Chapter 145

Research on the valuation of the net social benefit of reuse (BLSR) in the municipality of Paragominas, Pará

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ABSTRACT
Several initiatives culminate in environmental gains, such as recycling and reuse. This provides savings regarding natural inputs, especially minerals and vegetable cellulose. In this sense, the present work aims to investigate the Net Social Benefit of Reuse (BLSR) of steel, aluminum, paper, plastic and glass, which the municipality of Paragominas does not have with the poor management of RS. The method used was based on two hypotheses, (1) the scrap market operates in perfect competition; (2) true opportunity cost. Five classes of municipal waste were analyzed: steel, aluminum, paper, glass, and plastics, regarding their reuse and the financial resources generated by this action. The data obtained and analyzed indicated that, among the five classes analyzed for the municipality of Paragominas, plastic presents the highest BLSR, in both hypotheses (H1= R$ 511.77; H2 = R$ 433.04); and that all classes of waste present a potential benefit of up to R$ 17,542,924.95/year to the municipality of Paragominas.

Keywords: Waste, Reuse, Environmental impacts.

1 INTRODUCTION

Valuing the reuse of solid waste has the priority of identifying an estimate of the well-being of communities in relation to environmental services. Such services are under the responsibility of managers in the three political spheres (Federal, state and municipal). This value must be expressed in monetary units because that way they can verify if they lost or gained with the reuse of solid waste (YOUNG et al., 2015).

On the other hand, this valuation, which results in monetary terms, shows how useful reuse is to understand the relationship between the value of the environment and the natural resource, in addition to demonstrating how much this input represents for the socio-environmental being, that is, what is his real role in the life of the community (FREITAS et al., 2010). So, the complex situation of valuing environmental goods and services indicates a great opportunity in terms of income generation associated with those of natural resources (MOTTA, 2011).

From these arguments, two questions arise: 1) Are there any benefits from reusing waste? 2) What economic and environmental values does this represent? Both have not yet been satisfactorily answered in the literature involving this subject (CHAVES, 2012; RODRIGUEZ, 2014). What is known is that raw materials such as steel, aluminum, paper, plastic and glass can and should be reused, and that this can mitigate the high costs caused by selective collection.

As for the net social benefit, it is associated with four lines in the cause-effect relationship: reasons: 1) disorganized management of solid waste; 2) inadequate disposal and degradation of natural resources; 3) reduction in the quality of health in the community and, 4) income generation for a small part of the working population (CHAVES; SOUZA, 2013)

However, this benefit will only be visible when the problem, that is, the cause, is identified and, after analyzing the time and the solutions to solve it, with direct attacks on the core of the issue under study, the results culminate in advantages (Ex. .: income; health) to the population of the location where the study takes place. Consequently, the negative externality, that is, when an action (inadequate disposal of SR) imposes costs on another such as, for example, poor health and high treatment costs, is annulled (FILIPE, 2012).

For the reuse of solid waste such as steel, paper, plastic and glass, studies (RIBEIRO et al., 2014; VIEIRA, 2003) indicate that they still have economic value, as well as capacity to generate income. In these cases, there is a decrease in the cost of garbage collection, disposal in inappropriate places, changes in natural resources such as soil, water and air and, finally, the occurrence of negative environmental impacts (AQUINO et al., 2016).

Another factor for this action is linked to the increase in production costs because their exploitation in the environment causes a shortage of them, especially iron (Fe) and water. So, reuse is one of the actions that contribute to a lower need for these inputs, which contributes to the so-called "sustainability" (SOUZA et al., 2015). In the case of cans, their production uses steel and aluminum, and the glasses are produced from the association of sand, ash, limestone (LANDIM et al., 2016).

Regarding plastics, currently used by the community and industries are of two types: 1) Polyethylene whose chemical composition is "-(-CH2-CH2-) -n", which is highly resistant to humidity, as well as to substances chemicals; 2) Polycarbonate, it is transparent, resistant, it is similar to glass, however, it is more resistant to impact. As can be seen, disposal in the environment does not have a short decomposition period, since the minimum period reaches more than 100 years (NOGUEIRA et al., 2005; PIATTI; RODRIGUES, 2005).

But it is necessary that you have knowledge about the classification (article 13, item I, paragraph a) and definition (article 3, item XVI) of what you want to reuse. A better conceptualization of household SR is contained in the National Solid Waste Policy:

> Discarded material, substance, object or good resulting from human activities in society, whose final destination is proposed to proceed or is obliged to proceed, in the solid, semi-solid states, as well as gases contained in containers and liquids whose particularities make their disposal impracticable release into the public sewage system or bodies of water, or require technically or economically unfeasible solutions for this in the face of the best available technology (PNRS, s/p, 2010)

In addition, the law mentions that municipal and state governments are responsible for developing targets for the reduction of MSW following a priority order: non-generation, reduction, reuse, recycling, treatment of solid waste (garbage that can be reused or recycled) and environmentally appropriate final disposal of waste (which cannot be reused), as well as defining guidelines for waste management and the extinction of open dumps, which would be converted into sanitary landfills (BRASIL, 2010).

Another piece of knowledge concerns the composition of the MSW: 65% organic matter; 25% paper; 4% metal (steel, aluminum, among others); 3% glass and 3% plastic (MUCELIN; BELLINI, 2008). This knowledge is complemented with the quantity generated. In this case, according to data from the National Sanitation Information System (SNIS, 2018), 19,466.4 tons of household solid waste (RDO) and public solid waste (RPU) were generated in the municipality of Paragominas, coming from the population served by the collection and disposal service. waste transport, which is equal to 87,418 inhabitants in the urban area and 8,200 inhabitants in the rural area, in that year.

