. Consequently, KMC received the "Swarnapura" (Golden city) national award under the Municipal Council category in the national competition held in 2016. The competition is held annually by the Ministry of Provincial Councils and Local Government with the aim of recognising best performers in MSW among LAs.

2.2 PPP-BASED OPERATION (BALANGODA URBAN COUNCIL)

2.2.1 BACKGROUND

Balangoda Urban Council (BUC) is a large township in Ratnapura District of Sabaragamuwa Province. BUC is situated in the hilly central region of Sri Lanka, 150 km away from the capital, Colombo, has a total area of 16.2 km², resident population of 36,123, and daily floating population of 50,000 (Figure 9). The estimated waste generation and collection is 25 MTPD and 15-20 MTPD, respectively.

Although not a large town, BUC has struggled to manage its large amounts of waste generated from households, commercial and small industrial enterprises, government agencies, as well as the floating population. All collected wastes from BUC were previously disposed of on a marshy area of land



Country	Sri Lanka
Province	Sabaragamuwa
District	Rathnapura
Size	16.20 km ²
Land use	Residential, mixed crops, paddy Home gardens & built up lands
Population	Residential 36,123 (2012) Floating 50,000 (2012)
Dwellings	8,189
Waste generation	25 MTPD (estimated)
Waste collection	15-20 MTPD (estimated)

Figure 9 Location and basic information of Balangoda Urban Council (google maps, JICA 2017)

located along the Dorawela stream which runs through Balangoda town. The disposal of waste in the middle of city caused various environmental and health issues such as groundwater pollution, risk of infectious disease transmission by flies and mosquitoes, and bad odours and smoke from frequent fires at the dumpsite.

To solve these problems, in 1991 BUC established a separate section for Municipal Solid Waste Management (MSWM) under the Health Department, with the aim of promoting waste reduction and recycling at different levels through source segregation and subsequent promotion of onsite composting, biogas and recycling. Though the initiative reduced certain amounts of waste generation, BUC could not achieve all its objectives owing to insufficient financial capacity for the large-scale facilities.

2.2.2 INITIATIVE

In 2006, BUC established a Solid Waste Management Centre (SWMC) at Bankiyawatta, a remote corner of the city, to introduce integrated solid waste management. The SWMC comprises a waste sorting space, windrow composting facility to treat biodegradable waste, cleaning and storage for recyclables, night soil (sewage) treatment facility, and residual waste disposal site. Construction of the main infrastructure and building facilities were financially supported by the Central and Provincial Government and private organisations. The city's business chamber sponsored the development of materials and human

resources for an awareness-raising campaign. In the same year, BUC also introduced a new source segregated waste collection scheme for separate collection of biodegradable waste and other waste from households, with mixed waste collected only from the commercial sector which did not participate in the source segregation programme.

As the capacity of the installed composting facility was insufficient, it was expanded to treat 15 MTPD of biodegradable waste by 2008 with the technical support from NSWMSC and financial support from PILISARU. However, the aspect of management of other recyclables had failed to account for the unsegregated incoming waste, which required extensive labour resources for sorting prior to recovery of recyclables (Figure 10).

Under such circumstances the SWMC was supplied with a Plastic Recycling Centre (PRC) in July 2012, with financial support from NPCPRP and technical assistance from CEA. The PRC is used to clean, sort and pelletise or flake the segregated plastic waste from the city.

2.2.3 COLLECTION ACTIVITY

Waste collection is handled by municipal labourers with seven handcarts and 10 four-wheel tractors. Handcarts collect the street-swept waste and tractors collect waste from commercial and residential areas, and sometimes public places. Households are advised to discharge their waste in separate bags for biodegradables and



Figure 10 Sorting mixed waste at Bankiyawatta SWMC of BUC (2008) (source: author)



Figure 11 Storing and grading of source segregated plastic waste at Bankiyawatta SWMC of BUC (2017) (source: author)

other wastes. Biodegradable waste is collected three days per week, while other waste including recyclables is collected only once a week.

