

Recycled Plastic Based Industries of Bangladesh: Current Scenario and Future Prospects

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Abstract

This paper investigates the opportunities and challenges to expand the recycled plastics products industry in Bangladesh. The assessment was done through field-survey, focus group discussions and key informant interviews of stakeholders both from the recycling industry and the products manufacturing industry. Financial feasibility analysis for investments in the production of plastic products from recycled resins was found to be a profitable business; despite that the industry was not growing as expected due to a number of barriers. Business models developed for 20 products show that most of them have low payback period (less than 3 years) and the initial capital investment requirement is also low (less than 15 million Taka). The SWOT analysis and FGDs have revealed that (i) the products made from recycled resins are of inferior quality and the intrinsic value of the plastic resin is being gradually destroyed, and (ii) if many entrepreneurs enter the market with new products or if existing producers increase their volume of production, there will be a shortage of recycled plastic resins. The production process (import of high-quality machines) needs to be improved so that higher value products can be made and the recycled resins can be used several times. Additionally better management of post-consumer plastics (waste segregation at source and collection system improvement) is needed so that recycling of waste plastics can be increased. Ways of incentivising the setting up of industries for plastics products from recycled resins for promoting the industrial activities in this sector have been suggested.

Keywords: Plastics recycling; recycled products; profitability; payback period

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1. Introduction

Bangladesh is a resource scarce country. It needs to import most of its raw materials for its growing economy. Being a small country in terms of area, it faces shortage of timber and other construction materials used for rural housing. In this context plastics is a very important material. From wood to metals it can replace in many applications most of the materials that we now use in the modern society. For Bangladesh, the most important aspect of plastic is its low cost for a given application, thus making it affordable even to the poor. With the increase in plastic consumption, there is always associated the issue of proper disposal of plastics wastes. Current practice in Bangladesh with the disposal of waste plastics is landfilling at the dumping sites (Shimo, 2014; Hossain, 2016). To continue the use of plastic at the prevailing high rate, it is necessary to reuse of waste plastic.

In the recycling category there are more than 300 industries ranging in size from medium to small in Bangladesh¹. Many of the plastics industries in both categories are part of the informal sector and are thus ideal candidates for being classified as a small and medium enterprise (SME). The market value of the present plastics manufacturing industries alone is close to US\$ 4 Billion¹, and for an assumed conservative growth rate of 7% per year, the market value will exceed US\$ 8 Billion by 2030.

Data on plastics waste recycling remain inadequate and unreliable for Bangladesh. In a study conducted by Waste Concern in 2006, it was found that nearly 51% of the plastics consumed annually is recycled (Waste Concern, 2006). This was a very positive sign with the expectation that the recycling industry would grow, and the percentage of plastics waste recycled would increase. This expectation did not materialise because in a recent study done in 2019 by Waste Concern, it was found that the percent of plastics waste recycling has gone down to 36% (*National Workshop on Sustainable Management of Plastic to Leverage Circular Economy and Achieve SDG in Bangladesh, 2019*). An analysis of the constituents of municipal solid waste (MSW) in 2014 showed that the percentage of waste plastics was 8.5%². A very recent investigation by the Chemical Engineering Department of BUET found that 11.8% of the MSW is plastics waste³. Thus, the proportion of plastics waste in MSW is steadily increasing. This indicates that post-consumer plastics waste is not being managed properly.

¹ Personal communication with Bangladesh Plastic Goods Manufacturers & Exporters Association (BPGMEA)

² Personal communication with Waste Concern

³ Personal communication with the Principal Investigator of Integrated Concept for Solid Waste to Energy (InConSolE) project (funded by Energy and Power Research Council, Government of Bangladesh)

The increase in the percentage of waste plastics in MSW can largely be attributed to the widespread use of multilayer packaging of foodstuffs. The problem with multilayer packaging is that these cannot be recycled and, being small, pose huge collection problems. This collection problem can be confirmed by two facts – a significant quantity of material in MSW is plastics packaging and the widespread littering of plastic packaging. An interesting finding of the analysis of MSW is that all the waste plastics in MSW are packaging material (soft plastics, i.e., Low Density Polyethylene - LDPE, Polypropylene - PP and Polyvinyl Chloride - PVC). Nearly all the hard plastics such as HDPE (High Density Polyethylene), PET (Polyethylene Terephthalate) and Polycarbonates have been dutifully collected, and hence recycled. Therefore, any increased recycling must come from the management of soft waste plastics.

