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Viability analysis of a plastic waste business unit: assessing economic returns and environmental impact

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Abstract

The economic and environmental viability of a plastic waste business unit was assessed. The monthly historical value of plastic recycling industries in Guaranda canton was used to project supply and demand for the next five years. The results showed an Internal Rate of Return (IRR) of 0.67, surpassing the initial discount rate of 0.1433 and the Minimum Acceptable Rate (MAR) of 22% set by financial institutions. It is concluded that the project is viable, with a return of $0.46 per dollar invested, representing a business opportunity and a potential source of direct and indirect employment.

Keywords: *Circular economy, Financial feasibility, PET material, Plastic bottles, Solid waste..*

Introduction

The beginning of the Industrial Revolution marked the onset of modernization and automation in industries. Machinery emerged that enabled large-scale production, but this resulted in excessive use of natural resources. Industrialization brought about an increase in employment and contributed to improving wages and the quality of life for people, which led to an increase in consumerism and a mindset of using and discarding plastic waste (Molina-Castro, Gómez-Ronquillo, & De La Cruz-Lozano, 2021).

Especially those that are single-use and discarded once they have served their purpose, such as packaging, bottles, bags, brushes, medical supplies, and machinery components (Mastellone, 2020).

Plastics are highly relevant materials that find multiple applications in our daily activities.These materials have the ability to undergo multiple recycling processes, allowing both their value and

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functional properties to be preserved over time (Silvério et al., 2023). They are divided into various categories based on their composition, such as Polyethylene (PE), Polypropylene (PP), and Polyethylene Terephthalate (PET) (Drewniok et al., 2023).

Their impact on the environment is significant, as their accumulation in landfills and oceans causes soil and water pollution. Non-biodegradable plastics can persist in the environment for several centuries, releasing toxic substances and affecting marine life and terrestrial fauna. On the other hand, the production of plastics involves the extraction of natural resources and the emission of greenhouse gases (Xiao et al., 2021).

Globally, several countries and organizations have implemented legislation and regulations to address plastic waste management (Sahni, Chopra, & Gadhavi, 2023). These measures encompass the prohibition of single-use plastics, the promotion of recycling, the implementation of taxes on plastic products, and the establishment of quality standards for recycled plastics. Current trends in plastic waste management focus on the circular economy, which aims to reduce, reuse, and recycle plastics instead of disposing of them. The adoption of extended producer responsibility policies, the promotion of innovation in recycling, and the search for sustainable alternatives to plastic are being encouraged (Sorensen, Kanwar, & Jovanovi, 2023).

The circular economy is a strategy that aims to maximize resource efficiency and reduce waste generation through reuse, recycling, and regeneration. Instead of following the linear model of production and consumption, where products are manufactured, used, and discarded, the circular economy aims to close the product life cycle, allowing materials and resources to remain in use for as long as possible.

This involves promoting practices such as repair, remanufacturing, and sustainable product design (Silvério et al., 2023; Gutberlet, Preuss, & Thorpe, 2023).

It is based on principles such as design for the life cycle, waste elimination, and the use of renewable sources. Its objective is to create a sustainable system where products and materials maintain their utility for a longer period of time. The valorization of plastic waste involves approaches such as recycling, reutilization, and energy recovery. Recycling involves collecting, sorting, and transforming plastics into recycled materials; reutilization seeks to give a second life to plastic products; and energy recovery is achieved through the controlled incineration of waste to generate heat and electricity (Robaina et al., 2020).

There is a variety of technologies and methods available for the valorization of plastic waste (Mendoza et al., 2020). Mechanical recycling focuses on the sorting, crushing, washing, and extrusion of plastics to obtain recycled pellets. On the other hand, chemical recycling technologies involve the decomposition and chemical transformation of plastics into chemicals or fuels. Pyrolysis and gasification technologies enable the thermal decomposition of plastics in the absence of oxygen, generating gases or liquids. These technologies offer economic benefits such as job creation, cost savings in material production, income from the sale of recycled products, and a

reduction in dependence on virgin natural resources (Jang et al., 2020).

