# Environmental economic estimation: case study in the city of Tarija - Bolivia

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## Abstract

The use of plastic bags is growing considerably, and in order to face this, governments have taken measures to discourage its use. This study evaluates the economic impact of this fact in Tarija, Bolivia, where measures have not already been implemented. The study variables are: (a) centres where bags are used, (b) quantity and size of bags used, (c) degree of environmental awareness of this problem, and (d) willingness to pay an extra charge for the use of bags. The results show that if no action is taken, the use of plastic bags will increase.

## Keywords

Economic Impact, Financial Impact, Plastic bags, Environmental conservation

## 1. Introduction

As a consequence of the emission of greenhouse gases, global warming is a growing problem. Eighty percent of these gases come from energy sources such as petroleum, which is the source where plastics are made, which consumption has increased, with an economic and environmental impact [1].

According to PlasticEurope in 2019, the plastics industry has also generated jobs and profits in Europe in 2018, being one of the largest industries today.

In the actual markets, plastic bags can be classified into high-density polyethylene bags and low-density polyethylene bags.

Considering this situation, initiatives have arisen from different organizations to mitigate the environmental impact. Thus, in 1987, the World Commission on Environment and Development promoted "sustainable development", defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [2, 3]. Currently, Bolivia is one of the few countries that does not have regulatory measures for this phenomenon. Furthermore, there are few studies on the use and consumption of plastic bags, which focus on the economic and consumption impact, being the main findings that 4.1 million

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plastic bags are used annually in Bolivia's three main cities. One of the few regions in the country that has started to raise awareness is the city of Tarija, where a law to reduce the use of plastic bags is being considered.

## 2. The Problem of the plastics

The problems associated with solid waste are often on a par with the pollution of water sources and clean air. As living beings, we are conditioned to generate waste based on our daily activities; however, we differentiate ourselves from other species by including inorganic waste that we ourselves have generated. The more populated a city is, the higher the rate of solid waste generation is, and the more space is needed for the treatment and final disposal of such waste [4]. Litter from this plastic bag can have several impacts. According to Wagner et al. [5], direct impacts are the costs to collect, dispose and dispose or recycle and the deterioration of storm drains; indirect impacts are related to aesthetics, property, values, tourism and litter [6]. The concepts of reuse, reduce and recycle need to be used.

Plastic waste exists in such quantities that even if we cut off its production all at once, it will be with us for centuries. The negative impact of this kind of waste can be seen in the seas and oceans, where, due to their low density, plastics are dispersed by ocean currents, traveling thousands of kilometers from the area of origin to almost anywhere in the world. For years now, islands of rubbish have been discovered, large surface areas in all the oceans of the planet where the waste of mankind has accumulated.

The presence of plastic debris is therefore a threat to biodiversity, in particular aquatic biodiversity, where they can be injured, immobilized or even killed. Even sedentary organisms such as corals are harmed by plastics when the tide pushes the debris against them, fracturing the coral and damaging the fragile ecosystem that depends on them. Recent research has confirmed that microplastics have entered the food chain [7, 8], with evidence of polystyrene particles transported from green algae to aquatic fleas to carp, affecting their metabolism and behavior.

### 2.1. The problem in Bolivia

Situations similar to those seen in large cities in the world's major powers can be observed in Bolivia. Plastic waste pollution and degradation is a reality that affects every population center in the country to a greater or lesser extent. From the city of La Paz, to the communities in nature reserves, there is the problem of the amount of solid plastic waste, which in many cases is not adequately disposed of. At one time plastic waste in cities may have been simply an aesthetic and tourist attraction issue, but over the years and as the population has grown, the use of plastic has increased exponentially.

With increasing concern about the negative impacts of anthropogenic activities on ecosystems, environmental education proposals have been developed with the aim of fostering a protectionist attitude towards the environment. This awareness that is sought to be generated in society must be promoted by national and local governments, in agreement with educational institutions. It will be on the basis of this general pro-environmental awareness that will give rise to policies focused on changing negative attitudes in modern society. It is important to note that data from

any survey related to environmental awareness that shows a favourable inclination towards the notion of natural resource protection will not always have the same response when it comes to implementing regulations or changes, which may be considered drastic, to their lifestyles. Similarly, the need to appear more interested in these issues may negatively affect the reliability of such a study [9].