Recycled waste plastics are extensively used in Bangladesh, but the use in most of the cases is to produce low-end products; this process is known as downcycling. Moreover, the range of products made from recycled plastics is limited. Only recently, the large, reputed manufacturers have started using recycled resin because some of their clients, especially from Europe, have placed orders that require the inclusion of recycled plastics. There remains significant potential of increasing waste plastics recycling and reusing plastic waste as value added products in Bangladesh. Waste Concern, a research and consulting company, claimed that with improved plastic recycling, Bangladesh would be able to save a further 801 million USD as a result of less plastic resin import (*Prospects of Plastics Waste Recycling in Bangladesh*, 2016).

There is a great need to increase the number of products made from recycled plastics as well as to improve the quality of the products manufactured. In this study, the challenges and opportunities of plastic recycling industries of Bangladesh was assessed through field-survey, focus group discussions (FGDs) and key informant interviews (KII) performed on the stakeholders of this sector. Moreover, a number of business models for plastic recycling to assess their economic feasibility for future investments were identified.

2. Methodology

A desk study was conducted to gather information on the current practices in plastic industries, with an emphasis on Bangladeshi practices. Reports, journal and conference papers, and web based (verifiable) sources were used as the source of the desk study.

A field survey was conducted on several local companies who are directly involved with production of recycled plastic-based products. The questionnaire focused on a few major considerations, i.e. – i) how the recycled plastic is handled, ii) what quantity of recycled plastic can be processed per day, iii) what are the characteristics of the final product from recycled plastic, iv) who are the main consumers and the price of the product, and v) how much profit can be made from this business.

Three focus group discussions (FGD) were conducted with entrepreneurs, local and national trade bodies/ associations/ chambers in three different locations: Dhaka, Narayanganj and Chittagong.

Twenty-eight key informant interviews (KII) of the stakeholders relevant to recycled plastic product manufacturing was carried out. The key informants can be grouped in four broad categories: plastic product producers, plastic product retailers, end users and policymakers from various govt. and semi-govt. organizations.

Business models for twenty products manufactured from recycled plastic pellets have been developed. The assumptions for developing the business models are:

- (i) Plant life is 20 years;
- (ii) Operating days are 25 days per month;
- (iii) Minimum Acceptable Rate of Return (MARR) is 10%;
- (iv) Tax is 30%; and
- (v) Scrap value of machinery is 10% of the initial cost.

The typical scale of the industry varied from 600 pieces to 5000 pieces production of recycled plastic product per day, depending on the type of product. All plant machinery was assumed to be state-of-the-art (imported). The ROI was calculated as (Yearly Profit*100/Investment), while discounted payback period was calculated using equation (1) below:

$$\sum_{k=1}^{\theta} (R_k - E_k) \left(\frac{P}{F}, i\%, k \right) - I \geq 0$$

Where R_k excess of receipts over expenses in period k; E_k excess of expenditures over receipts in period k; where $i\%$ is the MARR, I is the capital expenditure

(CAPEX) usually made at the present time ($k = 0$), and θ is the smallest value that satisfies equation (1).

3. Current Practices in Plastic Recycling

There are approximately 5000 small, medium and large size plastic goods manufacturing units in Bangladesh with around 1.2 million workforces directly or indirectly employed in this sector, with an investment of 185.5 billion Taka (Islam, Hasan and Hossain, 2017). Large firms are mostly located in and around the major cities of the country. Small and medium firms are in highly fragmented clusters scattered around the country with the largest cluster being in the Lalbagh-Islambagh area of Dhaka.

