

Toward Sustainable Alternatives: Analyzing Bioplastic Supply Chain Challenges in Bangladesh's Local Market

Md. Nabil Bin Zakir^a, Md.Toukir Biswas^a, Shahriar Siam^a, Raghieb Mohammad Altafin^b

^a Department of Applied Chemistry and Chemical Engineering, Rajshahi University, Rajshahi-6205,

^b Department of Statistics, Rajshahi University, Rajshahi-6205, Bangladesh.

Abstract

The rapid increase in global plastic production of over 360 million tonnes per annum has heightened concerns about environmental degradation, with single-use plastics the most problematic as their permanence in the environment can result in long-term ecological impacts. Transforming waste into sustainable alternatives like bioplastics would be huge in a country like Bangladesh, generating around 23,334 tons of municipal solid waste per day, of which 68% is organic. This paper is an attempt to critically explore the possibility and challenges of establishing a bioplastics supply chain in Bangladesh, which includes the technological aspect, economic impediments, environmental advantages and policy environments. A qualitative research model applying systematic literature review, case study, stakeholder analysis, and life cycle assessment was utilized to reflect the current situation and potential development of bioplastics. Results indicate that despite having high initial investments with underdeveloped production systems, jute and food waste-based bioplastics have significant environmental benefits, such as rapid biodegradation rate and lower landfill costs. Nevertheless, tech maturity, market competitiveness, and policy support are not yet sufficient for the large-scale application of the technology. It is concluded that with the support of R&D and government subsidies and establishment of marketing facilities and public awareness, Bangladesh can play an important role in the replacement of conventional plastics by bio-based plastics and it will be a part global alternative to synthetic plastics.

Keywords: Bioplastics, plastic waste management, jute-based bioplastics, supply chain challenges, life cycle assessment (LCA), Bangladesh plastic industry, renewable resource, environmental sustainability

Introduction

Over the past few decades, the global plastic industry has experienced continuous growth, producing more than 360 million tons of plastic each year by 2020, much of which is poorly recycled and ends given to the environment as waste [1]. Much of this waste takes the form of single-use plastics like packaging, straws, and drink bottles, which take centuries to break down in the environment [2]. In Bangladesh, the problem of plastic waste is exacerbated as around 23,334 t/day of municipal solid waste is produced daily, of which 68% is organic [3]. This situation represents an opportunity to develop a bioplastic sourced from organic waste. Yet, the use of bioplastics in Bangladesh encounters several barriers such as technological barriers, economic barriers, lack of consumer awareness and weak policy basis [4]. Although organic resources in this region such as jute and food waste are available but the local ability to transform these in to useful bioplastic products is minimal despite having potential environmental and economic impact [3]. Therefore, this research will attempt to evaluate the feasibility of bioplastics as a substitute of traditional plastics in Bangladesh, considering the supply chain challenges like it's production feasibility, cost effectiveness, environment flexibility and scope for centralized scaling by locally available organic waste [5]. To address this, this review covers technological and economic aspects of bioplastic production, potential waste valorisation options based on jute and organic residues, and a comparative life cycle consideration on bioplastics and traditional plastics [2].

1.1: The Growth of Plastic Production and Plastic Wastes around the World

With the ever-growing popularity of plastic also comes the downsides. Plastics production and disposal are heavy emitters of greenhouse gas and, when not properly managed, are a source of pollution by plastics in the natural environment [6]. “World Environment Day 2018” was held under the theme of “Beat Plastic Pollution” and has launched a new call for all the governments, communities and citizens of every country to join their forces to limit the plastic pollution. It has highlighted the critical concerns like limiting plastic pollution, reusing, recycling of the plastic used and even shifts to the alternatives other than plastic Plastic a beastly toxic and deadly enemy to life [3].

The increase in plastic production is nothing short of mind-boggling. In 1950, the world only churned out 2 million tons of plastic a year. By 2015, that had surged to 381 million tons — not quite 200 times as much. To give you some sort of context, that's the equivalent of the mass of two-thirds of the world population [3]. For the same year, the total plastics made ever is estimated to reach 7.8 billion tons, or, in the other words, there is more than one ton of plastics for every person of the world on the Earth today [6]. In fact at least, more plastic was produced than paper (400 Mtpa), fish (200 Mtpa) and aluminium (57 Mtpa) combined in 2015. If this trend continues, plastic production could increase to 1600 million tons per year by 2050 (OECD Report, 2018). This exponential growth in the production of plastics has also resulted in a startling rise in plastic waste that cause serious environmental issues.