Finally, one should be aware of the costs that MSW consumes from government budgets, which are not negligible. In the case of Paragominas, the city hall spends a total of R$ 8,209,741.67/year on cleaning and MSW management services, divided into: RDO and RPU collection (R$ 3,712,979.7/year), RSS collection (R$ 262,036.5/year), sweeping of public places (R$ 2,624,136.79/year), other services (R$ 1,610,588.68/year), where approximately 111,000 inhabitants live (SEMUR , 2019).

All these arguments justified the realization of this study and increased its relevance, since it generated data about this valuation in the municipality of Paragominas, southeastern Pará, and identified, monetarily, the social benefits that the reuse proportional to the local society.

2 OBJECTIVES

2.1 GENERAL

Calculate the Net Social Benefit of Reuse (BSLR), and the viability of inserting the subsidy for the development of recycling and the financial potential of SRs.

2.2 SPECIFIC

- Identify which SR class has the highest contribution to the net social benefit.
- Know if the recycling segment needs a subsidy to develop.
- Calculate the financial potential arising from steel, paper, plastic and glass, in the Municipality of Paragominas.

3 LITERATURE REVIEW

3.1 THE STEEL

The steel segment in Brazil is the largest industrial emitter of greenhouse gases (GHG) and the second largest industrial consumer of energy. In 2014, primary iron and steel production accounted for 4%

of industrial energy consumption. Furthermore, the steel industry emitted 46% of the total emissions of the Industrial Processes Sector in 2010, and with regard to total Brazilian emissions, the sector accounted for about 3.7% (GOMES; DUTRA, 2016).

Still on the steel industry, there is a report (CALVANTE; ADAMIAN, 2012) that one of its most relevant impacts is atmospheric pollution, which generates critical situations for the health of the surrounding population (e.g. respiratory diseases), as atmospheric emissions consist of particulate matter, nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), heavy metals, volatile organic compounds (VOC's), aromatic alicyclic compounds, dioxins and furans, polychlorinated biphenyls , and acidic compounds.

Therefore, the reuse of steel is strategic, as the material does not lose in quality, has a high durability, in addition to the fact that it is 100% recyclable. In civil construction, for example, compared to others, steel has advantages because at the end of its useful life, it returns to the production chain. When their useful life ends, all products become scrap that returns to the furnaces of the plants for the production of steel with the same quality (SANTOS et al., 2015).

3.2 THE ALUMINUM

Both types of aluminum, primary and secondary, can be obtained in Brazil. The first is obtained from bauxite (Al2.nH20 +ganga), extracted from Lateritic soils, after vegetation suppression, rich in aluminum hydroxides (Al) and Iron (Fe), whose mining is done in the open. The second is obtained from the recycling of primary aluminum. mention that each ton of processed bauxite produces an average of 1.5 tons of slag, formed mainly by oxides of aluminum (Al2O3), iron (Fe), silicon (Si) and titanium (Ti) (SOUZA et al., 2015).

As for the production of this second type of aluminum, it involves a complex system that involves three distinct steps: 1) bauxite extraction, 2) alumina refining (separation of aluminum oxide from other bauxite elements) and 3) production of the metal itself, the so-called reduction process (which separates oxygen from aluminum, and requires high energy consumption). In this process, four to five tons of bauxite are needed to extract just one of the metal (LIMA; MOTTA, 2010). Another necessary observation is regarding energy consumption, in 2010, Brazil consumed 15.6 MWh/t (XAVIER, 2012), a value above the world average. As a result, the demand for the construction of hydroelectric plants increased, and this caused serious impacts on the communities that live close to the projects, such as compromising water quality, changing the hydrological regime of rivers, among others (SANTOS et al., 2017).

In this way, this production chain generates serious environmental impacts, mainly the extraction of bauxite, as there is high-scale plant suppression and soil disturbance, which destroys horizons and establishes layers, in addition to compromising soil fertility by inverting the microbiota , so reuse is one of the tools that contribute to mitigate such negative actions (IPEA, 2010).

3.3 THE PAPER

Currently, almost all paper production (95%) comes from tree trunks which, in general, originate from reforestation processes, especially eucalyptus (Eucalyptus spp) because these trees offer rapid growth (± seven years), and a diameter approximately 30 cm (FILIPINI, 2013). The problem is that there are environmental impacts caused by substances from these types of plants.

The impacts caused by resins produced by this plant have already been analyzed (DE VECHI; MAGALHÃES JÚNIOR, 2018). In it, the authors observed the process of destruction of the litter formed by them. It occurs from the presence of larvae belonging to the Oecophoridae family, which is endemic to Australia, therefore, in Brazil, the replacement of organic matter and soil nutrients is difficult and interferes with soil fertility, according to studies already carried out. in Florestal – MG (OLIVEIRA et al., 2018)

Another study about the environmental impacts in the production of paper from this tree was carried out in Vitória - ES, there, the authors identified that (1) the Brazilian Institute of Geography and Statistics (IBGE), classified this type of monoculture as "forest planted", in addition to replacing food crops with eucalyptus, as the pulp and paper industry grew from 7% to 79% in 2014 (LIMA et al., 2016).

Therefore, the reuse of paper allows a reduction in the volume of waste caused by excessive use and also saves trees in the ratio of 1 t = 20 trees, in addition to generating extra income for the community and opening up a market in the paper sector.

