

## ECONOMIC ASSESSMENT AND POTENTIALITY OF JUTE CELLULOSE BASED BIOPOLYMER (SONALI BAG®) IN BANGLADESH

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**Abstract.** With the undeniable demands of this era to develop and use eco-friendly reusable packaging material, the single-use biopolymer “Sonali bag” is a suitable alternative to plastic bags. The main focus of this study was to explore the production process, economic profitability and market potential of Sonali bags in Bangladesh. Besides secondary data, primary data were collected from Dhaka and Mymensingh districts followed by descriptive statistical analysis. Manufacturing of Sonali bags starts with raw jute collection and processing, then go through several steps that finally end with the printing of bags. The plant generated a profit of TK. 288.29 million annually (BCR 2.41) and if the price of the bag drops to half from the current (Tk.10/piece) that also yields profitability with BCR 1.34. Besides, at the current selling price (TK. 1200/Kg) and assuming 10% replacement of plastic bags use estimates TK. 56.07 billion market potentiality of Sonali bag annually in Dhaka city.

**Keywords:** Sonali bag, Biopolymer, Biodegradable, Jute cellulose, Green packaging material.

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### 1. Introduction

The sustained stability and expansion of Bangladesh's national economy have historically been closely tied to its agricultural sector, with particular emphasis on the cultivation of jute (*Corchorus* spp.). As the second-largest producer of jute globally, Bangladesh has played a pivotal role in meeting approximately 42% of the world's demand for jute goods (World Atlas, 2017; Arista Export, 2020). However, the jute industry in Bangladesh has experienced a gradual decline in recent decades. In the last few decades, global warming and awareness of the use of eco-friendly goods have created a new opportunity to produce more jute as well as jute-diversified products. Bangladesh has already taken this opportunity by producing some day-to-day necessary diversified jute products that are friendly to the environment. In this situation, there is a possibility to bring back the golden era of jute by production of jute cellulose based products. The invention of Sonali bag, a biodegradable and environment-friendly bag made from jute,

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has generated a buzz at home and abroad with its potential to substitute single-use plastic bags. There are a few alternatives to hazardous plastic poly bags where Sonali bags are more suitable than other conventional cellulose sources like wood pulp. The biopolymer Sonali bag has been developed as a green packaging material that is a suitable alternative to harmful petroleum based plastic bags due to its high biodegradability, higher strength, reusable raw materials, higher stability in water and low cost (BJMC, 2017) that leads to reduce environmental pollution as well as an increase in the economic growth of Bangladesh.

On the other hand, 1 million plastic bags are used every one minute worldwide (Pavel & Supinit, 2017) where Bangladesh's annual per capita plastic consumption in urban areas is 9 kg. In Dhaka city, 80% of water clogging is caused by plastic bags (BJMC, 2017). Used discarded polyethylene bags, in most cases accumulate in drains, canals and reservoirs causing water-logging conditions which have become a threat for rivers as sea water living animals (like fish, animal and plant parts). Being concerned about this problem around the world, Bangladeshi scientists have been searching for solutions for a long time, which has led to the development of biodegradable and sustainable packaging material Sonali bag from jute as a suitable alternative to polyethylene. The importance of using eco-friendly, biodegradable Sonali bags is an essential step towards sustainability for a densely populated country like Bangladesh. The demand for biodegradable packaging material is not only increasing nationally but also internationally. Globally, jute poly bag packaging material has become the best alternative to petroleum based plastic bags.