However, there are challenges that still persist, such as the lack of adequate infrastructure for plastic recycling, cross-contamination during the recycling process, and insufficient awareness about the importance of proper plastic waste management (Idumah & Nwuzor, 2019). Furthermore, there are environmental benefits that include the reduction of waste sent to landfills, the decrease in energy and natural resource consumption in the production of new plastics, the mitigation of environmental impact related to raw material extraction, and the reduction of pollution and greenhouse gas emissions (Mastellone, 2020).

Ecuador, both at the national level and specifically in the province of Bolívar, is not exempt from this issue. According to a study conducted in the cantons of Guaranda, Chimbo, and San Miguel, 22 tons of plastic waste are generated daily. It is estimated that due to their physicochemical characteristics, these plastics can take between 100 and 1000 years to decompose, depending on the type of plastic (Lara et al., 2022).

The waste generated in the cantons of Guaranda, Chimbo, and San Miguel is taken to the technical closure of the municipal landfill in the community of Curgua, located in the Santa Fe parish of Guaranda Canton. However, the treatment of this waste is carried out inadequately. Additionally, an environmental impact study has been conducted for the construction of a new sanitary landfill in the Bolívar intermunicipal association, carried out by a consulting company. However, the mentioned studies have paid little attention to private investment as a possible solution to transform plastic waste into raw material for the plastic industry (De Titulación, David, & Silva, 2017).

From an economic perspective, manufacturing products using recycled plastic material entails a significant reduction in costs, resulting in savings for consumers. Furthermore, this approach generates a productive chain that has a positive impact on the creation of both direct and indirect employment. This development benefits sectors such as heavy-duty transportation, individuals, and microenterprises that rely on recycling activities in the province (Jang et al., 2020).

The recycling process entails significant economic benefits as it generates job creation in the recycling industry and provides savings in material production costs. Furthermore, income is generated through the sale of recycled products, and there is a reduction in dependence on non-renewable natural resources (Anshassi & Townsend, 2023). From an environmental perspective, the transformation of discarded plastic into raw material has a significant positive impact. This approach reduces the excessive use of natural resources, decreases the amount of plastic waste sent to landfills, and extends the lifespan of materials in the market. By adopting a circular economy, the aim is to optimize resource usage and minimize waste generation through the reuse of plastics. This approach contributes to environmental preservation and promotes long-term sustainability (Lee et al., 2023).

The lack of infrastructure and efficient strategies for plastic waste management in Canton Guaranda is a problem that carries negative consequences for the environment and the quality of life of the population. The accumulation of plastic waste deteriorates the environment and poses a health risk. This situation poses a challenge within the framework of circular waste management, in compliance with the objectives established in the 2030 Agenda. Therefore, it is necessary to implement effective measures and solutions that maximize the utilization of plastic waste, promoting sustainable and environmentally friendly practices (González-Sánchez, Alonso-Muñoz, & Medina-Salgado, 2023). In this study, we proposed to evaluate the economic feasibility of implementing a plastic waste business unit by analyzing the economic returns in Canton Guaranda.

Methodology.

Population and sample.

To obtain the Population and Sample, data from the Ministry of Production, Foreign Trade, Investment, and Fisheries were taken, which is the entity responsible for formulating, executing, and regulating the commercial activity in this sector, to verify the plastic industries in Canton Guaranda. Surveys were developed and validated to obtain field data, aiming to establish the relationship between the cause and effect of a specific good or service on the consumer. It was used to determine the causes and effects generated by the investment model, primarily in the project sensitivity analysis, allowing us to assess the project's profitability in different scenarios (Akbarnavasi, Bararzadeh Ledari, & Shafiei, 2022).

Analysis of supply and demand.

To calculate the annual supply and demand, the historical reference value was taken on a monthly basis and multiplied by twelve months in a year. To estimate the projection for the next five years, Equation 1 was used. Unmet demand was determined as the difference between the projected demand and supply for each year (Espín, Lanchimba, & Remache, 2022).

Cn = Co(1+i)^n Equation 1

Where:

Cn = Future year consumption.

Co = Current consumption.

i = Growth rate = 7%.

n = Number of years to project.