3.4 GLASS

The glasses are manufactured using a process in which raw materials (silica, soda ash and limestone) in varying proportions are mixed and melted at a high temperature between 1350 °C and 1600 °C, which makes it possible to mold them into different shapes and sizes. Alumina can be incorporated to improve the chemical durability of the glass and refining agents act by reducing the temperature and time it would take in the melting process (LANDIM et al., 2016).

With regard to manufacturing, the impacts are linked to the extraction of the raw material necessary for its production: quartz (sand), limestone ($CaCO3$), dolomite ($CaMgCO3/CaMg.2CO3$), among others, as well as the emission of greenhouse gases. Greenhouse Effect (GHG) due to the consumption of electrical and thermal energy. In addition, the use of compounds in glass pigmentation: Iron oxide, Cadmium (Cd) or Chromium (Cr), generates toxins in the air, which can cause problems to human health (PETARNELLA; NASCIMENTO, 2017)

In this sense, glass is one of the materials that has the greatest potential for returning to the production chain, however, it is one of the most problematic to collect, sort and sell. In regions far from large production centers or where the consumption of glass packaging is not high, the revenue from the sale of this material does not cover transport costs and, for this reason, the material that often arrives at collectors' organizations ends up being disposed of in landfills (CAETANO; LUNA, 2018).

In addition, it is worth noting that for some industries, glass is one of the least interesting materials to recycle, as its raw materials are relatively low and abundant. However, glass recycling generates numerous environmental benefits, such as reducing waste in the environment, especially if one takes into account that a glass bottle decomposes, on average, in 4,000 years (PETARNELLA; NASCIMENTO, 2010)

3.5 PLASTICS

The production chain of plastics begins with the use of naphtha (C10H8), obtained by refining oil or natural gas (CH4), used as raw materials to obtain ethylene (C2H4), benzene (C6H6) , propylene (C3H6) and other basic petrochemicals. Resins are produced from these products, which are then processed to generate various products in the plastic transformation industries (DIAS; MAGRINNI, 2016).

The environmental impacts in the production chain of this material are directly linked to the impacts of oil exploration, which are changes in water quality through the disposal of tailings, GHG emissions during extraction and refining, soil contamination in the event of a spill , among others (MARTINS et al., 2017).

Currently, properly disposing of plastic-based RS has been a challenge, since they are durable in the environment due to their chemical components that are not decomposed by microorganisms. Even those that are considered biodegradable do not solve the problems, as they simply break up into smaller parts, only reducing the volume of these packages in the environment (SILVA et al., 2013).

With regard to the irregular disposal of this material, it has become one of the main factors responsible for obstructing urban drainage networks and for water pollution. In addition, its impact on biodiversity can be high for some populations of aquatic mammals, birds, reptiles, fish, among others, and that ingest or are intertwined with these materials (ESCOCARD et al., 2018).

In this way, the reuse of plastic is fundamental for the sustainability of the sector. Post-consumer plastic recycling in Brazil is 17.5%, a positive percentage compared to the European rate, which is around 22%, and what is important is that recycling in our country has grown 15% year-on-year year. Recycling can also be pre-consumer, that is, it can happen in the industries that use plastic waste, such as shavings, burrs and leftovers (PIATTI; RODRIGUES, 2005).

3.6 SOLID WASTE IN BRAZIL

Currently in Brazil, the average generation of urban solid waste is close to 1 kg/person/day in the country, a pattern similar to that of some countries of the European Union. Among urban populations with higher purchasing power, the consumption pattern is similar to that of North American citizens, recognized as the largest producers per capita of MSW (GOLVEIA, 2012).

In this sense, poor waste management has significant consequences for human health and results in a reduction in the ability to provide ecosystem services, essential to life, which generates environmental degradation (SOUZA et al., 2015). As an example of the impacts arising from poor management, soil pollution and degradation, pollution of water bodies and springs, intensification of floods due to the silting up of rivers and streams and obstruction of manholes, proliferation of flies, cockroaches, rats and other vectors of health importance, increased risk of waterborne diseases such as leptospirosis and dengue (KLEIN et al., 2018).

Currently, according to the Business Commitment for Recycling (CEMPRE), Brazil generates 206,000 tons of solid waste per day that can be commercially exploited, as 76% of them are deposited in the open in 'dumps'; 13% in controlled landfills; 10% dumped in landfills; 0.9% composted in plants, and 0.1% incinerated, causing serious damage to the environment (RIMOLI; RYLO, 2015).

3.7 WASHERS AND COLLECTORS

The situation becomes more critical for collectors of recyclable materials, who carry out their work in very unhealthy conditions, generally without protective equipment, resulting in a high probability of acquiring diseases. These problems include exposure to metals and chemicals, infectious agents, respiratory and musculoskeletal diseases and injuries from accidents, in addition to providing social inclusion for marginalized people who start working in collection or sorting (GOLVEIA, 2003)

In addition, the activity of urban cleaning workers is part of devalued jobs, tasks that are socially considered separate, avoided and hidden, as well as the worker who performs them through the bond established between him and his work object. (MOTTA; BORGES, 2013). Thus, for Brazil, investment in solid waste management is essential for the development and solidification of its infrastructure. It is possible to use the potential of biogas for energy generation, evolve in the matter of recycling and reuse, which involves social, environmental and economic aspects, create public-private partnerships, among other challenges (DEUS et al., 2015).