The biodegradable waste from households is sent to the composting facility but that from the commercial sector needs further sorting at the SWMC prior to composting to remove the small amounts of inorganic materials which accounted for 15% of the total waste, according to the report at SWMC. Other waste collected from all sources requires further sorting by type and grading into different recyclables, such as plastics, paper and cardboard and metal. All recyclables except for plastics are temporarily stored in a storage room for sale to the pre-registered bulk buyers. The plastic waste is further sorted into different plastic types (e.g., HDPE, PET, LDPE, PP), baled and stored. Because the sorting and grading require extensive labour (5-6 man days per 1 metric tonne) at SWMC, BUC developed a source segregation programme for household and commercial waste to promote further segregation of recyclable materials into plastics, paper, metal, glass, coconut shells and hazardous waste. At the time of compiling this report the planning and implementation mechanism was still in development. Once completed, it will require approval from the council before implementation.

To further promote recycling, BUC established its initial

Sampath Piyasa Centre (SPC) at Balangoda town in 2008. In 2009, NPCPRP and NSWSMSC sponsored similar centres in the form of School Resource Centres (SRC) at ten schools in the city, where school children are encouraged to bring recyclables such as glass, soft and hard plastic, newspapers, books, cardboard, coconut shells, and metal from home (see 2.2.6 Supportive Activity for detail). The recyclable materials collected at the SRCs are regularly transferred to the main SPC in the city centre.

At the main SPC which is owned and managed by BUC, various recyclable materials including plastics, glass, paper, cardboard, coconut shells and metals are received from citizens and individual collectors, which are partly sold directly to bulk buyers arriving from Colombo and other major cities. The collected plastics are transferred to Bankiyawatta SWMC by BUC for sorting and grading. This main SPC is managed by a supervisor-storekeeper assisted by two labourers (one male, one female) trained in identification, sorting, grading, and handling of different recyclables.

Figure 13 shows monthly collected recyclables in 2017 and 2018. The total annual recyclable materials collected at the SWMC collection centre and all SPCs in 2017-2018 was approximately 10 MT, of which plastic waste accounted for 33%.



Main Sampath Piyasa Centre in the city (established in 2008)



Sampath Piyasa Centre in a school (established in 2011)

Figure 12 Recyclables collection centres in BUC (source: author)

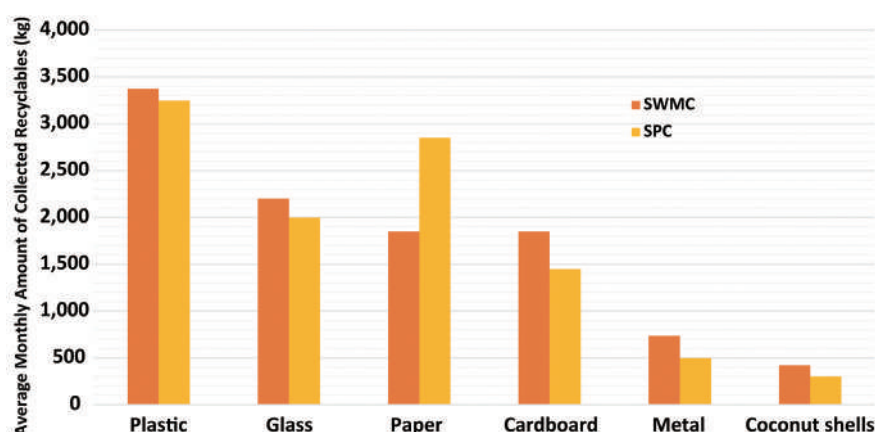


Figure 13 Average monthly collection of different types of recyclables at SWMC and SPC by BUC (2017-2018)⁶

2.2.4 PROCESSING ACTIVITY

After operating for two years since 2012, BUC recognised that operating costs of the PRC had become a burden on the municipal budget. This was because the facility, based on the processing equipment donated by NPCPRP, was not operating at maximum capacity, since it could handle higher capacity than the BUC's collection capacity. This led BUC to outsource management of the facility to a private company, which was expected to expand the scope of collection outside BUC boundaries in order to satisfy the equipment

capacity requirement of 6-10 MT of plastics per month. As a result, along with the increase in plastic waste collection, the overall PRC operation has become more effective and efficient due to the adoption, by the private operator, of a profit-seeking structure. This resulted in better marketing, more professional machine operators, the ability to develop value-added products and higher flexibility in daily operations than the non-profit based (public institution) structure. The new operation model was approved by BUC, which then stipulated rules that the private operator be selected through an annual open tender, that the

⁶ Data extracted from reports in 2017 and 2018



Figure 14 Plastic processing at the PRC (source: author)

selected operator shall purchase all recyclable plastic collected by BUC at market price, and that profits from the recycling activities shall be equally shared between the both parties. From 2014 BUC expanded its public awareness programmes and enforced mandatory source segregated waste collection for all sectors, which resulted in the PRC receiving well-segregated plastic waste from households, commercial enterprises and institutions, thus minimising the need for extensive labour for cleaning (Figure 11).