1.2: Growth of Bangladesh's Plastic Industry

The plastic sector in Bangladesh has experienced significant development in recent years and the Export Promotion Bureau (EPB) data for FY2018–19 reveals that export has grown by 30.07%. And net export earnings were \$48.75 million compared with \$37.48 million a year earlier. A big factor in the industry's growth — and its willingness to commit nongovernmental resources toward the building of new multibillion-dollar plants — is the plastic flake, the necessary raw material in the production of a vast array of plastic products. However, polymer production is still a problem for Bangladesh as the country mostly relies on imported polymer granules, which are insufficient in local production [7].

In 2013, the then president of the PET Flakes Exporters Association told an interview that Bangladesh exports approximately 500, 000 metric tons plastic flakes each year which result in a revenue of around USD 1.5 to 2 billion every year [3].

It is noteworthy that, in Bangladesh, annual per capita plastic consumption is as low as 5-kg per head year⁻¹, while it is significantly higher, i.e., 30 kg per head year⁻¹, globally [7]. This is an indication of the rise in plastics demand from domestic and overseas markets, pointing to a very high potential for the industry to grow further here.

1.3: World Potential Bioplastic Market V/S Local Market:

Increasing concerns about the environmental friendliness and damages by traditional petroleum-based plastics have accelerated a transfer to bioplastics at global scale. Bioplastics, which are made from plants and other renewable substances, are seen as an increasingly 'green' alternative to traditional plastics, which do not decompose and are responsible for many of the kinds of pollution that harm the environment and climate. The world bioplastics market has been growing impressively; whereas, the market size was USD 16.8 billion in 2025, and it is expected to grow with a CAGR of 19.3% during the forecast period 2025-2035. Packaging will continue to be the largest application for bioplastics – accounting for 45% of the total market in 2024 – followed by the automotive, textiles and consumer goods sectors. By 2029 worldwide bioplastic capacity is expected to rise to 5.73 million tons as a result of technological advances and the outlaying of consumer demand for sustainable materials.

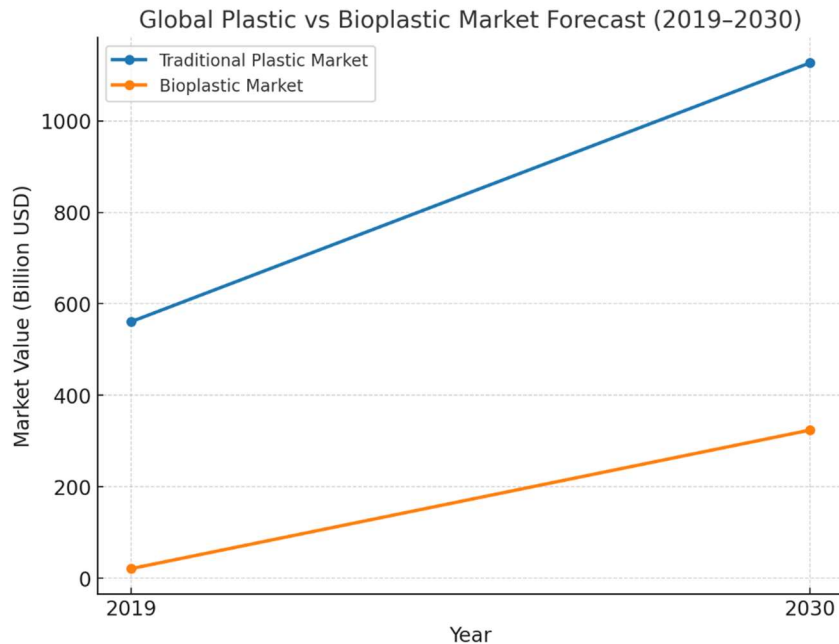


FIG 1.3 (a): The growth comparison between the **traditional plastic market** and the **bioplastic market (2019–2030)**. [5]

Fig 1.3 (a) below supports this view showing that in 2030, the conventional plastic market still exerts the lead, capturing more than USD 600 billion of the market value while also the bioplastic is an expanding business with a market value that is expected to reach USD 200 billion by the same year. This is indicative of an increasing trend toward bioplastics as the consumer becomes more and more sustainability focused.