The concept of green packaging is relatively new. A few companies are producing bioplastic poly bags that are made from crude oil and natural gas non-renewable sources that are not fully biodegradable. Literature analysis found that, in the last one-and-half decade, few biodegradable polymer packaging bags have been developed utilizing raw materials such as cellulose shellac, orange and banana peels, bamboo fiber, rice and sugar cane husk, cons, potato and sweet potato, shrimp shells and so on. The majority of them are produced with the funding of the government and environmentally conscious organizations, however owing to the long time of raw material production, high production costs and inferior quality of handy poly bags, these products do not sustain long in the market. On the contrary, biopolymer Sonali bag (Bangladeshi scientist invented) might be a suitable alternative of polythene bags because of its relatively low cost than other biodegradable packaging bags, high biodegradability (complete biodegradability in soil within 3 to 5 months), higher strength (ability to carry 1.6 times more weight than a polythene bag), quick raw material cellulose production (110-120 days), reusable raw materials and environmentally friendly manufacturing process (BJMC, 2017).

Permanent cessation of the use of banned polythene is possible if appropriate marketing efforts are made for the biopolymer Sonali bag. The market for biodegradable packaging is projected to reach US\$ 65.58 billion in 2022 and US\$ 78.1 billion by 2026. In a similar vein, Bangladesh need to concentrate on producing Sonali bags made of jute polymer as an environmentally friendly substitute for polythene bags in addition to serving national interests (domestic needs and export). Bangladesh could only meet a third of the global jute demand if all of the jute produced there was utilized to make jute polymer bags or other packaging products (Islam & Ali, 2021). Jute cellulose-based biopolymers Sonali bag is an innovative as well as value-added product that helps to gain a share in the world economy.

Furthermore, as jute is the primary cash crop, Bangladesh's rural economy may benefit immensely from encouraging jute production through a variety of jute uses. As a result, increasing the production of Sonali bags and spreading information about them will create a significant footprint for the whole world. As this innovative product is comparatively new in Bangladesh, it is also important to plan how to market this product along with the production expansion. This study provides insight to explore the production technology and market potentiality of jute based Sonali bags.

According to research, banana peel-derived material, orange peel trash and fruit waste account for the majority of biodegradable plastic (Chandarana *et al.*, 2021; Yaradoddi *et al.*, 2021; 2016). Additionally, shrimp shells (Gupta *et al.*, 2019; Darwin *et al.*, 2021; 2018), cassava flour, rice husk and sugarcane, bamboo fiber-PLA composite and starch-based polymeric composites are used by the food packaging industries in India and Indonesia for packaging or carrying bags. Numerous studies (Sonawane *et al.*, 2021; Mallic *et al.*, 2020; Abdullah *et al.*, 2019; Pan *et al.*, 2016; Mulyono *et al.*, 2015) demonstrated the sensitivity of starch-based polymers for food packaging, which are a viable alternative to petroleum-based polymers. Conversely, research by (Obradovic *et al.*, 2017) found that cellulose bio-composite films outperformed other biopolymer in terms of mechanical performance.

Though the market for biopolymer packaging materials is rapidly expanding throughout the world, there are just a few research studies on the subject in Bangladesh. As a result, assessing the current demand and possibilities for jute cellulose-based biopolymer packaging would aid in increasing the market potential and profitability of the Sonali bag. This study aims to address a research gap in the manufacture and marketing of Sonali bags in Bangladesh and throughout the world. The findings will assist in developing an effective marketing strategy and price policy for Sonali bags in Bangladesh. It will have a substantial impact on problems such as environmental, temperature, air, soil and marine pollution, as well as the potential to retain the glory of Bangladeshi jute in the international market.

## **2. Materials and Method**

### ***2.1. Data Sources***

Primary data were collected through personal observation and in-depth interviews of Dr. Mubarak Ahmad Khan (the inventor of the Sonali bag and the scientific advisor of Bangladesh Jute Mills Corporation), managers and other technicians at Latif Bawany Jute Mills Ltd. in Demra, Dhaka. A total of 80 (eighty) Sonali bag users of Dhaka and Mymensingh districts were selected by using purposive sampling and interviewed through a semi-structured questionnaire from February to April 2021. Besides primary data, secondary data were also collected from relevant websites, articles, research papers and journals, textbooks and annual reports.