3.8 THE REUSE OF SR

The act of reusing is one of the effective mechanisms in the face of the difficulties inherent in the management of SR because it contributes to the reduction of costs in the acquisition of raw materials, amount of waste that needs treatment and final disposal, in addition to providing social inclusion for marginalized people. who start working in collection or sorting (RODRIGUES et al., 2017).

In this sense, the Institute of Applied Research analyzed the benefits of this activity in relation to production from virgin raw material from two points of view, economic and environmental. Economic ones primarily include the avoided cost in terms of consumption of natural resources and energy. Environmental benefits are associated with impacts on the environment due to energy consumption, GHG emissions, water consumption and loss of biodiversity (IPEA, 2010).

Furthermore, this practice generates jobs and income, reduces the unrestrained exploitation of natural resources used as raw materials in the production of various packaging, and also reduces the need to occupy (and pollute) spaces to deposit materials that have only fulfilled their purpose once. socioeconomic function (SEBRAE, 2012).

Thus, in Brazil, reuse costs around 1.2 billion dollars, however, this number could be 5.8 billion dollars, since only a tiny amount of Brazilian solid waste is currently reused, which leads to the conclusion that, in the country, the perspectives for the sector are of strong expansion (RIMOLI; RYMO, 2003).

3.9 SR LEGISLATION IN BRAZIL

Thus, over the years some rules were created to deal with the issue of waste generation until the creation of Law n.º 12.305/10 that instituted the National Solid Waste Policy (PNRS), such as: CONAMA Resolution n.º 275 /01, which establishes the color code for the different types of waste; National Health Surveillance Agency (ANVISA) No. 306/04, health service waste (RSS), National Basic Sanitation Policy (PNSB), Law No. 11,445/07 (SILVA et al., 2013).

In addition to those cited, there is the Brazilian Association of Technical Standards (ABNT) which, through NBR 10,004/04, classifies waste into Class I (hazardous waste) and Class II, non-hazardous waste; Class II, divided into Class II A, that is, non-inert waste, and Class II B, inert waste (ABNT, 2004).

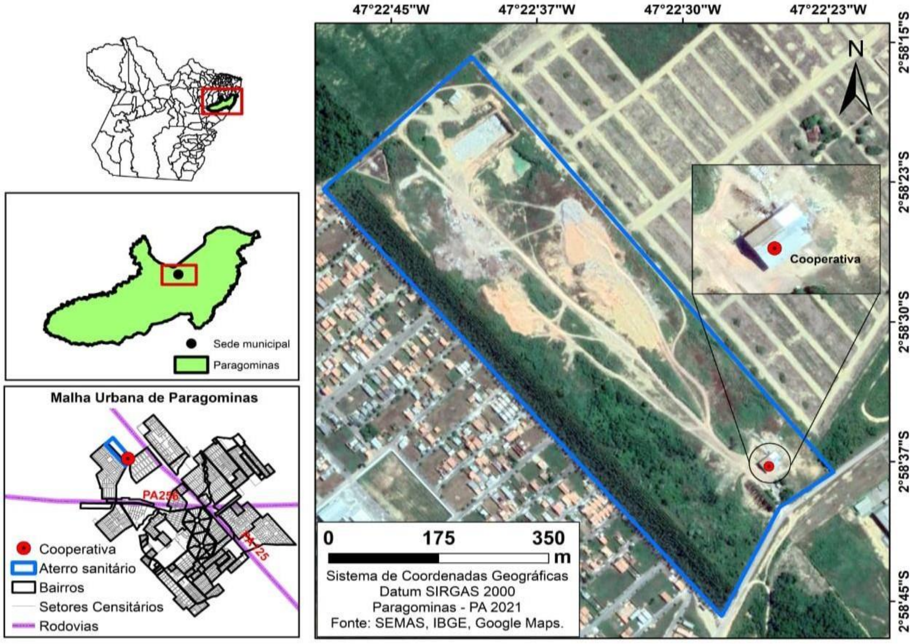
After the enactment of the 1988 Constitution, the following was defined in items I and V of article 30: “it is municipal attribution to legislate on matters of local interest, especially regarding the organization of its public services”. Then begins the process of decentralization of sectors such as basic sanitation, which defined municipalities as holders of the management of urban cleaning services (BRASIL, 1988).

4 MATERIAL AND METHODS

4.1PHYSIOGRAPHY OF THE MUNICIPALITY

The municipality of Paragominas is located in the Southeast of the State of Pará, 320 km from the capital, Belém. It has a tropical climate with hydrography determined by the rivers Uraim and Igarapé Paragominas, also called Igarapé Prainha. The vegetation is composed of dense submontane forest, dense lowland forest and dense alluvial forest (PINTO et al., 2009). The territorial extension is equivalent to 19,342.25 km² and the population, according to the 2010 census, is equal to 97,819 inhab., with estimates for 2018, at 111,764 inhab., and 2019, 113,507 inhabitants (IBGE, 2010).

Figure 1. Image of the location of the municipality and the landfill



Legends: Cooperativa = cooperative; Aterro = Landfill; bairros = Neighborhood

4.2 METHODS

To better conduct this scientific investigation, two methods were associated: 1) case study which, according to what was summarized by Clemente Júnior (2012), researchers can use evidence such as document analysis and participatory observation. 2) The deductive, because according to the report by Prodanov and Freitas (2013), the use of quantitative scope and applicative nature is allowed, and complement it with documentary data collection. It should be noted that the in situ information about the Paragominas Controlled Landfill and the Solid Waste Management Plan for that location were obtained from the managers of this SW reception and storage location. As for the selection of five of them, the proposal by Chaves and Souza (2013) was used as a basis (Chart 1).