When considering the specific issue of plastic bags in the context of environmental awareness, it must be recognised that there are no international environmental policies that sanction the excessive use of plastic bags. Instead, the proper handling of plastic bag waste has become the responsibility of individual governments, whether at national or sub-national level, who, through various instruments, policies and mechanisms, express concern about the growth of plastic bag waste [10].

### 2.2. Actions against plastic bags

In Nairobi, Kenya on the African continent, the risks posed by discarded plastic bags are recognized as a source of mosquito breeding and increasing the likelihood of malaria transmission, a serious problem considering that in 2005 their production of plastic bags exceeded 4000 tons per month and that half of them ended up as waste, clogging sewers and causing flooding in the rainy season [11]. In consideration of the severity of the problem, the government in collaboration with the United Nations decided to propose policies that would address the regulation of the amount of plastic bags produced and their disposal.

In Australia, the NGO "Cleaun Up Australia" promotes the "Say No to Plastic Bags" campaign, seeking the commitment of community residents, businesses, government and environmental groups based on three rules: refuse, reuse and recycle plastic bags [12]. Reusing multiple bags in a purchase, reusing bags held at home, returning unneeded plastic bags once shopping is done, and other actions that can be replicated on small and large scales. In Peru, Law No. 30884 has been enacted to regulate single-use plastic and disposable containers or packaging, based on the right of all people to enjoy a balanced and adequate environment for the development of their lives. This law seeks to progressively reduce the amount of single-use plastic used in Peruvian society, taking into consideration its great environmental impact on marine ecosystems and human health ("Law N° 30884 regulates the consumption of single-use plastic goods that pose a risk to public health and/or the environment")[1].

## 3. Methodology

The aim of this research is to approach the object of study, i.e. the use and frequency of plastic bags, and from this, to calculate the economic and environmental impact. The study population is made up of businesses and households in the city of Tarija-Cercado (concentrated area). This approach was carried out through two instruments; the first: questionnaires addressed to households in the city of Tarija to find out their consumption habits in the use of plastic bags, environmental awareness and their willingness to pay to reduce the use of plastic bags. On the other hand, questionnaires were sent to shops in the city of Tarija to find out the quantity of

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[1]https://sinia.minam.gob.pe/novedades/ley-ndeg-30884-regula-consumo-bienes-plastico-un-solo-uso-que-generan

bags given to the user. The sample was 599 people defined on the basis of the population of the city (Figure 1) and its distribution according to its districts.sv The statistical analysis was descriptive and inferential, using the SPSS statistical package.
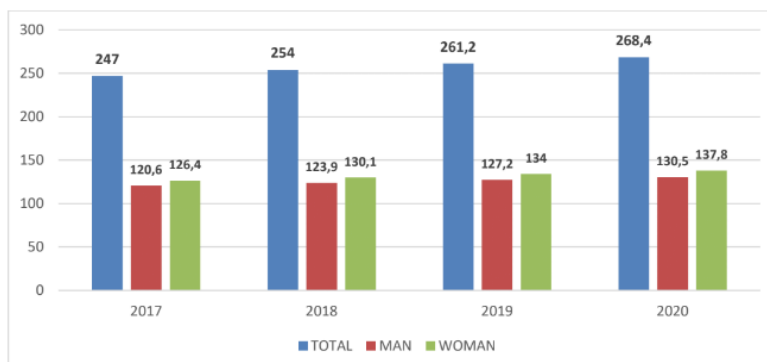


**Figure 1:** Population projections for the city of Tarija. National Institute of Statistics, 2014.

## 4. Analysis or results

In order to analyse the impact of plastic bag use in the city of Tarija, primary information was collected from the city's inhabitants about consumption, awareness and environmental measures. The data analysis included: descriptive, a non-parametric analysis (Chi Square) that allowed us to identify those traits of people who used plastic bags and an econometric model that allowed us to forecast the consumption of plastic bags according to the main features of the user of plastic bags in the city of Tarija, given the nature of the information, the stratified sampling technique was applied.