### ***2.2. Analytical Technique***

The conventional descriptive statistics were employed in analyzing the data which is based on the 'Sonali bag pilot project' under Bangladesh Jute Mills Corporation and different sources related to Sonali bag production. The profitability of the Sonali bag production was measured in terms of gross return, gross margin, net return and benefit cost ratio (undiscounted).

**Net Returns**

To calculate net return or profit, the following formula was used:

$$\text{Net return} = \text{GR} - \text{TC},$$

where, GR = Gross return and TC = Total cost.

Gross return (GR) was calculated by adding the annual Sonali bag total return and by-product (lignin) total return of the Sonali bag production plant. Total cost (TC) is the summation of total fixed cost and total variable cost.

**Benefit Cost Ratio (BCR)**

The benefit-cost ratio is a relative measure that is used to compare benefits per cost. The following formula was used to calculate the undiscounted benefit cost ratio.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return}}{\text{Total cost}}$$

**Estimation of Total Market Potential**

The total market potential is the maximum sales available to all firms in an industry during a given period, under a given level of industry marketing effort and environmental conditions. A common way to estimate total market potential is to multiply the potential number of buyers by the average quantity of each purchase, times the price (Kottler and Keller 2015). The total market potential is estimated using the Chain Ratio Method. This method involves multiplying a base number by several adjusting factors that are believed to influence market sales potential.

$$\text{Market potential, MP} = N \times Q \times S \times P$$

where,

MP = Market Potential;

N = Total number of potential customers (Total population of the area);

Q = Average annual consumption of plastic bag;

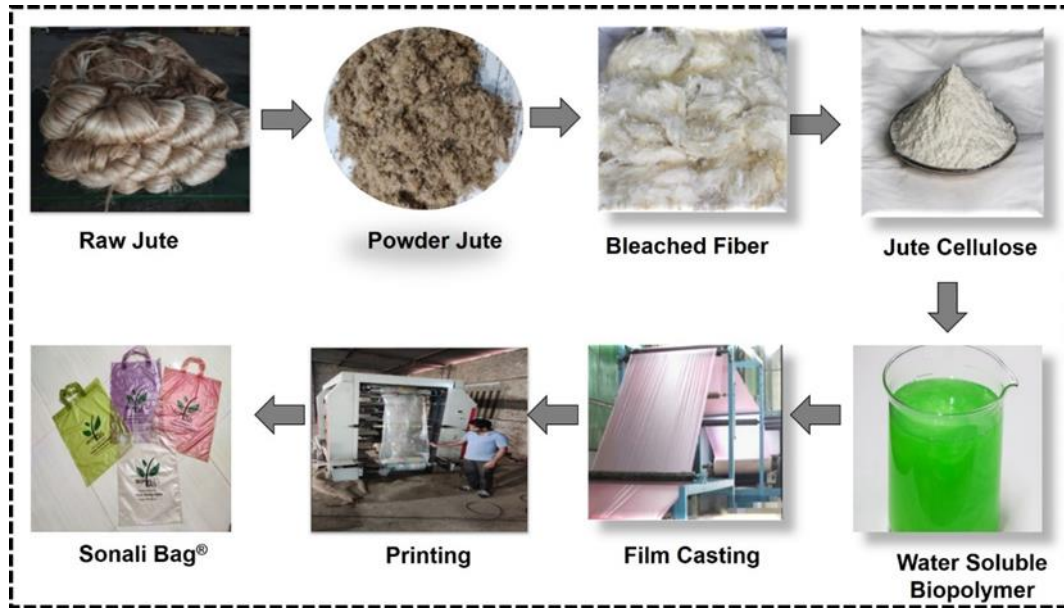
S = Share of plastic bag consumption (Percent of plastic bag use replaced by Sonali bag);

P = Average selling price of Sonali bag.