In early 2014, Green Earth Waste Management Pvt. Ltd. won the first and successive bids until the end of 2018, after which, in 2019, another private company, Beira Holdings PLC, outbid them and took over operations. Beira hired two male machine operators and six female labourers to perform sorting, grading, and cleaning. The female workers generally perform the sorting, which is a skillful task requiring high attentiveness but with lower physical requirements. All staff received training from NPCPRP on plastic sorting, processing, and occupational health as well as usage of protective gear during operations.

Figure 14 shows the processing activities at the PRC. Once plastic waste is received at the PRC, both soft and hard plastics are sorted into several categories according to resin type - High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Polypropylene (PP) and Polyethylene Terephthalate (PET) - and then further sorted by colour. The separated plastics are cleaned by removing dirt and labels, etc. by three labourers using simple scraping tools. PET, received in considerable amounts (1,000 kg/month), is usually compacted using a hydraulic bailing machine and

directly sold to buyers who then deliver it to major recycling factories for cleaning. This allows for more efficient cleaning using well-equipped recycling factories with large, modern machinery than cleaning manually at the PRC.

The processing of cleaned plastic to pellets or flakes is determined by buyer preference, type and form of plastic. Solid, hard plastics are usually crushed by a crushing machine to small pellets and flakes. Hard plastics are generally easy to process through crushing to small pieces. Soft plastics are first turned into flakes by a shredding machine and further processed into granules by an agglomerator machine. All machines are driven by 3-phase electric motors. When high quality pellets or granules from PP, HEPE, and LDPE are demanded, plastic flakes are further cleaned by washing with detergents, drying under sunlight, compacting, or agglomerating to granules. The daily processing amount varies from 200 kg to 500 kg depending on material availability and demand for processed plastics whereas the machine's processing capacity is up to 1,000 kg per day.

2.2.5 FINANCIAL ANALYSIS

As shown in Figure 15, the monthly sales volume handled at the PRC is about 3,000-7,000 kg comprising different types of plastics collected by BUC (3,000-3,500 kg) and by the operator (500-3,000 kg). On average, 78% of plastics are soft plastics that include packaging materials, soft containers, wrappings, bags, and plastic sheets, whereas hard plastics mainly consist of food containers, household utensils, furniture, cans, ice-cream cups, yoghurt tubs,

and toys.

Prices are determined by the type of resin, cleanliness of waste, and market price. For example, soft plastics are purchased at a lower price of 3.5 LKR/kg (2.3 US¢/kg), while PET is purchased at 5.5-10 LKR/kg (3.7-6.7 US¢/kg). The cleaned, sorted, and graded soft plastics are sold in a price range of 10-45 LKR/kg (6.7-30 US¢/kg). Hard plastics are purchased at 7-20 LKR/kg (4.7-13.3 US¢/kg). For example, BUC sold 3,000-3,500 kg/month of plastic waste to the PRC private operator and earned on average of 50,000 LKR (about 333 USD) per month for the period 2016-2018.

According to Figure 16, which was made based on annual sales amounts at the PRC, the income from plastic sales steadily increased from 2008 to 2012 resulting from increasing rates of collection at the SPC and establishment of the PRC in 2012. As shown, the revenue slightly declined during the period of 2013-2014, owing to a drop in market demand for recycled plastic. As a result, soft plastic collected and stored was processed and sold later thus the only revenue generated in this period resulted from daily collection of plastic waste by BUC. The rise in revenue after 2014 resulted from the PRC handing over operations to the private company in that year.