Process engineering.

In this aspect, the following elements were considered:

a) The production procedure of the product or service. First, the documents are received by the

secretary. Then, the weigher verifies the type of discarded material. Next, the discarded material is introduced into the industrial plant and weighed. A sampling of the discarded plastic material is performed, and it is classified according to specific codes. Afterwards, the plastic is ground and packaged. The packaged material is weighed and transported, and finally, the finished product is sold.

b) The process of supplier management and payment. First, the secretary receives the related documentation. Then, the weigher verifies the type of discarded material. Next, the discarded material is entered into the industrial plant, and the corresponding weighing is carried out. A weighing ticket is provided to the customer, and the information is recorded in the system by the accountant. Subsequently, the payment document is printed, and the payment is made to the supplier.

c) The accounting process encompasses several stages. Here, the verification of documents and data in the system is performed. Then, the data is transferred to the accounting ledger and the check is issued. Next, the data is transferred to the accounting entry and the corresponding financial statement. Data verification is completed with the signing of documents and financial statements.

RESULTS AND DISCUSSION

Population and Sample

The resulting population was the collection centers, and 100% of it was selected as the sample due to its small size (Gutiérrez Rojas, 2016). It consisted of 3 legal representatives from recycling industries according to the list provided by the Ministry of Production, Foreign Trade, Investment, and Fisheries. Additionally, according to data obtained through field research, there were 60 users of micro recycling enterprises, 1 legal representative from a waste material collection center, and 2 representatives from informal collection centers.

Demand Analysis There are various factors that influence demand, such as the size and growth rate of the plastic industry sector, the historical demand behavior, and future demand projections (Espín, Lanchimba, & Remache, 2022). A 7% annual growth rate was used for the industrial sector based on data from the Ecuadorian Plastics Association (ASEPLAS) (PRO ECUADOR, 2015).

To analyze the demand behavior for products used by the plastic industry, the data obtained from surveys conducted in the city of Guaranda were utilized. These data allowed us to calculate the annual demand by multiplying the monthly consumption value by 12 months, resulting in 840,000 kg. The price was determined based on supply and demand (Deng et al., 2021). A reference was taken from the three recycling companies in the studied area, and it was established at 0.90 USD per kg. Figure 1 displays the demand projection for the next five years determined using Equation 1.

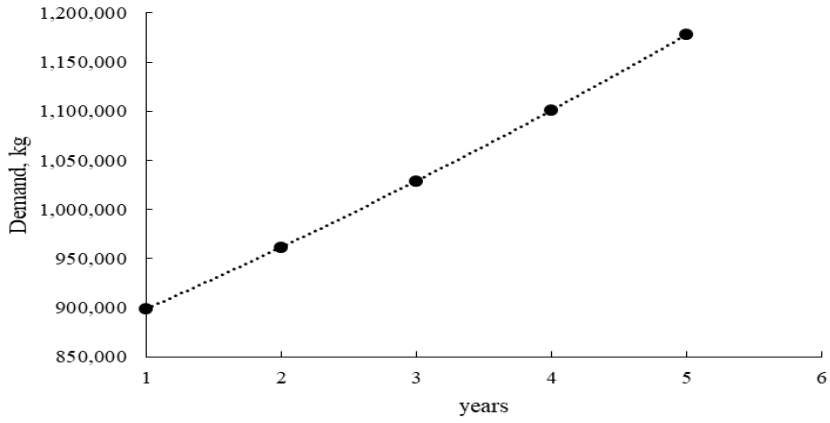

Figure 1: Demand Projection.

Supply Analysis

There were two factors that influenced the supply: the number and production capacity of competitors, and the historical behavior of the supply (Deng et al., 2021). The three recycling companies were taken into account, and the total monthly supply value was multiplied by 12 months, resulting in a total of 120,012 kg. Figure 2 displays the supply projection for the next five years determined using Equation 1.