**3. Results and Discussions****3.1. Production Technology of Sonali Bag**

The innovation of jute cellulose-based biopolymer packaging material is not only a revolution in Bangladesh but also around the world. Since the single-use jute cellulose based biopolymer “Sonali bag” is a new technology, its production technology is incredible and new and innovative also. Quality raw jute is required to start the process of Sonali bag manufacturing. Based on the required characteristics, jute is collected from the market (from a merchant or direct farmer). Raw jute is available almost all year round in local markets in Bangladesh, although during the peak jute-growing season, prices are considerably lower. The cost of jute is influenced by the quantity and quality of demand on a domestic and international level. Generally, Bangladesh Jute Mills Corporation provides the raw jute for the Sonali bag project (BJMC, 2017). Jute is a natural fiber that comes second only to cotton in terms of production and application of vegetable fibers. Moreover, Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads, fiber is off-white to brown and 1- 4 meters long (BJMC, 2017). In production, 1 kg of jute is required to produce 1 kg of Sonali bag. The biodegradable jute fiber is

chemically composed of cellulose (65.2%), hemi-cellulose (22.2%), lignin (12.5%), watersoluble matter (1.5 %) and fat and wax (0.6%) (BJMC, 2017). The steps involved in Sonali bag production process are shown in Figure 1.



**Figure 1.** Steps involved in the Sonali bag production process

The jute cutting machine sliced 3 to 4 meter long jute into 1.5-2cm pieces, allowing jute cellulose to be extracted by mixing it readily in a chemical solution. The cellulose extraction machine separated the cellulose by a chemical process that took 3 to 4 hours and the cellulose derivative machine converted it into water-soluble cellulose using chemical components. After that, an autoclave (homogenized machine) was used to properly mix the water-soluble cellulose, food-grade color and other chemical components for the biopolymer liquid solution which followed storing in the cooling machine before proceeding to the next step. A 100ft converse machine was used to convert the liquid soluble materials into biopolymer sheets whereas 1 ton of liquid polymer solution turned into a polymer sheet within 24 hours (BJMC, 2017). Various food-grade colors were added to the polymer sheets to make them more appealing, but not harmful to health. This fourteen-chambered machine starts with a liquid biopolymer solution supplied in the first chamber, which ends as a Sonali bag sheet in the last chamber. After that, Sonali bags were printed using the newest six-color printing technology. The bags were then produced automatically using a bag producing machine in a variety of preset sizes and forms.

### **3.2. Profitability Analysis**

#### **3.2.1. Production Cost Estimation of Sonali Bag**

In analyzing the profitability of a production facility for single-use Sonali bags, all expenses incurred in production and the gross profit from selling the final product are taken into consideration. These costs are based on data from the “Sonali bag pilot project” conducted by the Bangladesh Jute Mills Corporation and other relevant sources are shown in Figure 2. The total production cost for Sonali bags is Tk. 211,032,668, with fixed costs amounting to Tk. 4,751,273 and variable costs totaling Tk. 200,443,668.

Assuming full plant capacity, around 365,000 kg of Sonali bags could be produced annually. Consequently, the cost of producing 1 kg and 1 piece of Sonali bag is Tk. 562.18 and Tk. 4.69, respectively as described in Table 1.

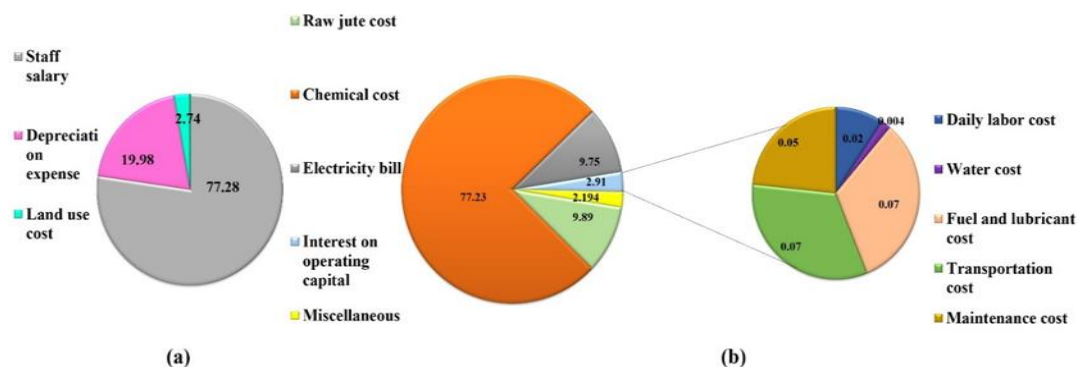
**Table 1.** Costs of Sonali bag production