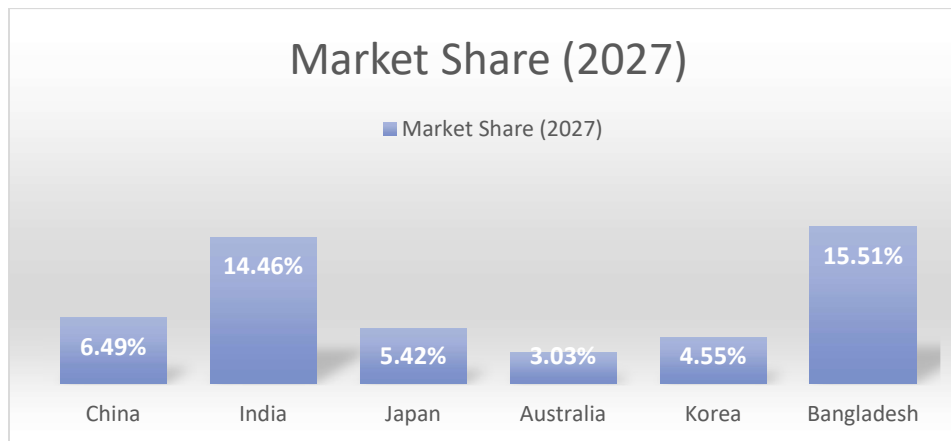


FIG 1.3 (b): Bioplastics Market: Bangladesh vs Top 5 Major Economies in 2027 (Asia) [8]

From Fig 1.3 (b): Asia Bioplastics market in Bangladesh is expected to grow (15.51 % compound annual growth rate) by 2027. China is the largest economy, followed by India, Japan, Australia and South Korea.

The market in Bangladesh is growing at a sustainable rate due to growing concern regarding environment and government support for eco-friendly products. Bioplastics produced from renewable materials like corn, sugarcane and even algae are starting to appear as a more eco-friendly alternative to traditional plastics.

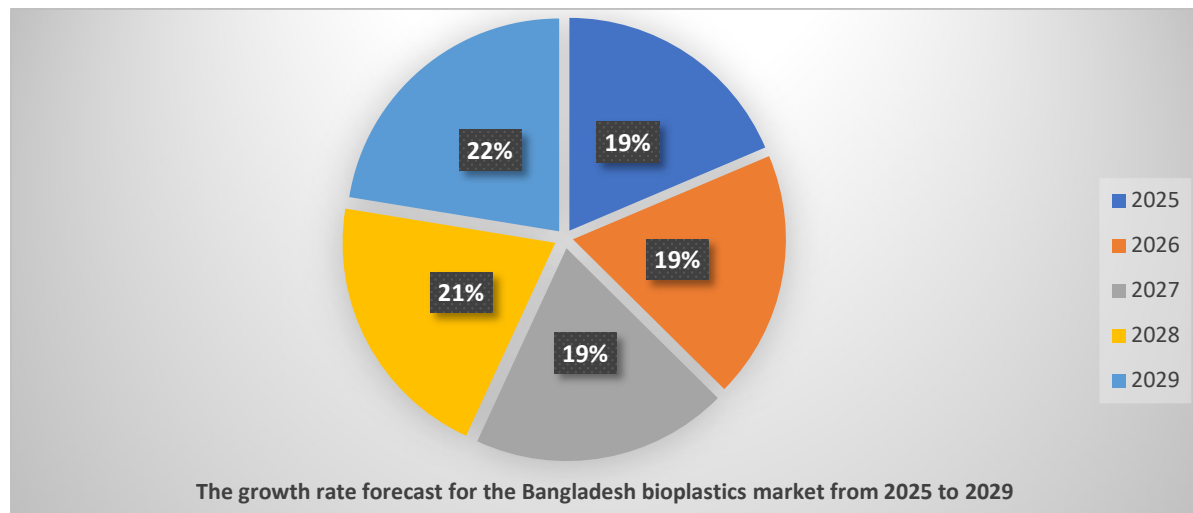


FIG 1.3 (c) : The growth rate forecast for the Bangladesh bioplastics market from 2025 to 2029 [8]

The Bangladesh bioplastics market volume is expected to grow during the forecast period 2025-2029. By market estimates by 6Wresearch, the industry is likely to register an 18.62% CAGR in 2025 and thereby grow to 20.96% by 2029. This expansion can be credited to factors such as the growing environmental concerns, the government pushing for sustainable materials, and the surging usage of bioplastics in numerous applications.