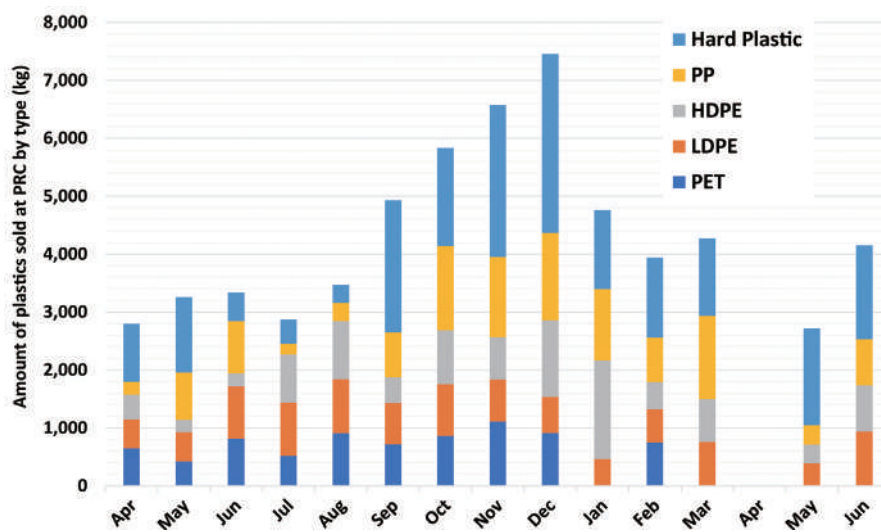


Figure 15 Monthly sales volume of processed and unprocessed plastics at PRC (2017-2018)⁷

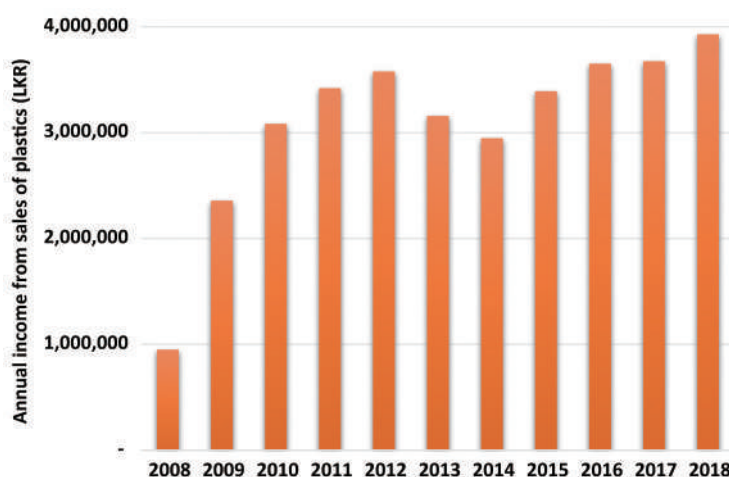


Figure 16 Estimated annual income from plastic recycling at BUC⁸

⁷ Data extracted from reports in 2017 and 2018

⁸ Data extracted from reports (2008-2018)

Table 3 A brief financial audit of the plastic recycling facility for year 2017⁹

Item	Value	Units
Plastic waste received	80.5	MT
<i>From BUC</i>	<i>55.5</i>	<i>MT</i>
<i>Other sources</i>	<i>25.0</i>	<i>MT</i>
Soft plastic in stores	10.0	MT
Income		
Revenue from unprocessed plastics	2,210,798 (14,739)	LKR (USD)
Revenue from processed plastics	1,384,240 (9,228)	LKR (USD)
Value of plastic stock	355,425 (2,370)	LKR (USD)
Total value of plastics (sales + stocks)	3,950,463 (26,337)	LKR (USD)
Expenditure		
Personal remunerations	2,160,000 (14,400)	LKR (USD)
Services (electricity, water)	528,000 (3,520)	LKR (USD)
Consumables	384,000 (2,560)	LKR (USD)
Machine repair and maintenance	336,000 (2,240)	LKR (USD)
Miscellaneous expenses	288,000 (1,920)	LKR (USD)
Total expenditure	3,696,000 (24,640)	LKR (USD)
Total profit before profit share (2017)	254,463 (1,696)	LKR (USD)
Profit share with BUC	127,232 (848)	LKR (USD)
Total profit after profit share (2018)	127,232 (848)	LKR (USD)
<i>Note: 1 USD = 150 LKR</i>		

Table 3 shows a brief financial analysis of the PRC operation in 2017, and is based on information made available by the PRC private operator as precise annual income and expenditure figures are not readily available at BUC. For 2017, the total income, 3,950,463 LKR (26,336 USD), minus total expenditure, 3,696,000 LKR (24,640 USD) realised an annual profit of 254,463 LKR (1,696 USD), which was then equally distributed between BUC and the private operator in 2018. The expenditure consists of salaries for the staff, electricity and water, consumables such as detergents, soap, and personal protective equipment, of which the main expenditure was salaries, accounting for 58%. The private operator is responsible for repairs and maintenance of the machinery as an additional item of expenditure.