Sl. No.	Cost item	Cost (Tk. / year)	Percentage
<b>Fixed Cost (FC)</b>			
1	Staff salary	3672000	77.28
2	Depreciation expense*	949273	19.98
3	Land use cost	130000	2.74
<b>Total FC</b>		<b>4751273</b>	<b>100</b>
<b>Variable Cost (VC)</b>			
1	Raw jute cost	19800000	9.89
2	Daily labor cost	50000	0.02
3	Chemical cost	154800000	77.23
4	Water cost	7300	0.004
5	Fuel and lubricant cost	150000	0.07
6	Electricity bill*	19548203	9.75
7	Transportation cost	150000	0.07
8	Maintenance cost	100000	0.05
9	Interest on operating capital	5838165	2.91
<b>Total VC</b>		<b>200443668</b>	<b>100</b>
Total fixed cost		4751273	2.31
Total variable cost		200443668	97.69
<b>Total cost</b>		<b>205194941</b>	<b>100</b>
Production cost of Sonali bag per kg (Tk.)		562.18	
production cost of Sonali bag per piece (Tk.)		4.69	

**Source:** Author's estimation based on collected data, 2021

**Note:** \* details shown in Appendix Table 1 & Appendix Table 2





**Figure 2.** Cost analysis of Sonali Bag production (a) fixed cost (b) variable cost

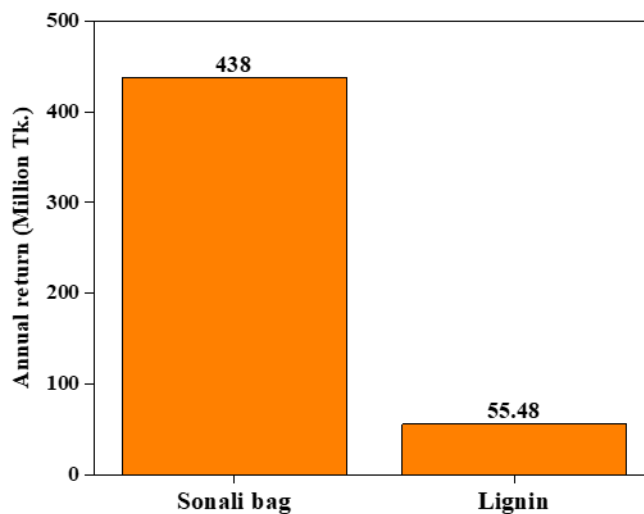
### 3.2.2. Gross and Net Return from Sonali Bag Production

According to the machine capacity, per day Sonali bag production size is 1000 kg which generates 365000 kg annually. By considering the current selling price of BJMC, it generated Tk. 438000000 annually, which accounts for 88.76% of the total return of the Sonali bag production plant, as shown in Table 2.

**Table 2.** The gross return of Sonali bag production 1 tons (1000 kg)

SI. No.	Items	Annually production amount (kg)	Price (Tk. /kg)	Annual return (Tk.)	Percentage of total return
1	Sonali bag	365000	1200	438000000	88.76
2	By product (Lignin)	36500	1520	55480000	11.24
<b>Total return=493480000 (Tk.)</b>					
Gross return of Sonali bag per kg (Tk.)					1352
Gross return of Sonali bag per piece (Tk.)					11.27

Source: Author’s estimation based on collected data, 2021



**Figure 3.** Annual return of Sonali bag production

In the Sonali bag production process, jute, the raw material, undergoes chemical treatment in a cellulose extract machine to separate it from other components such as lignin, fat, wax, hemicellulose and water-soluble matter (BJMC, 2017). About 10% of lignin is extracted from raw jute during this process and it commands a significant market value worldwide. At the current price of \$16 per kg (Alibaba.com, 2022), this results in an annual turnover of Tk. 55,480,000 (considering an exchange rate of \$1 = 95 BDT) for the Sonali bag production plant as shown in Figure 3.