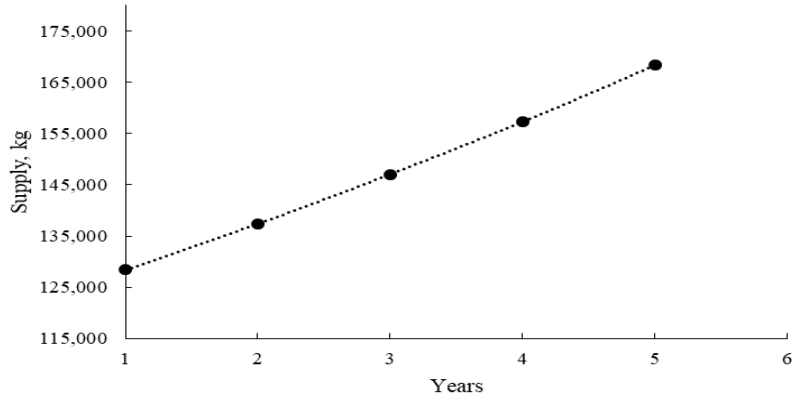

Figure 1: Supply Projection.

Unmet Demand

It was found that the unmet demand for each year would experience an increase. Figure 3 provides the details.

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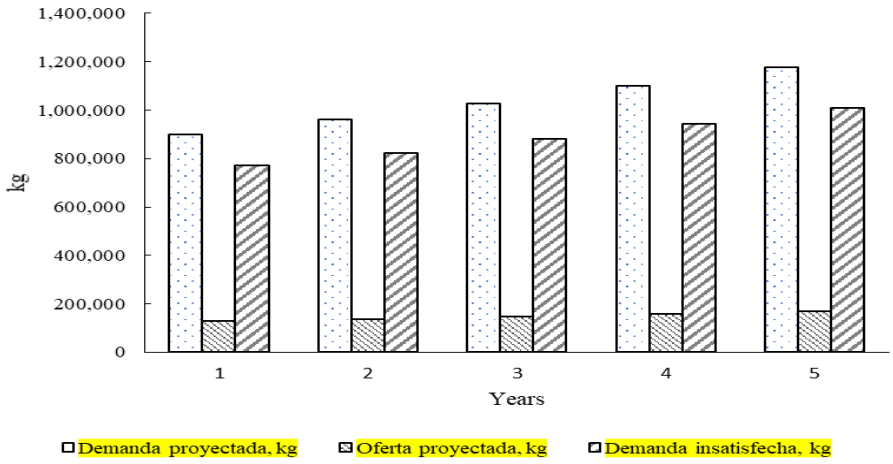

Figure 3: Unmet Demand Projection.

This pattern found in unmet demand offers the opportunity to discover new segments and business options, which contributes to strengthening the reputation and position in the market, with possibilities to increase profitability and sustainability of the company (Mercy Ejovwokeoghene OGBARI et al., 2022; "Your Guide To Reach Innovation: A step-by-step framework to understand... - Munther Al Dawood - Google Books" [no date]).

Process Engineering

A schematic diagram of the production process was developed. Figure 4 displays the details.