### 4.1. Respondent features



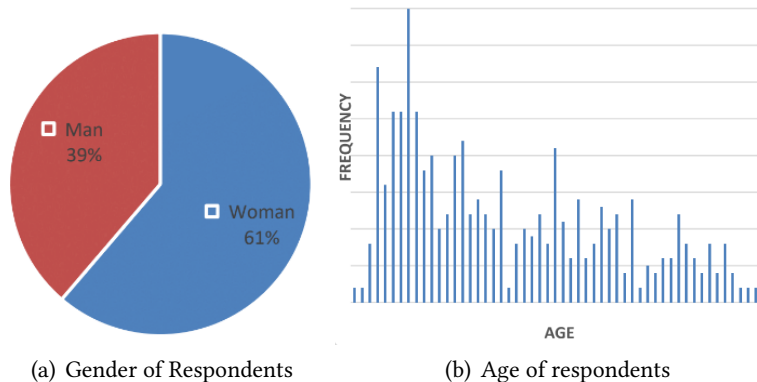(a) Gender of Respondents     (b) Age of respondents

**Figure 2:** Own elaboration

This first section details the demographic features of the sample, such as gender, age, number of household members, level of education and district of origin of the respondents.
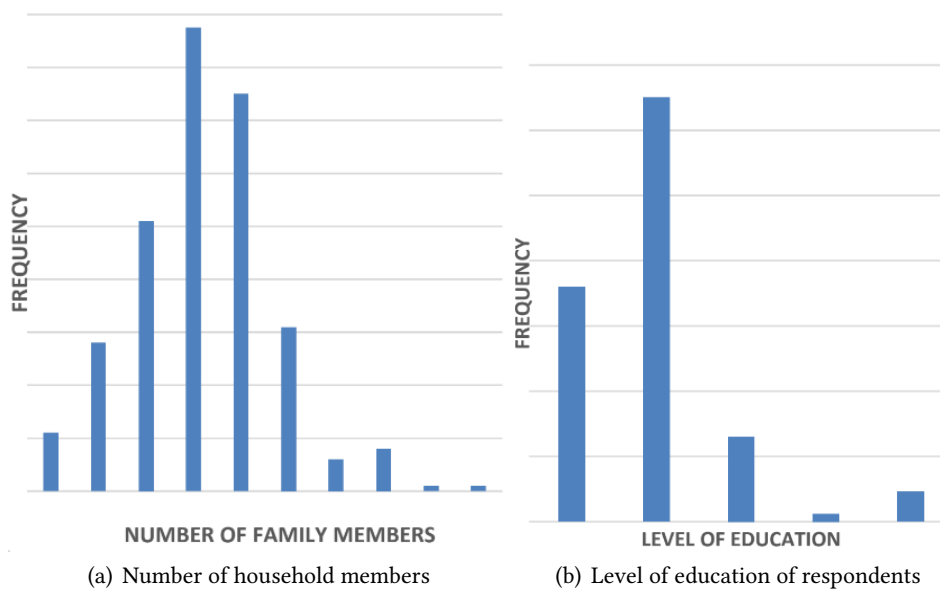


(a) Number of household members  (b) Level of education of respondents

**Figure 3:** Own elaboration

Finally, the information has been collected according to district and population (according to data from the Territorial Ordering of the city of Tarija).
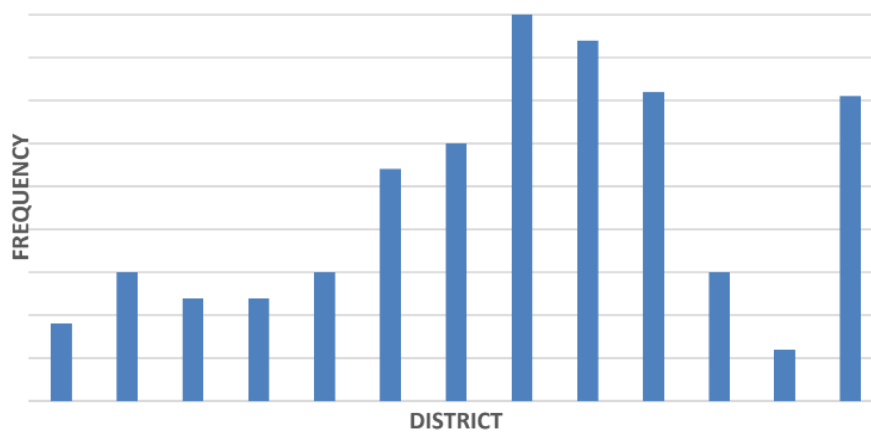


**Figure 4:** District of the interviewees. Own elaboration

### Frequency of visits by establishment

A key element in this research is to know the frequency with which people visit different consumer establishments, which allows us to identify the main establishments as well as to infer the consumption of plastic bags in the city of Tarija.

