The Blue Economy: Food Waste Valorisation

Cristina Vilaplana-Prieto

University of Murcia, Spain

Abstract

This teaching project connects to what is now known as the Blue Economy. The Blue Economy goes beyond the globalised economy and the Green Economy. The time has come to shift to a competitive business model that meets everyone's basic needs with what is available locally. The power of the Blue Economy is that it injects money back into the local economy and, contrary to traditional belief, offers high quality products at a lower price. Currently not many food waste valorisation techniques have been implemented on large scale as continuous waste management options. The main reason is cost effectiveness, due to high transportation and storage costs of wastes and overall process viability. Students have looked at food waste using data from the Food Loss and Waste Database (United Nations) for different cities around the world. The objectives pursued were: (1) analyze economic estimations involving cost and benefits of PLA production and (2) calculate net social benefits based on the assumption that bioplastic is an alternative to the existing petroleum-based plastic. The concept of Cost-Benefit Analysis was applied as a tool for evaluating a project in order to help public sector to inform their decisions about pursuing bioplastics as the new wave industry replacing fossil-based plastics.

Keywords: *bioplastics, economics, blue economy, food waste*

1. Introduction

Global plastic production reached almost 360 million tonnes in 2018 [1]. In contrast, bioplastics production capacity in 2018 was only 2.01 million tonnes, representing 0.56% of global plastic production [2]. Currently, around 80% of all plastic produced worldwide is not recycled or reused in other ways [3]. However, the cost of producing bioplastics is much higher than petroleum-based plastics. One option to reduce the manufacturing costs of bioplastics would be to use suitable waste and by-products as feedstock materials.

It has been estimated that, globally, approximately one third of the food produced is lost or wasted, corresponding to about 1.3 billion tonnes of food per year [4]. In addition, approximately 3.49 billion tonnes of carbon dioxide equivalent greenhouse gases are generated by food lost or wasted along the supply chain [5]. Food waste from the primary sector (pre-consumer food processing stage) comprises food that does not reach the consumer as it is disposed of or recycled, including inedible food parts and food that does not meet organoleptic, technical or microbiological standards. Food waste from the post-consumer supply chain includes household food waste and from the food service sector [6].

The European Union has also compiled guidelines on preferable food waste disposal technologies, also known as the food waste hierarchy, which stipulate priority actions from most to least preferable: (1) prevention, (2) redirection to human consumption, (3) redirection to animal feed production and industrial use (4) recovery (e.g. soil enrichment and renewable energy) and finally (5) disposal. The most conventional waste management options include landfilling, anaerobic digestion, composting, thermal treatment and feed production [7].

Food industry waste constitutes a large loss of nutrients and biomass that could be used as functional foods or as a source for other bioproducts such as enzymes, antibiotics, biofuels or biopolymers [7]. Currently, not many large-scale food waste recovery techniques have been implemented as continuous waste management options. The main reason is cost-effectiveness, due to the high costs of transporting and storing the waste and the overall feasibility of the process. In many cases, the costs of the process raise the price of the final product to such a level that it cannot compete with conventional alternatives. Other obstacles are the technical limitations to convert the extracted compounds into value-added products and the inadequacy of the legal framework for the use of the waste.

The aim of this paper is to show an educational innovation project combining three elements: the reuse of food waste, the production of bioplastics and the valorisation of the Blue Economy, which is a hybridisation between the Green Economy and the Circular Economy.

2. Method

This teaching innovation project is suitable to be carried out in any subject of "Introduction to Economics", such as those included in the teaching plans of the Degrees in Business Administration and Management, Economics, Political Science, Sociology or Labour Relations. The mathematical requirements are not an obstacle. The different phases of the project are described below. Firstly, a first phase of explanation of theoretical concepts, which are summarised in this document. Secondly, an explanation of how to carry out a cost-benefit analysis taking into consideration the costs and benefits derived from the production of fossil-based plastics and those derived from the production of bioplastics from food waste.

2.1. Circular Economy

The Circular Economy offers new business opportunities by changing the traditional linear material use model to a more sustainable, efficient and circular one [8]. It is a sustainable concept that focuses on maintaining material value to the maximum through the application of reduce, reuse and recycle practices, which benefits society in the aspects of economy and environment without aggravating the burden of primary natural resource extraction [9]. Defined by the Ellen MacArthur Foundation (EMF), three basic principles of the circular economy are: 1) preserving and enhancing natural capital, 2) optimising the performance of resources in use and 3) fostering system efficiency [10].