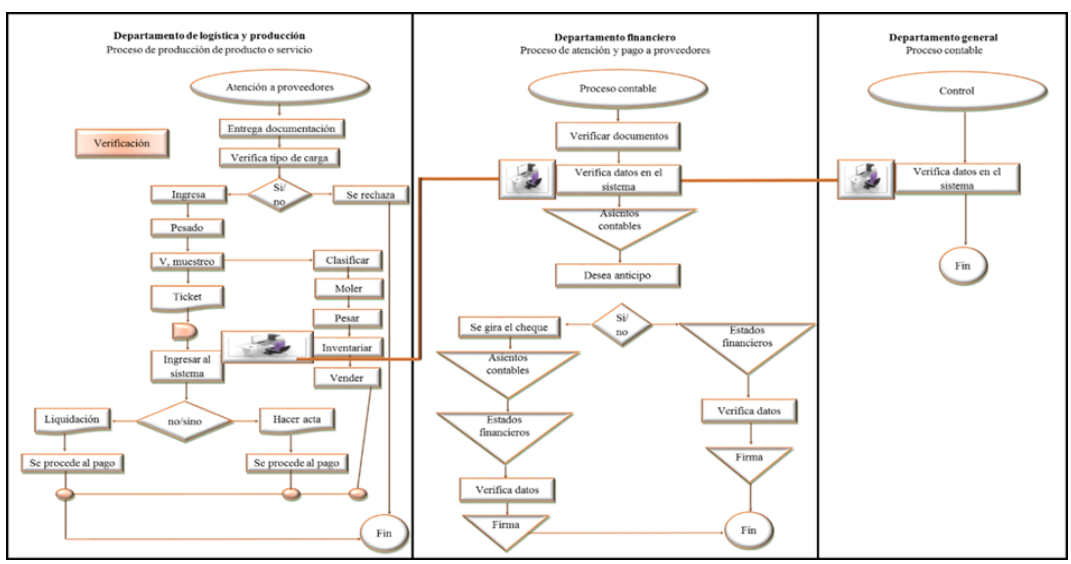

Figure 4: Proposed Diagram of the Production Process

The production process was divided into three well-defined sectors (Ding & Zhu, 2023):

1. Production process of the service, carried out in several stages. It begins with the reception and verification of documentation by the secretary, followed by the verification of the type of waste material by the weigher. Then, the waste material is entered into the industrial plant and weighed. Next, the sampling and classification of the plastic material is carried out according to specific codes. Afterwards, the plastic is processed into pellets and bagged, and the bagged material is weighed again. Finally, the finished product is transported and sold.
2. Process of supplier assistance and payment, which also involves several steps. It begins with the reception and verification of documentation by the secretary, followed by the verification of the type of waste material by the weigher. Next, the waste material is entered into the industrial plant and weighed. Subsequently, a weighing ticket is provided to the customer, and the data is recorded in the accounting system. Then, the payment document is printed, and the payment to the supplier is processed.
3. Accounting process, where various tasks are carried out. Documentation is verified, and data is cross-checked in the system. Next, the data is transferred to the accounting entry, and the corresponding checks are issued. The data is also transferred to the financial statement, and a final data verification is performed before signing the documents and financial statements.

For marketing and sales, a product strategy was developed that included both industrial products and distribution channels, such as the raw material processor and the industrial factory (Hassen MEHREZ, KHEMIRA, and Mohammed MEDABESH, 2023). Within the product strategy, the following actions were taken into account:

a) Establish institutional collaboration agreements between the entities responsible for solid waste management and the plastic recycling plant in order to plan, approve, execute, and evaluate the results of environmental plans, programs, and projects aimed at improving the profitability of the company's operations.

b) Establish interinstitutional cooperation agreements between the plastic waste recycling plant and institutions responsible for training and technical education. This aims to enhance the technical and administrative knowledge necessary for proper management of the company.

c) Halt the decline in production and sales through monetary advances and bonuses for individuals engaged in recycling activities.

d) Partner with waste management companies to obtain preferences for the purchase of raw materials.

Additionally, a technical study was conducted with the aim of proposing and analyzing various technological options for production. Factors such as project size, production capacity, project engineering, and business unit organization were taken into account. Market demand and resource availability were among the determining factors, which will be financed by private sector entities. The availability of workforce was also considered, which currently exists in the Ecuadorian labor market and is necessary to fill administrative, technical, and operational positions. It was identified that in the Guaranda canton, there is limited large-scale production, which benefits the establishment of this type of business.

Availability of input technology and raw materials

Production Capacity

In this aspect, the optimal size of the plan was considered based on a daily production capacity of 1,000 kg, equivalent to a maximum annual capacity of 360,000 kg, and an annual production growth rate of 7% (PRO ECUADOR, 2015).

Three recycling plants were considered, all located in the city of Guaranda, each with a committed annual production capacity of 120,000 kg.

Regarding the requirements, they were broken down by direct labor salary (two dockworkers and one machinery operator) and indirect labor (one accountant, one manager, one administrator, and one secretary), resulting in a total balance of 17,937.60 USD and 26,659.15 USD, respectively.