Table 3 reveals that the net return or profit from the Sonali bag production plant is Tk. 288,285,059. Given the current selling price set by BJMC, the net returns from producing 1 kg and 1 piece of Sonali bag amount to Tk. 637.82 and Tk. 5.32, respectively. With an overall average benefit-cost ratio of 2.41, it is evident that operating the Sonali bag production plant is indeed profitable.

**Table 3.** The net return of Sonali bag production plant

Sl. No.	Items	Amount (Tk.)
1	Gross return	493480000
2	Total cost	205194941
3	Net return	288285059
4	Net return of Sonali bag per kg	637.82
5	Net return of Sonali bag per piece	5.32
6	BCR (undiscounted)	2.41

**Source:** Author's estimation based on collected data, 2021

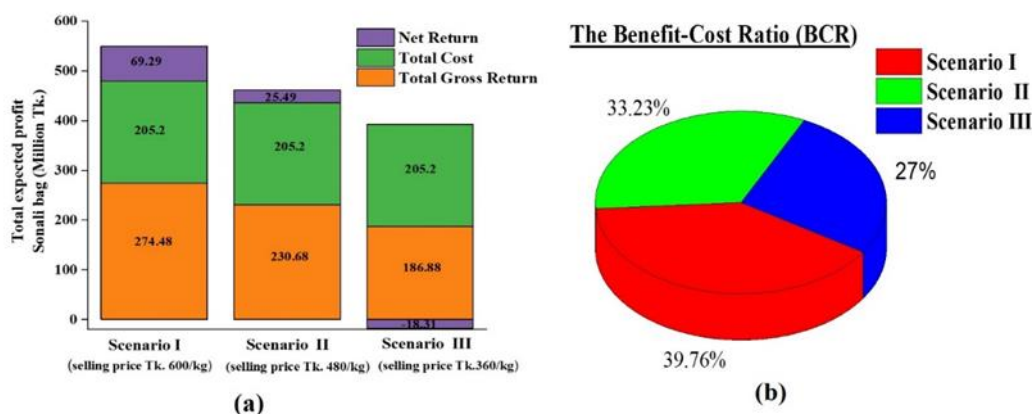
### 3.2.3. Scenario Analysis

It is found from Table 2 that the production of Sonali bags is a profitable business at the selling price of Tk. 1200 per kg (Tk. 10/piece) and a total annual profit of Tk. 288.29 million (Table 3). This price is so high compared to its other substitute packaging materials. Figure 4 illustrates several cost scenarios - whereas in the 1<sup>st</sup> scenario, if this production plant is fully utilized and the price of the Sonali bag drops to half (Tk. 600 per kg or Tk. 5 per piece), it will also be a profitable business with BCR of 1.34 and net return of Tk. 69.29 million (Table 4). Even in the second scenario, the business is still profitable with a BCR of 1.12 and a profit of Tk. 25.49 million when the production plant is fully utilized and the price of the Sonali bag dropped to Tk. 480 per kg (Tk. 4 per piece). However, if the selling price is further assumed to be dropped to Tk. 360 per kg (Tk. 3 per piece) it seems that business will no longer be profitable. These situations might be possible if Sonali bags are produced on a commercial basis and the government provides subsidies for the import of chemical components. As chemical component cost constitutes about 77.23% of total variable cost, it would be possible to produce at a lower expense and sell at a lower price with government support.