**Table 1**
Monthly visit frequency by establishment

| Establishment | Media | Standard Desviation |
|---|---|---|
| **Shopping Centres** | 3,39 | 2,65 |
| **Supermarkets** | 3,24 | 2,69 |
| **Markets** | 5,84 | 4,38 |
| **Small Business** | 10,45 | 8,54 |
| **Street Vendors** | 5,32 | 4,26 |
| **Restaurants** | 6,39 | 5,67 |

Own elaboration

**Table 2**
Ways of transporting the purchase depending on the establishment(Expressed in Percentages)

| | Shoppin centres | Supermarket | Markets | Small Business | Street Vendors | Restaurants |
|---|---|---|---|---|---|---|
| Plastic | 86.5 | 91 | 57.3 | 76 | 83.5 | 76.3 |
| Paper | 2.3 | 1.5 | 0.3 | 1 | 1.8 | 2.7 |
| Reusable | 7.5 | 5.8 | 37.1 | 12.4 | 4 | 6.7 |
| Other | 2.7 | 0.3 | 5.0 | 4.7 | 3.3 | 7.3 |
| None | 1 | 1.3 | 0.3 | 6 | 7.3 | 7 |

Own elaboration

In this case, based in the mean show that respondents visit more small business, restaurants, markets and street vendors. However, no matter the place, plastic bags are the preferred way to carry their shops, highlighting supermarkets and shopping centres.

## 4.2. Assessment of the consideration of environmental problems in the city of Tarija

In order to understand the attitude of Tarija's citizens with respect to current environmental problems, the study participants were asked to evaluate these problems according to their degree of relevance and the need for the corresponding authorities to address them.
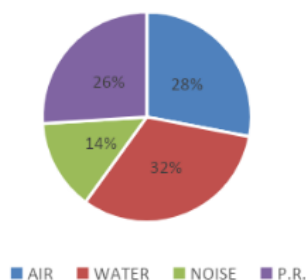


**Figure 5:** Priority environmental issues in Tarija. Own elaboration

For this part of the study, the sources of pollution that could affect the city were considered to be: air pollution, water pollution, noise pollution and problems related to the generation and management of solid waste, with special emphasis on plastics. According to the information collected, it was observed that for the population, the issue of water and its correct treatment is the greatest source of concern, while noise pollution is of lesser concern than the others.

**Solid waste pollution**, as far as the consequences on ecosystems that can be at a local and even global level. Considering this, the degree of awareness is analyzed according to the level of relevance they perceive with respect to this pollution.
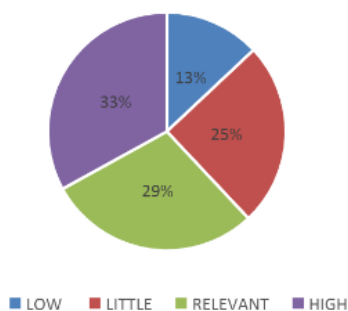


**Figure 6:** Solid waste pollution concern. Own elaboration

Around 50% of Tarija's population recognizes that solid waste pollution is in some degree of importance, and should be addressed. The problem is considered of high environmental concern by 33% of the population.



**Figure 7:** District distribution of solid waste pollution Concern. Own elaboration

## 4.3. The problem of plastic bags

In order to understand the measures to be applied to reduce the use of plastic bags, it is necessary to know at what level the citizens of Tarija understand the environmental consequences linked

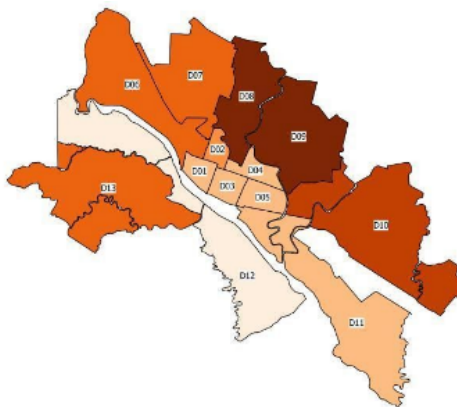to the generation of this type of waste. With this purpose, public opinion has been consulted regarding the degradation time of three types of bags: paper, plastic and domestic reusable bags.
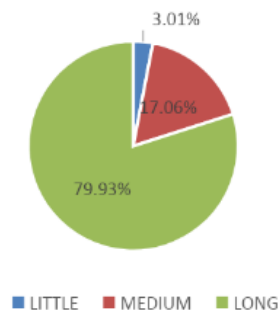