2.2.6 SUPPORTIVE ACTIVITY

In order to promote source segregation of waste, a number of awareness-raising activities, such as community meetings and door-to-door visits were conducted by Public Health Inspectors (PHIs), health supervisors and Community Development Officers (CDO). The CDOs are not attached to BUC but dispatched by the central government as part of an implementation of programme in support of reducing poverty and aiding the livelihoods of people in deprived areas. Such stance was adopted by the government in recognition of the fact that promotion of recycling can help create job opportunities for the poor, which explains the heavy involvement of CDOs in these activities.

The challenge for BUC is to maximise the collection of recyclables from the commercial sector including

⁹ Data extracted from reports at the PRC operator in 2017

hotels and restaurants. While business entities initially expressed concern over source segregation due to insufficient human resources and storage facilities, once BUC started to levy a volume-based fee for every large-scale waste generator (>50 kg/day) instead of a monthly fixed fee, source segregation at retailers, wholesalers and textile/garment traders improved by 50%, according to the analysis of the collected data. However, the hotels and restaurants sector still generates considerable amounts of contaminated recyclables.

School students have also become involved in recycling activities through the establishment of School Resource Centres (SRCs) at ten schools. A small room (25 m²) for storage and basic furniture for record keeping was installed at each SRC and each SRC is managed by a group of students called the “3R society”, which is responsible for promotion of 3Rs within the school. School children who bring in recyclables to the SRCs receive points (recorded on Point Card (Figure 17)) based on types and quantities of recyclables collected. After 1,000 points are accumulated this is converted into 1,000 LKR (6.67 USD), which they can save or donate to their schools. The thinking behind the point card system was to instill the notion in children of the value of accumulating value over time into a significant amount, which would not be accomplished if the very small amounts received every day were recompensed on a daily basis, as it would most likely be spent immediately. The 3R societies motivate not only school children to perceive waste as a valuable resource, but also their families through dissemination of the messages from the children.

2.2.7 OUTCOME AND LESSONS LEARNED

This case represents one of the best practices as it exhibits enhanced recycling activities at the LA level through the establishment of recyclables collection centres such as SWMC, SPC, SRCs in schools, and PRC as a plastic processing facility. A series of awareness-raising activities was carried out with the support of central and local governments. The operational efficiency of the PRC was improved and generated a profit with the management and operations handed over to the private sector.

Involving the private sector was seen as a good decision for handling the large-scale processing machine installed at the PRC. In donating the machine, NPCSRP had anticipated that the LA would treat increasing amounts of plastic waste at the PRC, but managing all activities related to waste management, such as waste collection with public awareness campaigns, training of staff on plastic sorting, grading, and processing with a limited budget, time, and human resources became a rising burden for BUC. As a result, the council decided to transfer operations to a private operator under the assumption that BUC would maximise the potential plastic recycling target together with the private operator. As it transpired, both BUC and the private operator achieved their short-term targets, which was to make a profit from plastic recycling activities. Since 2008, BUC has diverted approximately 500 MT of plastic waste from the dumpsite, littering, and burning to recycling. At present, of the total plastics generated within BUC, the maximum amount of non-recyclable plastic that ends up in the final disposal site is limited to 40% (JICA, 2017).

As a result of this innovative business model, BUC received the National Productivity Award in year 2015 under the Local Authority category. The award ceremony is organised annually by The National Productivity Secretariat of Ministry of Productivity Promotion. BUC also received the Green Job Award in 2010 and the Green Silver Award for Best Service Provider from Ministry of Local Government & Provincial Council and Ministry of Environment & Natural Resources in 2012 for the introduction of a school recycling programmes and implementation of an efficient source segregated waste collection and recycling system.

CONDITIONS

- This card is valid only for members.
- If your card is lost you should pay Rs. 25/- as penalty.
- The point card should be marked by the authorized person only.
- The authorized person should validate filled block with a seal.
- One block equal Rs. 4/- total value of this card is Rs. 1000/-.
- Completed card should be handed over to the centre.
- Rs. 1000/- will be paid for each completed card with 15 days.
- This point card is belongs to the Council and every 3R member should agree to above conditions.