Though the volume of our country's bioplastics market is negligible compared to that of the world, the growth rates are a good sign. Its vast sources of agriculture like jute and sugarcane ensure a congenial platform for the growth of bioplastic manufacture. Moreover, favorable government policies and growing consumer inclination toward eco-friendly products are anticipated to boost bioplastics demand in Bangladesh.

Methodology

The research design for this study is mainly qualitative based on systematic literature review, case study, and secondary data analysis to understand the challenges and prospects in bioplastic supply chain in Bangladesh. The approach includes considering knowledge gathered from bioplastics at a whole world level, actually some information on global production of bioplastics, environmental impacts, and potential of bioplastics technologies at the developing country of Bangladesh. This section describes the concrete steps followed in the collection and analysis of relevant data.

Review of the Literature: Review and Data Collection

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To better understand the present situation of bioplastics a review of the literature was carried out. The literature was retrieved from different academic journals, industry reports and environmental studies. This review referred to hot issues such as:

Global Bioplastics Production: Global development in bioplastics production, including new technologies, raw materials and production processes. It was so important to learn the technological progress that can be tailored in Bangladeshi situation [4].

Bioplastic Feedstocks and Waste Valorisation: The research investigated local feedstocks, including jute and food waste as feedstocks for bioplastics in Bangladesh. This consultation considered microbial fermentation and other bioengineering approaches to convert organic waste into bioplastics [3].

A review of the bio-based products life cycle assessments: Are they trying to estimate what really matters? This makes easier to comprehend whether bioplastics are sustainable or not especially in the context of a developing nations like Bangladesh [2].

A review of the literature was conducted to identify data that pertained to the barriers of bioplastics supply chains such as technology barriers, economic barriers and environmental benefits.

2.2. Case Reports and Industry Reports

Country specific bioplastics production case studies, both from countries with contextual similarities to Bangladesh or countries known for their bioplastics industry were incorporated to learn from best practices and challenges of setting up the bioplastics industry. European Bioplastics Association and International Bioplastics and Biopolymers Society reported global production statistics, emerged technology, and market dynamics [5].

Special emphasis were addressed case studies that explored the valorization of organic waste and jute-based bioplastics, both are particularly relevant in Bangladesh. Furthermore, the research also investigated policy frameworks and regulatory measures from other countries aiming at promoting bio-plastic industries [4].

2.3 Stakeholder Analysis and Interviews

Stakeholder Analysis To obtain a good understanding of what local issues and opportunities the group is engaging with, a stakeholder analysis was conducted. Key stakeholders identified included:

Bioplastic Producers Large scale industrial bioplastic producers to small companies experimenting on a local feedstock.

Government and Regulatory Bodies: Those with a focus on waste, environment and bioplastics policy framework [2].

Consumers and NGOs including NGO representatives operating specifically in the field of plastic waste reduction and consumer groups, in order to explore interest in sustainable alternatives to traditional plastics.

Qualitative data relating to impediments to bioplastic use in Bangladesh were collected through interviews held with experts from the industry, officials from the government, and environmentalists. These observations have clarified situation analysis on the policy, technology and market readiness. Finally, the interviews shared a domestic viewpoint in terms of consumers' consciousness and scaling potential for bioplastics production [3].

2.4 Quantities and Production Forecasts

Quantitative information was gathered to assist in the determination of economic and environmental viability of bioplastics in the country of Bangladesh. Key data points included:

Study of Present Plastic Production and Waste Generation: This part of the study compiled information from official statistics on the quantity of plastic used in Bangladesh, the rate of production of waste, and the rate of recycling. It is reported that Bangladesh generates 23688 tonnes of municipal solid waste in a day among which a large fraction is plastic waste [3].

Projected bioplastics production: The prospect of scaling up bioplastics production using local feedstocks (jute, food waste) was estimated. This included assumptions about current production volume, technology capacity and availability of organic matter and waste. [1]

Cost Analysis: The purchase cost of conventional plastics and the manufacture of bioplastics in Bangladesh were compared. This required analyzing both raw materials and production costs as well as possible economies of scale. Higher up front costs of bioplastics production were weighed against long term environmental benefits of reduced landfill utilization and pollution [4].