**Figure 8:** Opinion on lifetime of plastic bags. Own elaboration

In general, there may be a predisposition to support their reduction in their daily lives.
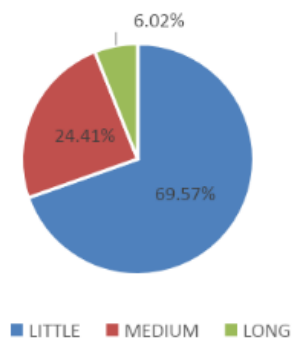


**Figure 9:** Opinion on lifetime of paper bags. Own elaboration

If we consider reusable bags as those made of different materials, such as sacks, cloth bags or recycled materials, public opinion is much more divided than in the previous cases.



**Figure 10:** Opinion on lifetime of reusable bags. Own elaboration

Encouraging people to use bags made of different materials for shopping could be an option to reduce dependence on plastic bags, which they recognise as a material with a long shelf life.

**Attitudes to Solid Waste**

The practices linked to solid waste management, including especially plastic bags, are expressed in the following chart:
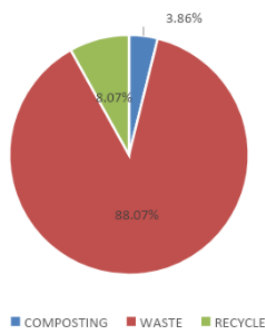


**Figure 11:** Main activity you do with your solid waste. Own elaboration

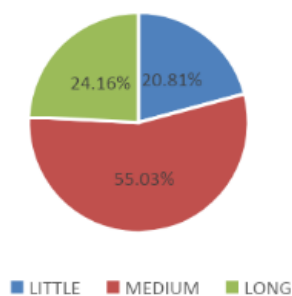The concept of "waste" includes everything from making use of the collection service provided by EMAT, to irregular activities such as burning and disposal in vacant lots inside and outside the city. The other categories include attitudes that are more friendly to the ecosystem, such as reusing plastic bags, sorting waste according to its characteristics, and even composting.

Considering that the population has a tendency to throw away their waste, it may be possible to implement measures to motivate the practice of recycling and composting at household level. It is interesting to note that, although the largest percentage reflects a neutral attitude towards waste, more than half of the population has knowledge about the proper handling and treatment of this type of waste, as expressed in the following graph.



**Figure 12:** District distribution of deficiency in waste classification and management. Own elaboration

A closer look at the positive attitudes of the population shows that District 12 and District 2 are those with the highest affinity to recycling, reuse and reuse of solid waste, which could be the most likely to accept new initiatives to reduce the use of plastic bags.

## 4.4. Normality test

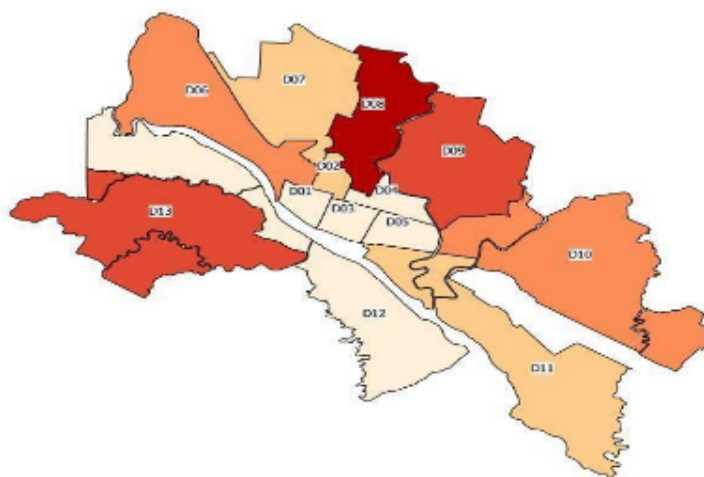To make the research more consistent and robust, variables that could influence the use of plastic bags have been contrasted, identifying three possible dependent variables: Willingness to change the use of plastic bags, Willingness to pay for the use of plastic bags and consumption of plastic bags. The first step in performing the various analyses is the normality test for these variables. The analysis is detailed below:

**Table 3**
Monthly visit frequency by establishment

| | Variables | | |
|---|---|---|---|
| **Statistics** | **Willingness to change** | **Willingness to pay for use** | **Monthly consumption plastic bags** |
| Degrees of freedom | 599 | 599 | 599 |
| z(K-S) | 0,540464 | 0,481996 | 0,153419 |
| P-value | 0,00 | 0,00 | 0,00 |
| Own elaboration | | | |

In all cases, normality is not accepted so the non parametric analysis is the way to threat the information.

## 4.5. Non - parametric analysis

***Willingness to change plastic bags***
When analyzing the factors that may influence the willingness to change the use of plastic bags in the city of Tarija, variables such as gender, age, level of education and the degree of awareness of the time it takes for plastic bags to disintegrate were taken into account. Considering the type of variables involved, a Chi-Square analysis was carried out, which is detailed below:

**Table 4**
Chi Square

| | District | Genre | Level instruction | Perception of plastic bag disintegration time |
|---|---|---|---|---|
| Pearson Chi-Square | 0,094 | 0,078 | 0,217 | 0,027 |
| Own elaboration | | | | |

The values obtained (p-values) for each of the variables reflect the fact that when thinking about changing the use of plastic bags, one has to work with the degree of awareness that exists about the bags, leaving aside the rest of the variables.

### Degree of awareness of the time it takes for plastic bags to disintegrate

Considering that the degree of awareness of the time it takes for plastic bags to disintegrate, has been found to be a fundamental element, we have proceeded to contrast what this knowledge depends on, and for this we have taken into account the district they come from, age, gender, level of education and number of family members. Once again, given the nature of the data, Chi-Square analysis was applied.

**Table 5**
Chi Square

|  | Age | District | Genre | No. Family members | Level training |
|---|---|---|---|---|---|
| Pearson Chi-Square | 0,000 | 0,002 | 0,322 | 0,000 | 0,000 |

Own elaboration

## 4.6. Econometric analysis

### Multiple regression analysis (Number of bags)

Proposing a model for predicting the consumption of plastic bags by an inhabitant in Tarija is one of the objectives of this work. For this purpose, multiple regression analysis has been used with the different variables. The results are shown below:

**Table 6**
Multiple regression analysis

|  | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
|  | Coef | p-value | Coef | p-value | Coef | p-value |
| District | -1,698 | 0,000 | -1,653 | 0,000 | -1,647 | 0,00 |
| Age | -0,398 | 0,000 | -0,428 | 0,000 | -0,416 | 0,00 |
| Knowledge time disintegration | 9,633 | 0,000 | 9,511 | 0,000 | 9,122 | 0,00 |
| Genre | - | - | -0,580 | 0,821 | -0,665 | 0,79 |
| Training | - | - | 2,567 | 0,073 | 2,357 | 0,10 |
| Int. No. Family | - | - | - | - | -1,200 | 0,15 |
| Classification and handling | - | - | - | - | -4,368 | 0,09 |
| Intercept | 70,224 | 0,000 | 69,099 | 0,000 | 76,587 | 0,00 |

Own elaboration

Therefore, the monthly plastic bag consumption prediction model looks like this:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \tag{1}$$

Where, $\beta_0$ = Constant, $\beta_1$ = District, $\beta_2$ = Age, $\beta_3$ = Knowledge of the disintegration time of plastic bags.

**Table 7**
Anova

| Model | Gl | sig |
|---|---|---|
| Regression | 3 | 0,000 |
| Own elaboration | | |

## 4.7. Quantification and projection

### *Quantification of plastic bag use*

According to the data collected, an estimate has also been made of the amount of plastic bags consumed in the Cercado province of the Department of Tarija from 2019 to 2025. For this purpose, the projection technique applied was the projection with a percentage value.

Prior to this analysis, it is important to know some relevant data collected. Firstly, the individual behaviour of average plastic bag consumption according to seasonality.