Quadro 1. Detailing the components present in each class of material worked on.

Index	**Solid Waste**	**Features**
1	Steel	Iron, metal and plating.
2	Aluminum (Al)	aluminum and hard aluminum cans
3	Paper	white paper and cardboard
4	Plastic	empty butter wrappers, empty QBoa bottles, Polyethylene terephthalate (PET) bottles, cooking oil and cling film
5	Glass	clear glass bottles

Elaborated by the authors.

After obtaining data regarding the selected SR, the calculation was made for the estimated value of the Net Social Benefit of Reuse (BLSR), based on the environmental valuation methodology proposed by Motta (2006), and the application of Equation 1.

$$BLSR = GCD + CA + GMI - GAR \ (1)$$

Where: GCD – current and effective expenses for collection, transport and final disposal of urban waste; CA – costs and environmental damage resulting from poor collection and disposal of urban waste; GMI – cost reductions associated with raw materials and other inputs provided by reuse; GAR – expenses associated with reuse. It is worth noting that the term "reuse" refers to the concepts of both recycling and reuse.

The calculations for the four components of Equation 1 were performed from the data for the composition of the BLSR (Table 2).

Table 2. Indication of how the values of the formula were reached.

Index	**Ações para o cálculo**
GCD	For current expenses with waste collection, the values in the SNIS platform (2019) were used, referring to the year 2018.
CA	The estimated value of Greenhouse Gases (GHG's) was used, contained in the IPEA report (2010), as recommended by Chaves and Souza (2013).
GMI	Use of two hypotheses, in line with Motta (2006): (1) The scrap price itself was taken into account, which already provides the GMI minus the expenses associated with reuse (GAR). It is worth mentioning that this hypothesis suggests that the scrap market operates under perfect competition. - For this study, an estimate of this item will be made from the data collected from the Cooperative of Recyclable Materials of Paragominas - COOPERCAMARI. (2) is calculated on the basis of true opportunity cost, and is based on avoided energy and raw material costs, minus private costs of reprocessing, provided by reuse..
GAR	For the calculations of this item, the average value (R$260.00) recommended by IPEA (2010) was used. This choice is justified by the search for a value that would reveal the real cost for Paragominas, due to the population growth in the 53 years of existence of the municipality.

Elaborated by the authors.

For the final calculation of the BLSR, two steps were used: 1) individual calculations for steel, aluminum, paper, plastic and glass; 2) weighted average value between them. As for the weights used to carry out the weighting, the recommendation by Rodrigues et al (2017) was followed, who used the gravimetric percentage of each material contained in 1 t of garbage, whose predominance was the four residues studied (Table 1).

Table 1. Gravimetric composition used for weighting.

Material	**Gravimetric composition IPEA (%)**	**C.G.U(%)**
Steel	2,1	7,11
Aluminum	0,3	1,01
Paper/Pulp	14,1	47,79
Plastic	10,7	36,27
Glass	2,3	7,79

Caption: C.G.U – Gravimetric composition used Source: Prepared based on IPEA data (2010).

4.3 CALCULATION OF ANNUALLY WASTE FINANCIAL POTENTIAL

The calculation of amounts that are annually wasted was based on what was summarized by Rodrigues et al. (2017), and with the application of Equation 2.

$$P = BLSR \ x \ Qntrs \quad (2)$$

Where: O = Wasted financial potential; BLSR = The final BLSR value, after weighting; Qntrs = total amount of RS (RDO and RPU) directed to the landfill, annually.

4.4 DOCUMENTAL INFORMATION

For discussions and calculations, stored in electronic storage bases that deal with solid waste in Brazil, literature was selected for the discussion of the data obtained (Chart 3).

Table 3. Sources used for the selection of the literature used in the discussion of the data obtained.

Ano	B. A	Acrônimos	E. E	Objectives
2006	Motta	Período	3(4);41-60	It establishes the Equation for the BSLR1 and the guidelines for the calculation. $BLSR = GCD + CA + GMI - GAR$ (1)
2010	Institute for Economic and Applied Research	IPEA	IPEA Platform Publications	CA: The report sets out the benefits of recycling in terms of GHG emissions, biodiversity loss and the average landfill value; GMI: reduction of costs associated with raw materials and other inputs; GAR: relative expenses to selective collection in Brazil.
2013	Chaves e Souza	Revista FEE	34;683-714	Classes of Materials to work with.
2015	Rodrigues et al.	FEE	43(1);115-128	Equation to calculate financial potential
2017	Rodrigues; Marin; Alvarenga	RG&SA	6(1);470-486	Methodology for carrying out the weighting
2018	Brazilian Institute of Geography and Statistics	IBGE	IBGE Platform-Cities	Obtain data on the number of people assisted by RS collection (rural and urban areas) in the municipality of Paragominas.
2018	National Sanitation Information System	SNIS	SNIS-Platfom Solid Waste	GCD value and the total RS value destined for the landfill.

Elaborated by the authors.

5 RESULTS AND DISCUSSION

5.1 GCD

The analysis of the data obtained indicated that in the year and 2018, the average amount spent for the collection of all types of solid waste produced in the urban area of Paragominas, presented a value equivalent to R$ 191.67/t.

About this value, Souza et al. (2015) carried out studies in the municipality of Breu Branco - PA, and concluded that the average expenditure in 2018 for the collection of waste in that locality was equal to

R$ 190.00/t. It was noted that the average value obtained in that municipality was literally similar to that found in Paragominas, therefore, the calculations performed for the GCD are correct. It is noteworthy that, according to Chaves and Souza (2013), the calculation of the GCD varies according to the characteristics (eg RS production; collection; final disposal) of each municipality.