The plastic forward supply chain, involving the production of plastic products from virgin plastic resins, starts with the extraction and refining of crude oil, followed by manufacturing of plastic pellets. Bangladesh does not have a petrochemical industry and as a result all polymer pellets have to be imported. The value of import of these plastic materials according to their HS code (Harmonized Commodity Description and Coding System), explained in Table 1, between 2013-14 and 2017-18, are shown in Figure 1. The breakdown of import of polymer resin pellets, totaling 1465 kiloton, for the year 2017-18 is shown in Figure 2. Total cost of import were 154 billion Taka (~1.8 billion USD) and accounted for 2.79% of the total national import for the year. At approximately 375 kilotons, Polyethylene (PE) and its copolymers were the leading category, closely followed by PP, PVC and PET. All other plastics combined were approximately 240 kilotons for the year 2017-18. Average price of virgin plastic resins in 2020 was approximately 105 Taka per kg; price, however, is directly linked to the price of crude oil.

Table 1: Harmonized Commodity Description and Coding System as per National Bureau of Revenue (NBR, 2020)

HS Code	Name of the commodities
3901	Polymer of ethylene, in primary forms
3902	Polymers or propylene or of other olefins, in primary forms
3903	Polymers of styrene, in primary forms
3904	Polymers of vinyl chloride or of other halogenated olefins, in primary forms
3905	Polymers of vinyl acetate or of other vinyl esters, in primary forms; other vinyl polymers in primary forms
3906	Acrylic polymers in primary forms
3907	Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms
3908	Polyamides in primary forms
3909	Amino-resins, phenolic resins and polyurethanes, in primary forms
3910	Silicones in primary forms
3911	Petroleum resins, coumarone-indene resins, polyterpenes, polysulphides, polysulphones and other products, in primary forms
3912	Cellulose and its chemical derivatives, in primary forms
3913	Natural polymers and modified natural polymers, in primary forms
3914	Ion-exchangers based on polymers of HS code Nos. 3901 to 3913, in primary forms
3915	Waste, parings and scrap, or plastics

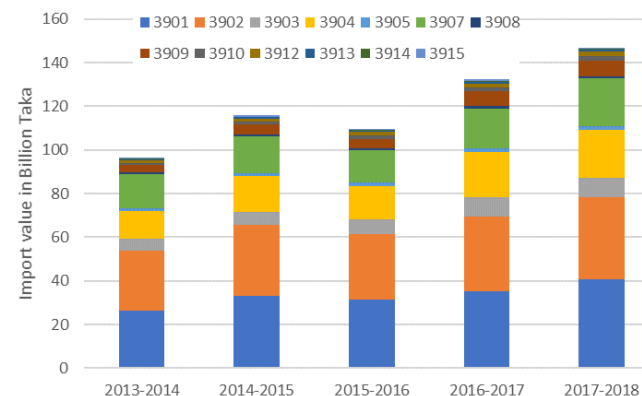


Figure 1: Import value of plastic raw materials between 2013-14 and 2017-2018

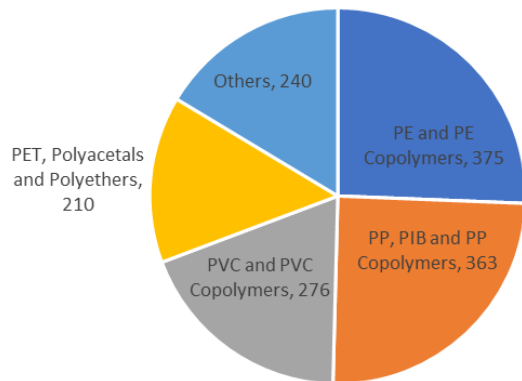


Figure 2: Plastic raw materials import in 2017-2018 in Kilo Ton

The forward supply chain for plastics in Bangladesh starts from the import of pellets. The pellets are supplied to the plastic product manufacturers who then produce different types of plastic products. The plastic products are then either sent to the retail sector or used by the industrial sector before reaching the consumers. The discarded plastics from the manufacture of plastic products and post-consumer plastic wastes then contribute to the industrial, commercial and municipal solid wastes, respectively. Figure 3 shows the forward supply chain for plastics in Bangladesh.