Also, equipment was considered for each sector:

a) First sector: a hydraulic baler, a complete plastic crusher and automatic bagging line, and a 4-ton capacity electronic scale, as well as furniture and fixtures.

b) Second sector: a warehouse including 4 offices, covering an area of 200 m2.

c) Third sector: three desks, 42 swivel chairs, four filing cabinets, and 10 regular chairs), computer equipment.

d) Fourth sector: three computers and three printers, industrial warehouse.

e) Fifth sector: incorporation expenses, a construction permit, an architectural plan, an operating permit, and an environmental impact study.

f) Sixth sector: a land area of 2,000 m2, intangible assets.

g) In the case of raw materials, it was for blown plastic waste (production plan) and supplies for 12 months (60 units of sacks with a monthly pressure capacity of 500 kg and one 18-pound roll of tying twine per month).

Additionally, environmental aspects were taken into account, including current legislation, identification and evaluation of potential environmental impacts based on affected factors and

resources, as well as necessary mitigation measures. It is proposed to improve products and adapt them to environmental parameters, along with other design aspects, with the aim of promoting the creation of environmentally conscious products that contribute to the environmental well-being of society (Rio, Riel, & Brissaud, 2017).

The proposed approach presented here will promote sustainability by preserving the environment through the manufacturing of products that are environmentally friendly, focusing on utilizing waste as raw material. This will result in improved environmental efficiency of the products, cost reduction, cleaner production, and a positive impact on the environment. Additionally, it contributes to the safe disposal of toxic waste, generates economic benefits, creates employment opportunities, and contributes to reducing the unemployment rate in the region (Alzlzly, 2023).

An economic study was conducted, which required analyzing the investment budget, fixed and intangible assets, amortization of intangible deferred expenses, working capital investment, and cost structure (Stowell & Stowell, 2024).

To conclude, an economic study was conducted that took into account the financial structure (Table 1), debt repayment with the calculation of the fixed annual installment, cost requirements, income proforma, financial situation upon completion of investments, one year after starting operations, income statement, and cash flow.

Table 1: Financial Structure.

Source	Fixed Investment, USD	Intangible Investment, USD	Working Capital, USD	Total, USD
Own Contribution	79.401,00	2.673,30	$ 12.399,41	94.473,71
Credit	34.200,00	0,00	0,00	34.200,00
TOTAL	113.601,00	2.673,30	$ 12.399,41	128.673,71

It was found that 30.11% of the investment in fixed assets represents a credit amounting to $34,200. According to the results obtained, it is necessary to repay 5 annual installments amounting to $11,942.00 to cover the credit taken from the National Financial Corporation. The net equity at the start of operations is $128,673.71, which will increase to $203,539.22 after one year of operation. Based on the results obtained, the company will generate a profit of $46,544.18 during the first year of operation.

The minimum acceptable rate and financial costs were calculated for both those contributing with their own capital and those financing through the National Financial Corporation (CFN). According to the results obtained, the project achieved a minimum acceptable rate of 14.33% on

the investment to cover financial costs. This information was used to calculate the net present value (NPV).

By calculating the net present value I, it was possible to confirm that the plastic waste company in the Guaranda canton is viable because the result exceeds the investment made. When calculating the net present value II to determine the internal rate of return (IRR), it was 0.67, which exceeds the initial discount rate of 0.1433, the minimum acceptable rate (TREMA). The project is profitable as long as the financial costs do not exceed 67%. Based on the results obtained, the estimated payback period for the investment is one year and three months.

In this regard, according to the results obtained, the project is viable with a return of $0.46 for every dollar of project investment. Additionally, for the company to reach the break-even point, it needs to sell 257,435 kg of plastic flakes, which represents a monetary value of $205,948.00.

Conclusions

During the market analysis, an existing demand for plastic flakes was identified, indicating a potential market that provides relevant information for decision-making by those interested in making the investment. In the technical study, it was confirmed that in the Guaranda canton, there is the technology, workforce, and resources necessary to process plastic waste and convert it into the raw material required by the major plastic industries in the country. The economic and financial analyses support the viability of the project and provide financing options to carry out the investment. The presented proposal not only addresses the issue of plastic waste but also turns it into a business opportunity and a potential source of direct and indirect employment, thereby contributing to the economic growth of investors and the community at large.

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