5.2 C.A.

For this item, the data analyzed indicated that the estimate of environmental costs related to the emission of GHGs and loss of biodiversity were higher for aluminum and, after adding the average landfill value in Brazilian municipalities (R$ 44.27), which is the average grounding value in Brazilian municipalities, updated to current monetary values (Table 2), varies for each type of material investigated.

Table 2. Table of CA estimates.

(1)	**(2)**	**(3)**	**(4)**	**(5)**
Steel	48,12	0,47		92,86
Aluminum	169,77	-	*44,27	214,04
Paper	9,02	5,38		58,67
Plastic	51,13	-		95,4
Glass	8,36	-		52,63

(1) Materials; (2) Costs associated with reducing GHG emissions (R$/t); (3) Costs associated with the preservation of biodiversity and non-timber resources (R$/t); (4) Grounding costs (R$/t). (5) CA (R$/t) *single value related to all materials. Source: adapted from IPEA (2010).

Thus, it is clear that the material whose production represents the highest environmental cost (AC) is aluminum, and this cost is related to the large amount of GHGs released to produce the metal (R$214.04/t). Regarding this relationship, Souza et al. (2015) in a survey carried out in Porto Alegre - RS, stated that the class of material with the highest environmental cost (R$ 203.18/t). The difference in value is justified due to the costs with grounding.

With regard to the costs associated with the preservation of biodiversity, there is intensive and extensive use of planted forest areas as a source of raw material for the production of Paper and Steel, and the recycling of these RS's allows for a smaller area of those planted with exotic species, which enables the existence of native species and, therefore, greater protection of biodiversity, as well as the exploitation of non-timber resources in a sustainable manner. In the cases of aluminum, plastic and glass, this type of environmental problem occurs on a smaller scale, since the extraction of raw materials takes place in more concentrated spaces (IPEA, 2010).

5.3 G.M.I.

5.3.1 – Hypothesis 1: GMI - GAR

In hypothesis 1, the GMI is already deducted from the GAR, which reflects the price at which scrap metal is sold in the municipality. The analysis of the data obtained together with the cooperative that operates in the Paragominas landfill, allowed the composition of the estimated scrap values, by tons, for each of the five SR objects of this study (Table 3).

Table 3. Price estimate of RS's sold by the cooperative that operates in the Paragominas landfill.

Material	Price (R$/t)
Steel	201,00
Aluminum	1.126,66
Paper	1.056,87
Plastic	2.351.00
Glass	422,22

Source: Based on data from COOPERCAMARI's 2018/2019 Annual Report.

Note that the aluminum class (rigid and flexible, aluminum cans) is the type of scrap with the highest value (R$2,351.00/t), however, it is the one with the lowest participation in the gravimetry of waste (0.3%), which, according to one of the cooperative's managers, is due to the action of collectors who prevent the metal from going to the landfill. According to Costa and Pires (2007), the increase in funds generated between 2003 and 2005 was equivalent, in Brazil, to R$ 469,106. So, the data obtained in Paragominas indicate that aluminum recycling can still generate more resources for collectors and contribute to the mitigation of the environmental impacts caused by the presence of this chemical element in the environment.

Another SR with a high value was plastic (empty butter packaging, QBoa and PET bottles), with a value of R$1,126.00/t. About the value for these types of RS's, Sanjad (2018), carried out a study in Belém - PA, and concluded that the billing with plastic recycling is on average R$ 1,020.00/t, when there is 50% recycled plastic, the segment will have revenues of over R$ 26,000,000.00.

5.3.2 – Hypothesis 2: True opportunity cost

The values of this work are constant in the IPEA Report (2010) which deals with “Payment for Urban Environmental Services for Solid Waste Management” (Table 4).

Table 4. Estimate of environmental benefits associated with reduced energy consumption. Paragominas - SHOVEL.

Material	Environmental costs associated with energy generation for primary production (BRL/t)	Environmental costs associated with energy generation for recycling (BRL/t)	Net benefit from recycling (BRL/t)
Steel	34,18	7,81	26,37
Aluminum	176,78	7,92	168,86
Paper	11,98	2,26	9,72
Plastic	6,56	1,4	5,16
Glass	23,99	20,81	3,18

Source: Adapted from IPEA (2010).

With regard to energy consumption reduction estimates, it is possible to observe that the "aluminum" class is the one that presents the greatest benefit (R$168.86/t), followed by "steel" (R$26.37/t). These values corroborate the research by Souza et al. (2015), held in Porto Alegre - RS, where the author states that aluminum is the material that most contributes in terms of reducing electricity consumption, although the rest of the materials also contribute significantly.

This happens because the items demand large amounts of energy for their production, in the case of primary aluminum, for example, there is a need to build hydroelectric plants to keep the product competitive, as stated by Santos et al. (2017), in a survey carried out in Paragominas, Pará. In this sense, according to ABAL (2017), the specific consumption of electricity in production in 2015 was 14.95 Megawatt hours per ton (MWh/t), about 5% above the world average of 14.23 MWh/t .

Table 5. Estimate of economic benefits associated with reduced consumption of inputs.