**Table 4.** Estimation of total profit/ Net return of Sonali bag production plant

SI. No.	Situation	Total expected profit Sonali bag® (Million Tk.)
Scenario I (selling price at Tk. 600/kg)	Total Gross return	274.48
	Total Cost	205.20
	Net return	69.29
	<b>BCR</b>	<b>1.34</b>
Scenario II (selling price at Tk. 480/kg)	Total Gross return	230.68
	Total Cost	205.20
	Net return	25.49
	<b>BCR</b>	<b>1.12</b>
Scenario III (selling price at Tk. 360/kg)	Total Gross return	186.88
	Total Cost	205.20
	Net profit	-18.31
	<b>BCR</b>	<b>0.91</b>

**Figure 4.** (a) Total profit; (b) benefit-cost ratio (BCR) of Sonali bag® production plant for scenario I- II

Furthermore, according to the Engineer of BJMC, using steam boilers during commercial production will save 20% on power expenditures, lowering the overall cost of Sonali bag manufacture. Another opportunity for business expansion might be possible by exporting the produced bags to the international markets, as currently a 20% incentive is provided by the government in case of exporting jute goods.

#### 3.2.4. Total Market Potential of Sonali Bag in Dhaka City, Bangladesh

Dhaka, the capital of Bangladesh, is one of the largest and most densely populated cities in the world, with 47,400 people per square kilometer (Population Stat, 2022).

Considering the high population percentage, Dhaka city is considered in this study to identify the market potential of Sonali bags. Besides the expanding population, higher environmental awareness and income capacity of the residents of Dhaka are also taken into consideration.

Population Stat (2022) estimates that there were 21 million people living in Dhaka in 2020 and the city's annual per capita usage of plastic bags was 22.25 kg (The World Bank, 2021). Based on the information gathered from the prospective consumers who were questioned, it is projected that if the Sonali bag is priced at Tk. 480/kg (Tk. 4/bag), users will switch out 45% of their plastic bags with Sonali bags. Sonali bags are now being sold by Bangladesh Jute Mills Corporation for Tk. 1200/kg. In addition, we calculated market potentials based on 10% and 30% replacements of plastic bag use at Sonali bag selling prices of Tk. 1200 and Tk. 360 (Tk. 3/bag).

**Table 5.** Estimation of total market potential of Sonali bag in Dhaka at different consumption rates and selling prices

Scenario	Situation	Total market potential (Billion Tk.)
I	10% of plastic bag consumption at a selling price of Tk. 1200/kg	56.07
II	45% of plastic bag consumption at a selling price of Tk. 480/kg	100.93
III	30% of plastic bag consumption at a selling price of Tk. 360/kg	50.46
IV	45% of plastic bag consumption at a selling price of Tk. 1200/kg	252.32
V	45% of plastic bag consumption at a selling price of Tk. 360/kg	75.69
VI	30% of plastic bag consumption at a selling price of Tk. 480/kg	67.28
VII	30% of plastic bag consumption at a selling price of Tk. 1200/kg	168.21
VIII	10% of plastic bag consumption at a selling price of Tk. 480/kg	22.43
IX	10% of plastic bag consumption at a selling price of Tk. 360/kg	16.82

**Source:** Author's estimation based on collected data, 2021

The market potential analysis for Sonali bags in Dhaka city suggests that adjusting the price could have a substantial impact on market size. Currently priced at Tk. 1200/kg with a 10% replacement rate of plastic bags, the estimated annual market potential stands at Tk. 56.07 billion. However, a price reduction to Tk. 480/kg, combined with a 45% replacement rate, could elevate the market potential to Tk. 100.93 billion annually. This underscores the significance of pricing strategies in expanding the market for Sonali bags, particularly by aligning with customer acceptance levels and promoting a shift away from plastic bag usage.

However, if it is feasible to make Sonali bags widely available and strongly advertise them, customer perception may shift and demand might increase. Then, with 45% and 30% replacement of the hazardous plastic shopping bags, respectively, it could be possible to acquire a potential market for Dhaka city worth Tk. 252 billion and Tk. 168 per year, as shown in Figure 5.