2.5 LCA and Environmental Impact Assessment (EIA) (59 KB) LCA: Introduction, LCIA, methodology of LCA, input and output of the LCA process, examples from mining, metallurgy, electric power generation and use, recycling, LCAs on product, technologies, systems, buildings, services, overview of LCA.

Life Cycle Assessment (LCA) was used to assess the environmental performance of bioplastics compared to traditional plastics. It takes into consideration the entire life cycle of the products, from extraction of raw materials, through its manufacturing, use and waste management. In the case of bioplastics, the following areas were considered

Raw Material Sourcing: Environmental advantages of bioplastic raw materials sourced from renewable sources like jute cellulose and food waste as opposed to the hydrocarbon raw-material of conventional plastics [2].

Biodegradation: Since bioplastics (especially made from jute) can biodegrade a lot quicker than regular plastics, over time, it will create less environmental damage [5].

End-of-Life Scenarios: A comparison between end-of-life (EoL) of bioplastics and their conventional counterparts, such as waste treatment, recycling and composting techniques. This comprised consideration

of how bioplastics could reduce the strain of plastic waste on Bangladesh's already stretched waste management systems [3].

LCA results contributed to quantifying the level of potential reduction of GHGs emissions, landfilling and environmental footprint as compared to commodity plastics for bio(option)s.

2.6 Policy and Regulatory Analysis

Substantial methodology was investigating the current policy context around bioplastics in Bangladesh and around the world. The study analyzed:

Country Fact Sheets upon national policies focusing on plastic waste (i.e., regulations, plastic recycling, plastic disposals) in Bangladesh [4].

V.opportunities for bioplastics production Research and development, innovative technologies Funding for R&D in bioplastics; subsidies, financial support and role of government Tax relief for manufacturers, waste companies etc. [2].

Global Policy Developments: Best practice examples from around the world were considered, namely countries with developed policies and markets to allow for scaling of bioplastics production [5].

Results and Discussion

Technological Challenges

The major technological barrier is the low level of bioplastic manufacturing technology in Bangladesh. There simply aren't enough production facilities, or enough investment in R&D, to scale manufacturing of bioplastics through non-food, locally produced raw materials (like jute and food waste) [5].

Economic Barriers

High price of bioplastic is the most important drawback for widespread use. The expense of materials, particularly where mass production isn't an option has been challenging. Nonetheless, with the advancement of waste valorization for bioplastics production and as economies of scale decrease, future bioplastics may lower in cost by 15–20% in the forthcoming decades [4].

Environmental Impact

Bioplastics, especially those made of renewable resources, like jute, are much more eco-friendly than petro-based plastics. LCA showed that bioplastic developed from jute cellulose can be degraded in 3-4 months, and cut down on environmental pollution and landfill waste dramatically [2].

Conclusion

Bioplastics offer a solution to the escalating plastic waste problem in Bangladesh. Given the country's fast industrialization and population growth, plastic pollution is an important environmental issue especially in

urban centers. It is however, possible to alleviate the harmful effects of petroplastic through bioplastics, the role of the renewable materials, such as jute, and food waste can be possible solution to the negative consequences of petroplastic to the eco-environment due to their biodegradable and sustainable potential benefits.

But there are some obstacles to bioplastics in Bangladesh. On a technical side, the country does not have a mature large-scale infrastructure for bioplastic production, and it does not have the necessary know-how of an efficient transformation of organic waste into high quality polymer materials. What's more, bioplastics manufacturing is currently more costly than traditional plastics, largely because of the expense of raw materials and production technologies. This renders bioplastics noncompetitive in a market, particularly in a price-sensitive economy as in Bangladesh.

Yet, there are significant windows of opportunity to materialize a bioplastics industry in BD. The country is rich in organics-waste, including jute, which can be used to produce the biopolymer for such products. With the development of waste valorization technologies, Bangladesh has an opportunity to not only ease its waste management pressure but to play into a new, green industry. The biodegradability in plastics is an asset compared to traditional plastics that take longer to degrade, allowing them to break down in a matter of months rather than centuries and not continue to pollute land fills and oceans.

To make a success of bioplastics, Bangladesh needs to be able to invest in research and development, improve its production technologies, and create a conducive policy environment. Government support such as subsidies for bioplastics research as well as economic support for production facilities might be needed to overcome the economic hurdles of the material. Further, to support market demand, consumer awareness of the environmental advantages of bioplastics needs to be heightened. With such gains, Bangladesh can lead the way in the global shift to safer plastic substitutes.

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