Material	**Input costs for primary production (R$/t)**	**Costs of inputs for production from recycling (R$/t)**	**Net benefit from Recycling (BRL/t)**
Steel	552	425	127
Aluminum	6162	3447	2715
Paper	687	357	330
Plastic	1790	626	1164
Glass	263	143	120

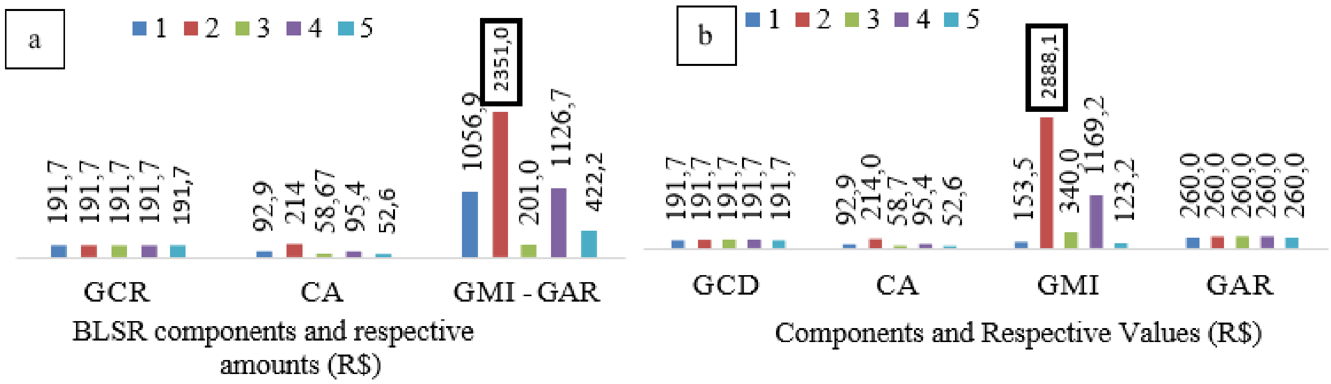
Source: Adapted from IPEA (2010).

As for the benefits related to the reduction in the consumption of inputs, "aluminium" once again appears as the material that presents the greatest benefit (R$2,715.00/t), followed by plastic (R$1,164.00/t). These values are in line with that presented by Rodrigues et al. (2017), in a survey carried out in Florianópolis -SC. In the case of aluminum, according to Lima and Motta (2010), four to five tons of bauxite are needed to extract one ton of this metal.

5.4 GAR

The data obtained indicated that the sale of scrap, for H1 – Market price (Figure 2a), in the municipality of Paragominas made the market more suitable, and this is evidenced by the GAR value, after deducting the value for the GMI. As for H2 – Opportunity cost (Figure 2b), the analysis of the data obtained indicated that the opportunity cost allowed a reduction in the cost of obtaining the raw material due to the reuse of the SR objects of this study.

Figure 2: a) Data obtained for H1; b) Data obtained for H2. Paragominas – PA. Captions: 1 – Steel; 2 – Aluminum; 3 – Paper/cellulose; 4 – Plastic; 5 – Glass. GCD: Expenses with Collection and Disposal; CA: Environmental Damage; GMI; Cost reductions in raw materials and other inputs provided by reuse; GAR: Expenses associated with reuse.



Source: authors (2021).

After analyzing the data, it was found that the value of environmental damage the average price value (GMI-GAR) for aluminum was higher than the other values of the RS's analyzed. In H2, when GAR is not deducted, the GMI value rises, however, aluminum continues to be the RS with the highest GMI. This indicates that the social and environmental gains with regard to aluminum are high. Regarding this, Souza et al. (2015), in a survey carried out in Porto Alegre – RS, the data they obtained also indicated that aluminum was the RS that presented the highest GMI-GAR ratio and, subsequently, the highest GMI.

Regarding the GCD, in H1 and H2, there were no variations in costs as they reflect the fixed expenses with collection per ton for the municipality of Paragominas. This corroborates the study carried out by Chaves and Souza (2013) in Porto Alegre – RS. In it, the authors concluded that the values of the GCD and GAR are fixed, as they are based on the costs of regular collection, which was observed in the investigation carried out in Paragominas.

5.5 BLSR

The analysis of the obtained data indicated that there were divergences of values between H1 and H2 (Table 6).

Table 6 – BLSR calculation under Hypotheses 1 and 2. Paragominas – PA.

	H_1				H_2		
RS's	**Total[1]**	**P**	**T. P**	**RS's**	**Total[1]**	**P**	**T. P**
Steel	1.341,40	0,071	95,24	**Steel**	178,01	0,071	12,64
Aluminum	2.756,71	0,01	27,57	**Aluminum**	3.029,82	0,01	3030
paper/pulp	451,34	0,477	215,29	**paper/pulp**	330,38	0,477	157,59
Plastic	1.413,73	0,362	511,77	**Plastic**	1.196,25	0,362	433,04
Glass	666,52	0,077	51,32	**Glass**	107,49	0,077	8,28

1[GCD + CA + (GMI-GAR)]. P - Weighting (1); T. P – Weighted. BSLR¹: R$901,19; BSLR²: R$641,85

Source: authors (2021).

After obtaining the mean value for the BSLR[1], comparisons were made with two surveys carried out in southern Brazil (Table 7).

Table 7. Comparison of the mean values obtained for the BLSR.

Cities/States	Authors	Publication year	BSLR (t)
Paragominas – PA	----	---	1,056,9
Florianópolis – SC	Rodrigues et al.	2017	296,25
Porto Alegre – RS	Souza et al.	2015	130,00

Source: authors (2021).