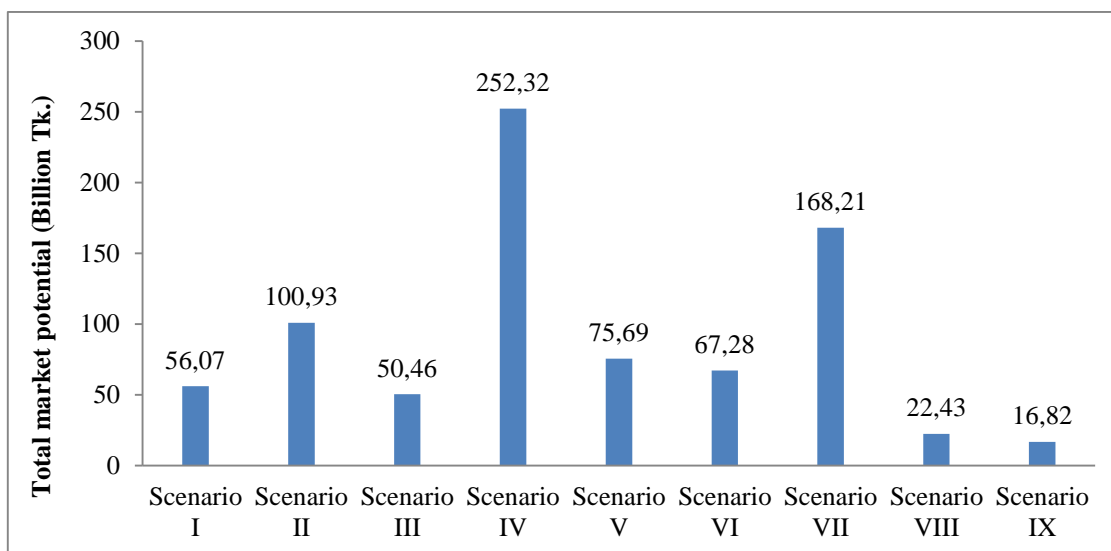


Figure 5. Total market potential of Sonali bag in Dhaka market at varying consumption

#### 4. Conclusions

Based on the findings it can be concluded that there is enough scope to develop and sustain this biopolymer technology due to domestic and foreign demand. The study findings proved manufacturing of single-use Sonali bag production plants is a lucrative industry with an annual profit of Tk. 288.29 million at a selling price of Tk. 1200 per kg. In comparison to its other replacement packaging materials, this pricing is extremely high. Based on the scenario analysis, if the Sonali bag price is reduced to half or less of the current levels it will also be a profitable business with BCRs (undiscounted) of 1.34 and 1.12 and net returns of Tk. 69.29 million and Tk. 25.49 million, respectively. The government's 20% incentive for exporting jute goods and commercial replacement of the electricity in the Sonali bag production plant with a steam boiler will result in a 20% reduction in electricity costs, which will increase the profitability and benefit cost ratio (BCR) of the Sonali bag production plant in the future. A single-use Sonali bag at current selling price (Tk. 1200/kg) and assuming 10% replacement of plastic bag use estimates Tk. 56.07 billion markets per annum and if the price falls to a major customer acceptance level (Tk. 480/kg) and assuming 45% replacement of plastic bag use estimates Tk. 100.93 billion markets in Dhaka city. These figures indicate that setting the price at a lower level expands the market potentiality of the Sonali bag at the beginning level. Consumers consider the Sonali bag to be a noble technological advancement and if it is reasonably priced, they will drastically replace their usage of plastic bags with it. Due to the huge worldwide demand for eco-friendly single-use Sonali bags, it is recommended to go through commercial production and meet both domestic and international demand through exporting which leads to earning foreign currency and on the other side it will make a great opportunity to bring back the prosperity of the jute industry.

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