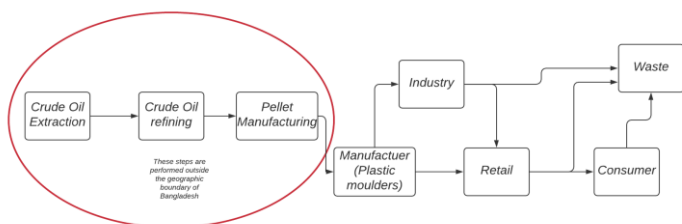


Figure 3: Plastic forward supply-chain in Bangladesh

The plastic recycling supply-chain starts with the collection of used plastic. The existing plastic recycling supply-chain is shown in Figure 4.

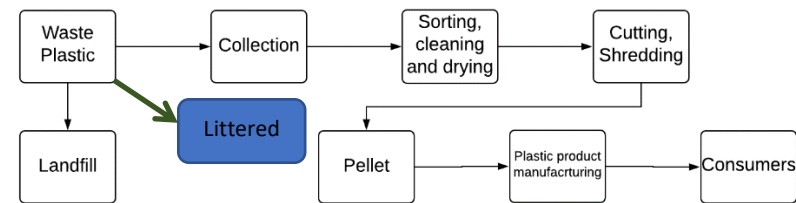


Figure 4: Plastic recycling supply-chain in Bangladesh

There is no accurate data on the amount of waste plastic generated every year. It is estimated that 25% of the total annual generation ends up as waste, which is approximately one million tons (Enayetullah and Sinha, 2019). Bangladesh currently does not have a formal system of collection and recycling of waste plastics. The waste plastic generation in the country can be categorized according to their source of generation: industrial, commercial, and household. The waste generated from the first two categories can be collected more efficiently than the waste generated from household uses. The household waste is generally collected by waste collectors who usually provide their service in exchange of a monthly fee. The plastic wastes disposed by the households are usually separated by these waste collectors at the source before transferring the waste to the secondary transfer stations for MSW. The soiled waste plastic is usually not collected and finds its way to landfilling sites operated and maintained by the city corporations or municipalities.

Littering is a common practice, and therefore, a significant quantity of plastic wastes accumulates in streets, parks, canals, rivers and in the sewerage system. Littered plastic products, as well as plastic items from the dustbins, dumpsters, secondary transfer stations and landfills, are also collected by street children and sold to small-scale buyers. A material flow diagram of waste plastics in Bangladesh for the year 2019 (Enayetullah and Sinha, 2019) is shown in Figure 5.

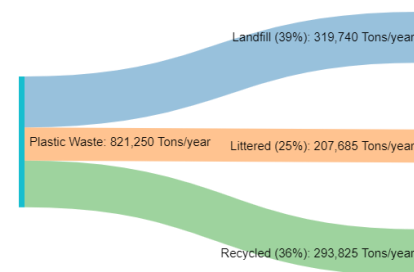


Figure 5: Plastic waste situation of urban areas of Bangladesh for the year 2019 (Enayetullah and Sinha, 2019)

The plastic products are sorted according to their types and colours. The sorting is done manually. The workers use their limited knowledge on plastic to sort the items. The sorting also includes separation of soiled and unsoiled categories. The soiled plastics are washed using in-house water drums/tanks or in the river.

Sorted and cleaned plastic are sent for cutting and shredding. The shredders used in Bangladesh are mostly locally fabricated. The shredded plastic is washed and dried before sending to the pellet manufacturers. The pellet mills use moulding followed by cooling and cutting to prepare recycled plastic pellets.

The small-scale plastic products manufacturers collect the recycled plastic pellets according to their needs and manufacture various items. When it comes to recycled products, the usual practice for a small-scale manufacturer is to produce one product only. This is because moulds are very expensive, and they usually own only one mould to produce a particular product. Some manufacturers mix virgin pellets with recycled ones to improve the quality of the final products.

Large-scale recyclers are mostly involved in recycling of PET. Bangladesh Petrochemical Company Limited (BPCL) is the first of its kind and can produce 10,500 tons of recycled PET resins every year. Several other companies also have processing lines for waste PET bottles.