Ministry of Local Government and Provincial Councils
National Solid Waste Management Separation Centre

POINT CARD
SAMPATH KENDRAYA
Only for 3R Members

Name _____
School _____
Class _____
Membership _____
Phone No _____
Address _____
Local Authority _____

Signature of Authorized Officer _____
Signature of member _____

3R Society
VIDYALAYA
nsuWSC

Checked _____
(Teacher incharge)
nsuWSC

Figure 17 A Point Card (source: author)

AUTHORS

University of Peradeniya Sri Lanka: Anurudda Karunaratna, PhD, Thilini Rajapaksha, MPhil, With the field assistance from Yasas Gamagedara, MSc, Shenal Kaldera, MSc, and Nadeesha Vidanage, MSc

CCET/ Institute for Global Environmental Strategies (IGES): Kazunobu Onogawa, Premakumara Jagath Dickella Gamaralalage, Miho Hayashi, Rajeev Kumar Singh

REFERENCES

- Alahakoon, Y. and Karunaratna A. K. (2020). Modelling of Post-Consumer Plastic Flow in Municipal solid waste Stream: A Case Study in Few Major Local Authorities of Sri Lanka. In *Urban Mining and Sustainable Waste Management*, ed: Sadhan Kumar Ghosh, Springer Nature Singapore Pte Ltd. ISBN 978-981-15-0531-7, ISBN 978-981-15-0532-4 (eBook). <https://doi.org/10.1007/978-981-15-0532-4>.
- Aruna Shantha A. and Samarakoon A. (2019). Cost Benefit Analysis for the National Post Consumer Plastic Waste Management Project, Central Environmental Authority, 104 Denzil Kobbekaduwa Mawatha, Sri Jayawardenepura Kotte, Sri Lanka.
- Basnayake, B.F.A., Ariyawansa, R.T.K., Karunaratna, A.K., Werahera, S.M., Mannapperuma, N. (2020). A. Pariatamby and M. S. Bhatti Ed. *Sustainable Waste Management Challenges in Sri Lanka. Sustainable Waste Management Challenges in Developing Countries*. IGI Global. Doi:10.4018/978-1-7998-0198-6.ch015. pp 352-381.
- BOI (2017). Annual Report, Board of Investment of Sri Lanka. West Tower, WTC, Echelon Square, Colombo 01.
- Central Bank of Sri Lanka (2019). Annual Report- 2019. Central Bank of Sri Lanka, Colombo, Sri Lanka.
- Dangalla, N., Chandrasena, U., Semasingha, W. and Amarasingha A. (2013). Report of the Survey on the Usage of Polythene Shopping bags and Lunch Sheets in Sri Lanka - Case studies of five Selected Municipal Council. Colombo: Central Environment Authority of Sri Lanka.
- Gunarathna, H.A.Y.R., Kapukotuwa, A.S.B., Karunaratna, A.K. and Basnayake B.F.A. (2007). Construction and Evaluation of a Low Cost, Waste Polyethylene Based Liner for Small Landfills. Proceedings of the International Conference on Sustainable Solid Waste Management, 5 - 7 September 2007, Chennai, India. pp.226-233.
- Ilesinghe, A. M. (2017). Post-Consumer Plastic Waste Generation and Resin Types for Recycling: A Case Study in Kandy Municipal Council. BSc dissertation, Department of Natural Resources, Faculty of Applied Science, Sabaragamuwa University of Sri Lanka, Sri Lanka.
- Japan International Cooperation Agency (2017). Survey on Method of Solid Waste Management Annual Budget Making and Utilizing Waste Collection and Disposal Data in Local Authorities of Sri Lanka- Final Report.
- Kandy Municipal Council (2013). Master Plan for the Kandy Municipal Council Solid Waste Management Division (Year 2014 - 2024). Solid waste management Division, Kandy Municipal Council.
- Ratnakara, R. B. (2000). Market survey on plastic recycling in Sri Lanka, Practical Action, Sri Lanka.
- SACEP (2020), Plastic free Rivers and Seas for South Asia (P171269). Environmental and Social Assessment (ESA), South Asia Co-operative Environment Programme.

For More Information:



IGES Centre Collaborating with UNEP
on Environmental Technologies (CCET)
2108-11 Kamiyamaguchi, Hayama,
Kanagawa 240-0115,
Japan
Tel: +81-46-855-3840
www.ccet.jp
ccet-info@iges.or.jp