2.2. Green Economy

The Green Economy is defined as low carbon, resource efficient and socially inclusive. In a Green Economy, employment and income growth is driven by public and private investment in economic activities, infrastructure and assets that reduce carbon emissions and pollution, improve energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services [11].
However, the substitution of one product or process for another has revealed unintended consequences, including collateral damage. For example, the use of maize as a feedstock for biofuels and bioplastics has increased the cost of tortillas (made from maize), putting the food security of millions of people at risk and further spurring industry to adopt genetic controls to master standardised and predictable production. The pursuit of bioplastics may further endanger food security. This is not sustainable development.

2.3. Blue Economy

The UNEP draws the Blue Economy from the green economy. It encourages tackling climate change through low-carbon and resource-efficient shipping, fisheries, marine tourism and marine renewable energy industries [11]
The Blue Economy can be seen as a hybridisation between the Circular Economy and the Green Economy. On the one hand, the Circular Economy still focuses on companies that are based on a single core business. On the other hand, the Blue Economy shows that having a portfolio of businesses can create more value, not only in economic terms, but for society and nature as a whole.
On the other hand, reality has shown that in the Green Economy everything that is good for you and the environment is expensive [12]. This is not what was intended, because the Green Economy was supposed to be for everyone. These high prices were often justified because local producers could only produce on a small scale, and therefore could not take advantage of economies of scale. In the Blue Economy model, you start from community resources, and build a commitment to the resilience of your community. If there is no waste, you can generate more value, you can create more jobs.

2.4. Bioplastics

European Bioplastics describes plastic material as "bioplastic" if it is biodegradable, bio-based or includes both properties. It is estimated that the production capacity of bioplastics will tend to increase to 2.4 million tonnes by 2023 (Bioplastics and nova-Institute, 2019). The main drivers of this growth are innovative biopolymers such as PHA (polyhydroxyalkanoates) and PLA (polylactic acid) [13]

2.5. Food waste

The FAO defines food waste as "losses of food in quality and quantity through the supply chain process occurring at the production, post-harvest and processing stages" [4]. around 1.3 billion tonnes

of food are lost or wasted each year worldwide, corresponding to one third of all food resources produced for human consumption [4].
Food waste entails a substantial loss of other resources such as land, water, energy and labour. The European Union generates 90 million tonnes of kitchen waste annually. Among them, 38% comes from the food manufacturing sectors [14]. Although EU guidelines stated that food waste should preferably be used as animal feed, it became illegal due to the concern of disease control [15]. Therefore, the valorisation of food waste through the production of value-added products may be an ideal and practical end-use.

2.6. Bioplastics, food waste and the Blue Economy

In 2000, Professor Yoshihito Shirai of the Institute of Life Sciences, Kyushu Institute of Technology (Japan) opted for a simple but rather innovative solution [16]. He observed how restaurants in Japan discard large quantities of food. Professor Shirai designed a PLA production unit based on raw material in the form of raw material in the form of starch from food waste. Although the starch content is lower than that of corn, his model is convincing, and the environmental benefits outweigh any other bioplastic. The city of Kita-Kyushu soon embarked on a composting programme to reduce pressure on the landfill. Japan, an island with little living space, charges one of the highest landfill rates in the world. Diverting restaurant food waste from landfill generates a first cash flow: restaurants still pay for waste collection, but the money is now collected by the plastic producer, who is charged for collecting the waste. Although conversion rates are much lower than for maize, the energy cost for transport and processing is a fraction of the market standard, while its size can be adapted to the local landfill.

2.7. Cost-Benefit Analysis of manufacturing bioplastics from food waste

The main objective of this research was to analyse the net societal benefits of switching from petroleum-based plastics to bioplastics, based on a cost-benefit analysis. The specific objectives are:

1. To analyse the economic estimates regarding the costs and benefits of PLA production; 2. to analyse the economic estimates regarding the costs and benefits of PLA production
2. To calculate the net social benefit based on the assumption that bioplastic is a substitute for the current petroleum-based plastic.

The concept of Cost-Benefit Analysis was applied as a tool to evaluate a project in order to help the public sector to inform their decisions on the pursuit of bioplastic. Two scenarios have been compared.

- Scenario 1: Status quo scenario in which the production of bioplastics is not introduced, and only the production of fossil-based plastics is used.
- Scenario 2: New scenario in which PLA bioplastics are produced with a production capacity conditioned by local food waste generation.