The local manufacturers are currently producing a wide array of products mostly to meet the need of the local market. Production for local market accounts for more than 80% of total production (Islam, Hasan and Hossain, 2017). Majority of the export-oriented producers are co-dependent on the garment industries as they produce plastic products as accessories for apparel. Some manufacturers export their products directly to Europe, USA, Canada, and Asian countries.

Small manufacturers depend on wholesalers to market their products. Medium manufacturers also depend on wholesalers. However, some of the medium sized producers own shops in major wholesale markets. Large manufacturers usually have their own distribution channels. The distribution channels usually consist of a network of distributors, dealers, and retailers. In addition to these channels some of the large manufacturers have their own chain shops around the country to directly sell their products to the consumers.

4. General business structure

The scale of business of the recycle resin producers is small to medium. The owners usually start their business as a sole proprietor, and it remains the same for the duration of the business. The business is usually operated from a rented place, with no more than one technician, a few skilled workers and some unskilled sessional workers. In many places, the proprietor also serves the role of technician. The proprietor, technician and skilled workers are usually male, while there is a larger share of female in the unskilled labour group. According to the survey, partnerships are not unheard of but are rare for this business.

The survey showed a wide variation in the age of the proprietors, from below 30 to 60 years. Even the younger owners have long experience of this business since they start very young, in their early twenties. At the initial stage of the business the owners take loans from private individuals as well as from Banks and other money-lending organizations. However, there is a wide range on the interest rates for loan from private individuals and varies from 5% to 19%. On the other hand, loans from various financial organizations have similar cost; the interest rate varies between 14 to 17%, identified from the field survey.

The businesses are usually a part of trade bodies such as Bangladesh Plastic Goods Manufacturing and Exporters Association (BPGMEA). Most of the owners have got trade license for their business. However, none of the trade licenses are current as they were not renewed after expiration.

The machineries used by the recycled resin manufactured are locally fabricated with a few exceptions. The imported machines were sourced from China or Taiwan. The purchased cost of the imported machines was expensive, even costing 10 times of the locally fabricated machines for per unit capacity of production. All recycled resin manufacturing facilities have pellet machine (also known as “dana” machine), while some facilities also have cutting machine (for cutting/shredding of the waste plastic to make flakes) and mixing machine (for cleaning and adding colour).

The scenario is opposite for the plastic product manufacturers. The injection moulding machines were sourced from China or Taiwan. Only one the manufacturers have locally fabricated moulding machine.

According to the proprietors, there is no shortage of raw materials. However, there may be delays in the supply of raw materials during monsoon as the supply slow down due to difficulties in collecting and transporting of waste plastic. The

recycled resins are products of high demand and readily consumed by the plastic product manufacturers. The resins recycled by the pellet manufacturers include but not limited to LDPE, HDPE, PP, PS (polystyrene), PVA (Polyvinyl Alcohol) and ABS (Acrylonitrile Butadiene Styrene).

For the plastic product manufacturers, they usually own moulds for single products. The products range from disposable spoons, plates, glasses, food-boxes, buckets, shoes to electrical switch boards and components of ceiling fans.

5. SWOT Analysis

A strength, weakness, opportunity, and threat (SWOT) analysis was performed based on 28 key informant interviews (KII) performed on a wide range of representatives directly or indirectly connected to the recycled plastic sector. The roles of the interviewees can be classified into four major categories: plastic products producer, plastic dealer, plastic user and policymaker/technology developer. The summary of the KIIs as SWOT analysis is presented in Table 2.