**Table 8**
Consumption of plastic bags per inhabitant per season

| Year | Station | Quantity |
|---|---|---|
| 2019 | Winter | 103 |
| | Autumn | 99 |
| | Spring | 103 |
| | Summer | 111 |
| **Total** | | 416 |

Own elaboration

**Table 9**
Consumption of plastic bags province fencing and quantification

| Year | Station | Quantity | Percentage growth | Total Amount 2019 |
|---|---|---|---|---|
| 2019 | Winter | 26.936.811 | | |
| | Autumn | 25.906.012 | -4% | |
| | Spring | 26.805.999 | 3% | 108.526.884 |
| | Summer | 28.878.062 | 8% | |
| | Growth rate | | 2% | |

Own elaboration

Parameters:

- Population Cercado Province: 261,188 inhabitants
- Wholesale bag $cost = 0.24$ ctvs
- Growth Rate: 2% (Calculated on a seasonally adjusted basis)

**Table 10**

Projection of plastic bag consumption and economic quantification current scenario

| Year | Station | Quantity | Total annual | Annual cost |
|------|---------|----------|--------------|-------------|
| 2019 | Winter  | 26.936.811 | 108.526.884 | Bs 26,046,452 |
|      | Autumn  | 25.906.012 |             |               |
|      | Spring  | 26.805.999 |             |               |
|      | Summer  | 28.878.062 |             |               |
| 2020 | Winter  | 27.599.202 | 111.195.619 | Bs 26,686,949 |
|      | Autumn  | 26.543.055 |             |               |
|      | Spring  | 27.465.173 |             |               |
|      | Summer  | 29.588.189 |             |               |
| 2021 | Winter  | 28.277.881 | 113.929.980 | Bs 27,343,195 |
|      | Autumn  | 27.195.763 |             |               |
|      | Spring  | 28.140.557 |             |               |
|      | Summer  | 30.315.778 |             |               |
| 2022 | Winter  | 28.973.250 | 116.731.580 | Bs 28,015,579 |
|      | Autumn  | 27.864.522 |             |               |
|      | Spring  | 28.832.548 |             |               |
|      | Summer  | 31.061.260 |             |               |
| 2023 | Winter  | 29.685.718 | 119.602.073 | Bs 28,704,497 |
|      | Autumn  | 28.549.726 |             |               |
|      | Spring  | 29.541.556 |             |               |
|      | Summer  | 31.825.073 |             |               |
| 2024 | Winter  | 30.415.706 | 122.543.152 | Bs 29,410,357 |
|      | Autumn  | 29.251.779 |             |               |
|      | Spring  | 30.267.999 |             |               |
|      | Summer  | 32.607.669 |             |               |
| 2025 | Winter  | 31.163.644 | 125.556.555 | Bs 30,133,573 |
|      | Autumn  | 29.971.096 |             |               |
|      | Spring  | 31.012.306 |             |               |
|      | Summer  | 33.409.509 |             |               |

Own elaboration

Based on these parameters, and assuming the actual situation. It has been estimated that for 2019 there has been an approximate consumption of 108,526,884 plastic bags, which in economic terms represents an economic cost of $us. 3.742.306. However, for 2025 this annual cost increases in 14%.

One of the objectives of this work is to analyze the impact that the law would have on plastic bag consumption. For this purpose, in addition to the current scenario, two other scenarios are considered: the first one called "pessimistic" and the second one called "optimistic".

**Table 11**

Projection of plastic bag consumption and economic quantification pessimistic scenario