The differences between the values show, according to IPEA (2010), two factors: 1) the types of materials that make up the "steel" class, for each case; 2) Market location variations caused by supply and demand for each item, as in the South, steel consumption is dependent on the input extracted in the North, as in Paragominas. It was also observed that in H1, the scrap market is responsible for the variations of these prices/t, it can be said that in Paragominas, the figure obtained indicates that the scrap market is a good income generator, and that it can improve, if there is a tendency to increase the percentage of reuse of these collected residues.

For H2, the average value for BSLR (R$ 641.85) is related to the true opportunity cost. This explains the main differences found for the final values for Aluminum (H1 = R$95.24; H2R$12.64) and for Glass (H1 = R$51.32; H2R$8.28). In the study carried out by Chaves and Souza (2013) in Rio Grande do Sul, about these wastes and their reuse values, the authors found values for aluminum (H1 = R$ 16.00; H2 = R$ 29.09; and for glass (H1 = R$30.81; H2 = R$17.29.

Thus, the analysis of the data obtained, for H1 and H2, indicated that the weighted mean values for the BSLR, in H1 and H2, are intermediate mean values when compared with those obtained in Florianópolis and Porto Alegre (Table 8).

Table 8. Comparison of mean values obtained for BSLR.

Cities/States	Authors	Publication year	BSLR (t)	
			H1	H2
Paragominas – PA	----	---	901,19	641,85
Florianópolis – SC	Rodrigues et al.	2017	806,00	447,92
Porto Alegre – RS	Souza et al.	2015	880,00	1,148,00

Source: authors (2021).

The differences found in each of the investigated cases are mainly associated with the average scrap price (GMI-GAR) and the expenses with selective collection (GAR), which differ in the three cases. Thus, the benefit arising from this segment for the municipality of Paragominas is equal to the value of the BSLR[1], that is, R$901.19/t., as the value of scrap reflects the net gains from the reduction of reuse costs.

5.6 ESTIMATE OF THE FINANCIAL POTENTIAL OF USW

The data obtained and analyzed for this action indicated that the estimate of the amount of recyclable material is associated with the final disposal of the MSW, that is, the open dump existing in the municipality (Table 9).

Table 9. Potential recyclable material sent to landfill.

Material	IPEA 2010 gravimetric composition (%) *	Estimated potential quantity (t/year)
Steel	2,1	408,79
Aluminum	0,3	58,40
Paper/Pulp	14,1	2744,76
Plastic	10,7	2082,90
Glass	2,3	447,73

Source: IPEA (2010); SNIS (2018).

It is noteworthy that, according to SNIS data (2018), a total of 19,466.4 t of solid urban waste (RDO and RPU) was sent to the Paragominas landfill in 2018, with the largest contribution coming from the paper/cellulose class , with 2744.76 tons. After organic waste, which was not the object of this investigation, the paper/cellulose class is usually the main type of material found in landfills, followed by plastic (2,082.9 t), which is corroborated by academic literature (IPEA, 2010 ; SOUZA et al., 2015).

To estimate the financial potential arising from the studied waste classes, taking into account the BLSR values individually (net benefit of the material) and how much they would generate (potential benefit) if they were fully recovered, the data obtained indicated that they present values compatible with the reuse (Table 10).

Table 10. Estimate of the potential benefit of each material.

Material	Net benefit of the material (BRL/t)	Potential benefit (R$/year)	
		H_1	H_2
Steel	12,64[2] – 95,24[1]	1.853.979,9	246.055,3
Aluminum	27,57[1] - 30,3[2]	589.831,92	536.688,64
Paper/Pulp	157,59[2] – 215,29[1]	4.190.921,25	3.067.709,97
Plastic	433,04[2] – 511,77[1]	9.962.319,52	8.429.729,85
Glass	8,22[2] – 51,32[1]	999.015,64	160.013,8

BSLR[1]: R$ 17.542.924,95/ano; BSLR[2]: R$12.493.340,84/ano.
Source: authors (2020).

After analyzing the data, it was verified that the class of material that most contributed to such financial gains is Plastic, which, both in H1, presents a higher contribution value when compared to the other SR. After Plastic, we have the Paper class. This information is corroborated by the research by Rodrigues et al. (2017), in Florianópolis, where the author also found that the main materials with potential benefit were Plastic, followed by Paper and Aluminum. So, there is a financial waste, both in H1 (BRL 17,542,924.95) and in H2 (BRL 12,493,340.84) for the BSLR, compared to 19,466.4 t/year, which drives public managers to create a type of subsidy for the segment of recyclable materials. According to COOPERCAMARI's Annual Report (12/18 to 10/19), R$195,033.1 was collected from the sale of recyclable materials, a value well below the potential identified in this investigation

6 CONCLUSION

In the two hypotheses analyzed, for BSLR, it is feasible, especially for the plastic that has the greatest financial potential, if it is fully recycled from the total that is collected. The financial waste with poor management of urban solid waste ranges from R$ 12 to 17 million/year. Therefore, an increase in the amount of waste destined for recycling will generate great benefits for the municipality of Paragominas, in addition to combining environmental conservation, quality of life and will add income, especially to collectors, who receive special attention in the PNRS.

In this sense, due to the difficulties found for the composition of this investigation, such as scarce sources of information and differences in the calculation methods between the materials, the values must be understood as estimates (with the exception of the GCD) and must be used with care by municipal managers . Therefore, it is recommended that more research, in this line of knowledge, need to be developed in order to generate more concrete data for the municipality of Paragominas, which will contribute to the elaboration of Public Policies for the management of urban solid waste, more adequate in an economic and environmental sense.

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