Table 2: SWOT Analysis of recycled plastic sector based on Key Information Interviews

Strength	<ul style="list-style-type: none"> • Low cost of recycled plastic products • Huge demand for plastic products due to their versatile properties • Recyclability of plastic products • Low labor cost and high profitability • Good balance between the supply and demand of plastic products 	<ul style="list-style-type: none"> • Overpriced raw materials • Poor quality of available machineries • The absence of proper supply chain for recycled resins • Lack of skilled manpower • Post-consumer collection of plastic goods • Absence of guideline for recycling plastics • Absence of health and safety measures 	Weakness
Opportunity	<ul style="list-style-type: none"> • Products from recycled resins can be increased by introducing new items • New products can be produced by recycling PVC, HDPE, and PPE • Plastic waste segregation at source and collection system improvement would create new possibilities • Production can be increased by promoting more recycling • Soft loans on easy terms and better technology for recycling, can open up new opportunities 	<ul style="list-style-type: none"> • Disruption of the informal supply chain leading to shortage of waste plastic • Biodegradable and environment friendly products like jute and fabric products can be used as alternative products • Government restrictions on plastics products especially on the use of recycled materials as food grade plastics • Entry of large-scale factories for recycled plastic product • No policy support from the Government for plastic recycling industries 	Threat

Along with the KIIs, three focus group discussions based on three locations (Dhaka, Chattogram and Narayanganj) were carried out to identify the potential issues hindering the rapid growth of this sector. The discussants pointed out the core issues

that are relevant to recycled plastic processing and production of recycled plastic products. They highlighted the possibilities of developing new products and, asked for supports from the concerned bodies of the government to make this sector flourish. The major issue with recycling plastic and recycled plastic products in Bangladesh was identified as the quality control and lack of technical knowledge. Training is needed for plastic sector to identify the food grade plastics and other types of plastics. Moreover, automation can be brought in by large companies, but for small and medium enterprises, it is important to organize training sessions to run the local recycled plastic production machines efficiently and safely. Without good quality products, it will not be possible to keep the export oriented recycled product producing industries in operation. Also, the participants expressed their opinion to consider the recycled plastic product sector as a green or environment friendly sector by national and international bodies.

Another issue (especially for PET flakes) is the raw material unavailability. Moreover, there is no grading of the recycled plastic products (logo or, marking to determine the quality or, grade of the product). There is no dedicated body to take care of this issue to segregate the plastic products according to their quality. Also, laboratory support to test these products would be also essential for this sector to identify good quality recycled products.

Focus group discussants coincided on the verdict that recycling plastic and producing recycled plastic products help the environment as plastic products cannot be completely avoided in any future scenario. Emphasis was given on converting waste to asset through plastic recycling and reusing it through new innovative application areas.

6. Economics of Plastics Products Manufacturing Using Recycled Resins

Natural gas and crude oils are the primary raw materials of plastic. Therefore, the production cost of plastic products depends on the natural gas and oil price around the world. If there is a hike in gas and oil prices, the virgin plastic resin price increases.

Landfilling, incineration and recycling are the three main processes to deal with post-consumer plastics wastes. Among the above 3 routes, the most environmentally friendly option is the recycling of plastics (Chen *et al.*, 2019). Energy can be recovered from waste plastic from incineration. However, the process is not environmentally friendly. The waste plastic handling is to landfill which has the highest environmental burden because plastics can remain in its original state and cause all kinds of problems for hundreds of years. other processes

such as hydrocracking, pyrolysis and fluid catalytic cracking are yet to achieve full commercialization (Ragaert, Delva and Van Geem, 2017; Gu *et al.*, 2020).

The financial analysis has been performed for the entire business model to determine the financial parameters such as return on investment (RoI) and payback period (discounted at 10% MARR). The key outputs from the models are provided in Table 3. The return on investment is high for most of the investments. All the industries from the recycled plastic products were found to be very profitable except business model number-7, which takes 7 years to recover the investment.

It has been observed that the production cost of plastic products from recycled resin is significantly lower than from virgin resins, thus making the investment recoverable in a short period. From the financial analysis, it has been seen that recycled plastic-based industries are highly profitable. That the risk of investment in this sector is low has also been confirmed by surveys of small and medium industries in Dhaka and Narayanganj.