| Year | Station | Quantity | Total annual | Annual cost |
|---|---|---|---|---|
| 2019 | Winter | 26.936.811 | 108.526.884 | Bs 26,046,452 |
| | Autumn | 25.906.012 | | |
| | Spring | 26.805.999 | | |
| | Summer | 28.878.062 | | |
| 2020 | Winter | 28.014.284 | 112.867.960 | Bs 27,088,310 |
| | Autumn | 26.942.253 | | |
| | Spring | 27.878.239 | | |
| | Summer | 30.033.184 | | |
| 2021 | Winter | 29.134.855 | 117.382.678 | Bs 28,171,843 |
| | Autumn | 28.019.943 | | |
| | Spring | 28.993.369 | | |
| | Summer | 31.234.511 | | |
| 2022 | Winter | 30.300.249 | 122.077.985 | Bs 29,298,716 |
| | Autumn | 29.140.741 | | |
| | Spring | 30.153.103 | | |
| | Summer | 32.483.892 | | |
| 2023 | Winter | 31.512.259 | 126.961.105 | Bs 30,470,665 |
| | Autumn | 30.306.370 | | |
| | Spring | 31.359.228 | | |
| | Summer | 33.783.247 | | |
| 2024 | Winter | 32.772.749 | 132.039.549 | Bs 31,689,492 |
| | Autumn | 31.518.625 | | |
| | Spring | 32.613.597 | | |
| | Summer | 35.134.577 | | |
| 2025 | Winter | 34.083.659 | 137.321.131 | Bs 32,957,071 |
| | Autumn | 32.779.370 | | |
| | Spring | 33.918.141 | | |
| | Summer | 36.539.960 | | |

Own elaboration

In the worst scenario, where no law is applied, the trend show that for 2025, approximately 137.321.131 plastic bags will be consumed, representing an increase in the annual cost of 21%.

Finally, in the best scenario where the law is applied, the results shows that from 2019 - 2025 just an increase of the 6%.

**Table 12**

Projection of plastic bag consumption and economic optimistic Scenario

| Year | Station | Quantity | Total annual | Annual cost |
|------|---------|----------|--------------|-------------|
| 2019 | Winter | 26.936.811 | 108.526.884 | Bs 26,046,452 |
|      | Autumn | 25.906.012 |             |               |
|      | Spring | 26.805.999 |             |               |
|      | Summer | 28.878.062 |             |               |
| 2020 | Winter | 27.206.179 | 109.612.153 | Bs 26,306,917 |
|      | Autumn | 26.165.073 |             |               |
|      | Spring | 27.074.059 |             |               |
|      | Summer | 29.166.842 |             |               |
| 2021 | Winter | 27.478.241 | 110.708.275 | Bs 26,569,986 |
|      | Autumn | 26.426.723 |             |               |
|      | Spring | 27.344.800 |             |               |
|      | Summer | 29.458.511 |             |               |
| 2022 | Winter | 27.753.023 | 111.815.357 | Bs 26,835,686 |
|      | Autumn | 26.690.991 |             |               |
|      | Spring | 27.618.248 |             |               |
|      | Summer | 29.753.096 |             |               |
| 2023 | Winter | 28.030.554 | 112.933.511 | Bs 27,104,043 |
|      | Autumn | 26.957.900 |             |               |
|      | Spring | 27.894.430 |             |               |
|      | Summer | 30.050.627 |             |               |
| 2024 | Winter | 28.310.859 | 114.062.846 | Bs 27,375,083 |
|      | Autumn | 27.227.479 |             |               |
|      | Spring | 28.173.375 |             |               |
|      | Summer | 30.351.133 |             |               |
| 2025 | Winter | 28.593.968 | 115.203.475 | Bs 27,648,834 |
|      | Autumn | 27.499.754 |             |               |
|      | Spring | 28.455.108 |             |               |
|      | Summer | 30.654.644 |             |               |

Own elaboration

## 5. Conclusions

It is concluded that the implementation of measures can reduce the consumption of plastic bags in Tarija. So far, our first conclusion is that people have the perception that supermarkets, shopping centers and street vendors should provide them with plastic bags for free. Then authorities have to increase their effort in this establishment in order to make aware. About seasonality, in spring and summer more bags are consumed. In addition, it has been shown that the more remote districts of the city are more aware of the situation. Also, the law should be accompanied by socialization programmers, in the non parametric analysis some clues are given. Authorities must design these plans having attention in the age, district, formation and

the number of the families.

As this is an exploratory research that evaluates measures to reduce the use of plastic bags, an econometric model has been proposed to predict the consumption of plastic bags by each inhabitant according to age, environmental awareness and district. In this model, higher consumption is identified in the first districts (central and commercial zone), apparently younger people have less consciousness in the consume of bags.

If current conditions are kept up, the trend is towards an increase in plastic bag consumption. These situation is not only backup by the statistical analysis, also by the economic quantification and financial projection. Finally, our sample seems to agree for economics measures as a way to mitigate this problem. Therefore, if this law that targets the consumption of plastic bags is applied, we can gradually reverse this situation.

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