The steps necessary to carry out this cost-benefit analysis are as follows:

1. *Identify the actors involved.* The reference group refers to the group(s) of individuals whose welfare will be taken into account when assessing the costs and benefits of the project. In principle, these are the population groups where the waste generation is located and additionally, the government and the fossil-based plastic production industry. Groups of four or five students are formed. Each group chooses a city from the "Food Waste Index Report 2021" [17], provided that there is no overlap between two groups. This report includes indicators on food waste generation per inhabitant per year. Multiplying this figure by the number of inhabitants gives an estimate of the total annual food waste generation in this city. Each group must then analyse the costs and benefits of using this volume of waste to produce bioplastic, and then compare these with the costs and benefits of producing fossil-based plastic.

2. *Catalogue impacts and select measurement indicators*. On the cost side: investment costs, production costs, water treatment costs. On the benefit side: obtaining secondary products (ethanol, gypsum), reduction of carbon emissions and reduction of hazardous waste. CO2 emission is the sum of energy use (electricity and fuel oil) and emission into the atmosphere. As the production technology of fossil-based plastic has been developed over more than 60 years, its energy consumption has been effectively improved up to the maturity stage. Consequently, this process should logically require less energy (per tonne of product) than PLA production, which is at an embryonic stage.

3. *Quantitatively predict the impact over the life of the project.* The production of bioplastics will have an impact over long periods of time. This study assumes a time horizon of 25 years due to the current roadmap for the development of the bioplastics industry. Monetisation of outcomes and impacts does not imply that money is the only thing that matters but simply a convenient way of

translating comparable physical measures of impact into common units [18]. Since many environmental goods and services are not traded on the market, there are no prices that can be used as a benchmark. Shadow prices are used to reflect the true economic values of costs and benefits.

4. *Discounting of benefits and costs to obtain present values.* Net present value (NPV) is calculated by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate and subtracting the total sum of discounted costs from the total sum of discounted benefits. Discounting reflects the time value of money. In this research, we assume a project life of 25 years. A real discount rate reflecting expected inflation will be used to discount nominal benefits and costs. For each of the countries assigned, the students are asked to find the 30-year government bond rate. The discounting of benefits and costs transforms gains and losses occurring over different time periods into a common unit of measurement. In principle, all projects with NPV > 0 are considered to have passed the NPV test, as they improve social welfare.

3. Results

As a sample of the results, a fictitious case is given comparing the production of 100,000 tonnes of fossil-based plastic and 100,000 tonnes of bioplastic from food waste. Table 1 shows that the production costs and capital investment in technology for bioplastic are higher than for fossil-based plastic. However, the reductions in pollutant gases and the direct and indirect spin-off benefits are higher for bioplastic. Consequently, the total benefit is 7.34 million euros compared to a loss of 186.66 million euros.

Table 1. *Cost-Benefit Analysis of the production of 100,000 tonnes of plastic of fossil origin or bioplastic (millions of euros)*

		Bioplastic	**Fossil based plastic**
Direct cost	Production cost	225	77
	Capital and technology	330	108
	Land cost	0.74	0.74
Indirect cost	Greenhouse gas emissions	30	143
	Land oportunity costs	0,92	0,92
Total cost		586,66	329,66
Direct Profit	Sales	300	143
Indirect Profit	Sales	294	0
Total profit		594	193
Net profit		7,34	143

4. Discussion

Continuing with the previous example, the NPV of PLA production calculated for a lifetime of 25 years with a real discount rate of 1.89% is positive (results available). As for the environmental aspects, the CO2 that was produced for PLA production was 1.83 kg CO2 per kg PLA, which is less than the equivalent CO2 emission of its electricity, the fuel oil used and the waste water. Consequently, it follows that PLA production has great opportunities for improving its production, increasing energy efficiency, utilising waste and recovering greenhouse gases from wastewater treatment as a source of energy. Investment in advanced technology research and innovation for cleaner alternative PLA production is essential for the long-term sustainable development of the bioplastics industry.

For a net social benefit, the government must also provide favourable policy conditions to support both the demand and supply side of the bioplastic industry, not just the supply side. Further studies on pollution impact and bioplastic life cycle management will be beneficial for the greening of the bioplastic industry.

5. Conclusions

The evaluation of this teaching project has been very positive. Students have become familiar with new approaches to economics that are not usually covered in traditional textbooks. The Blue Economy is a way of making economic profitability, care for the environment and a local/regional approach compatible. In addition, students have become familiar with the reality of food waste, which is not given the importance it deserves. They have also become familiar with economic and environmental vocabulary in English, thus practising their competence in a language other than their native one.

Finally, the exhibition of their work has helped them to learn about the realities of other cities around the world, promoting the concept of caring for the environment as a global concern.

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