An interesting finding of this research is that the recycled plastics products are mostly made from polypropylene (PP). As can be seen from Table 3, all but three products utilise PP. From Figure 2, it can be seen that PP constitutes only about 25% of the total polymers used in the country. The other polymers are therefore either not being collected properly or the recycling techniques of these polymers are not well established in Bangladesh. This could be one of the reasons why the recycling rates are low. This implies that a lot of applied research is needed in Bangladesh in expanding recycling of others polymer types such as PVC, HDPE and PET.

Table 3: Key outputs from the business models

Sl. No.	Product Name	Raw Material	CAPEX (Tk)	OPEX ^{**} (Tk/month)	Payback Period (years)	Return on Investment (%)
01	Footwear	PVC	9913075	408075	3	42
02	Bucket	PP	10803500	873500	3	49
03	Mug	PP	10254100	584100	3	45
04	Fan blade	PP/ABS/HIPS	10116750	511750	1	165
05	Switchboard	Crystal HIPS*	14797500	3017500	1	112
06	Jorda pot	PP	12863750	1958750	4	36
07	Egg tray	PP	10528800	728800	7	22
08	Jewelry box	PP	10116750	511750	3	41
09	Hanger	PP	9979400	439400	3	48
10	Flower tub	PP	10803500	873500	3	49
11	Waste Bin	PP	10803500	873500	3	49

Sl. No.	Product Name	Raw Material	CAPEX (Tk)	OPEX ^{**} (Tk/month)	Payback Period (years)	Return on Investment (%)
12	File Cover	PP	9773375	330875	4	37
13	Gardening water can	PP	10116750	511750	3	41
14	Water Pot	PP	10116750	511750	3	41
15	Toys (cars)	PP	9773375	330875	4	37
16	Service Tray	PP	10288437	602187	2	94
17	Mobile Cover	PP	9979400	439400	2	90
18	Showpieces	PP	9979400	439400	5	27
19	Plastic Tool	PP	10116750	511750	2	62
20	Plastic bobbin	PP	9773375	330875	4	37

* HIPS - High Impact Polystyrene

**OPEX – Operating Expenditure

However, the availability of financial support is inadequate for investing in this lucrative sector. This is mostly due to the wrong portrayal of the sector and due to the lack of proper authorization of the industries from authorities such as the Ministry of Industries and Department of Environment (DoE). The sector still needs support from the Government and other relevant authorities and organizations and academics. There are still plenty of scopes for improvement in all aspects: collection, production, profitability, workers' safety, etc. Besides, recycling plastic is limited by the number of recyclers. If plastic is recycled twice, it might not be possible to recycle anymore (depending on the type of plastic).

7. Existing Policies and Implementation

To obtain the maximum benefit from plastic recycling, the so-called circular economy has been proposed for the European Union (European Commission, 2014). It maintains a hierarchy of using of plastic products (when to recycle and when to dispose) through minimum waste generation; the fundamental concept being plastic products need to be designed in such a way to make them easily distributable, collectable and reusable/recyclable. To reduce the environmental burden of plastic wastes, sooner or later, Bangladesh will have to adopt a circular economy or, similar strategy (e.g., 3R - Reduce, Reuse and Recycle) to balance the plastic product uses, recycling and final disposal as incineration or, conversion to energy.

Regarding the plastic industries in Bangladesh, a draft for national plastic industry development policy has been prepared in 2020 by the Ministry of Industries (modification is on-going on the draft) (*National Plastic Industry Development Policy Draft, Ministry of Industry, 2020*). This policy is developed for the plastic product producers and their waste management. However, there is

no definite guideline for recycled plastic product manufacturers. To include the efforts of the plastic recyclers and support the recycled plastic product manufacturers, a clear policy is required to identify the method for plastic waste collection and their reuse. To ensure this, it could be proposed that at least 40-60% recycled plastic should be used in non-food grade plastic products. Incentives might be given to the small-scale recycled product manufacturers to rejuvenate this sector.

Apart from the National Plastic Industry Development Policy, there are three other government policies that are relevant to plastic industries (as listed in BPGMEA), namely – export policy, import policy and industrial policy. Apart from these, SME policy strategies (published in 2005) is also considered as a relevant policy. However, all these documents merely mention that the plastic industry is a potential thrust sector for business which might need support for further development. Also, all of these documents are published before 2011. Moreover, none of the policies are directly relevant at providing any sort of guideline for developing sustainable industries and practices for plastic and recycled plastic. It is imperative to revise the existing policies and to formulate new policies to support the sustainable growth of these industries through appropriate guidance.

The polyethylene bags under 55 µm thickness are banned under section 6(A) of the Bangladesh Environmental Conservation Act (BECA) 1995 (*The Bangladesh Environment Conservation Act, 1995*). Also, the High Court recently directed the concerned authorities to ban single-use plastic products in coastal areas, hotels, motels and restaurants across the country as these are causes of health and environmental hazards (Rahman, 2020). However, this ban has not been implemented.

The Department of Environment (DoE) and World Bank are implementing a technical assistance (TA) program to develop a roadmap to reduce plastic pollution. The TA program consists of a baseline study to formulate a circular economy model for plastic in Bangladesh. The study includes waste plastic generation in three major cities: Dhaka, Chittagong, and Cox's Bazar.

Another component of the on-going TA project is a three-phase approach of Extended Producer Responsibility (EPR) policy in Bangladesh. The first phase is a pilot study in Narayanganj and includes formalization of plastic collection and recycling led by private sector. Second phase is focused on pilot institutionalization of EPR policy by formulation of fee structure (e.g., fee

charged to manufacturers, producers and refund/subsidy provided to collectors/recyclers). The final phase is development of legislation of EPR policy and setting up standards for recycled materials.

DoE has published a solid waste management rule in late 2021 (*Solid Waste Management Rules (SWMR), 2021, 2021*). This rule emphasizes on recycling plastic wastes after segregation from organics, and in some cases, incineration (wherever applicable). While the rules are in place, it is necessary to implement those to obtain the desired results to mitigate the environmental burden as well as to motivate the small and medium entrepreneurs who are contributing to the plastic recycling process.

8. Conclusions and recommendations

This study focused on the downstream part of the recycled plastic industry, i.e., the production of retail plastic goods from recycled waste plastic resins. The study also looked briefly at the recycling of plastics wastes, i.e., the production of waste plastics resins. Also, for the sake of completeness the import of virgin resins and the production of plastic goods from those resins, which ultimately after use end up as post-consumer wastes, was scanned.

The five main findings of the study are –

1. The waste collection system is totally unorganized leading to huge quantities of wastes rounding up in landfills and being littered
2. The production of recycled resins is done mainly by the informal sector in small to medium scale industries
3. The supply of sufficient quantity of good quality resins prevents manufacturers from making better quality products
4. The production of plastic products from recycled plastics is a vibrant and profitable business, however, many challenges exist, such as unskilled workforces, operation without approval from proper authority, insufficient policy-level support, etc.
5. The plastics recycling industry need to be strengthened both for reducing the environmental burden and promoting the production of products using recycled plastics

At its current state, the production of plastic products from recycled resins is a viable industry and new products can be promoted. Business models developed for 20 products show that most have low payback period (less than 3 years) and the initial capital investment requirement is also low (less than 15 million Taka). Thus these are ideal as SMEs.

The SWOT analysis and FGDs have revealed that there are several serious weaknesses and threats in this business. Two noteworthy issues that need to be considered in promoting the business are (i) the products produced from recycled resins in Bangladesh are of inferior quality and the intrinsic value of the plastic resin is being gradually destroyed, and (ii) if many entrepreneurs enter the market with new products or if existing producers increases their volume of production, there will be a shortage of recycled plastic resins in the market. Therefore, there is need and urgency to improve the production process (import of high-quality machines) so that the recycled resins can be used several times and higher value products can be made. Additionally better management of post-consumer plastics (waste segregation at source and collection system improvement) is needed so that recycling of waste plastics can be increased. To provide additional incentives to plastics waste recycling (i) tax on virgin resins can be imposed (ii) extended producer responsibility (EPR) can be introduced (iii) an industrial zone can be created, (iv) a plastic quality testing/certifying laboratory can be set up, and (v) a training institute can be established.

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