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Financial analysis of residual vegetable oil reverse logistics on a Park Road, Brazil

Análise financeira da logística reversa de óleo vegetal residual em uma Estrada Parque, Brasil

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ABSTRACT: The objective of this study was to evaluate the reverse logistics of residual vegetable oil (RVO) in the restaurants on a Park Road in Brazil by identifying their waste disposal methods and analysis of the economic and financial ratio of four reverse channel scenarios proposed by the authors: (1) private-sector transformation of RVO into biodiesel; (2) transformation of RVO into biodiesel by local cooperatives and public administration; (3) RVO reused for soap production by the private sector; (4) RVO reused for soap production by local cooperatives and public administration. The methodology used was a qualitative and quantitative research. The questionnaire applied through personal interview was the method for data collection. The analysis of the results was supported by the capital budgeting techniques: net present value (NPV), internal rate of return (IRR) and discounted payback. To determine the economic risk of each scenario, the Monte Carlo method was used. The main results showed that there was a monthly production of 1,134 liters of RVO; reverse waste logistics achieve a high rate of adequate disposal, but some problems remain to be solved, such as periodicity of collection; lack of return to the local community and incentive for waste collection. Among the considered proposed scenarios to a better reverse logistics, the production of artisanal soap through a partnership with the public administration was predicted to perform best. In this scenario the estimated payback time of the invested capital was 3 years and 2 months.

Keywords: Cooking oil. Profitability. Sustainability. Waste.

RESUMO: O objetivo deste estudo foi avaliar a logística reversa do óleo vegetal residual (OVR) de restaurantes em uma estrada-parque no Brasil, identificando os meios de destinação do resíduo e realizando uma análise da viabilidade econômico-financeira de quatro cenários de logística reversa propostos pelos autores: (1) transformação do OVR em biodiesel pelo setor privado; (2) transformação de OVR em biodiesel por cooperativas locais e administração pública; (3) OVR reutilizado para produção de sabão pelo setor privado; (4) OVR reutilizado para produção de sabão por cooperativas locais e administração pública. A metodologia utilizada foi uma pesquisa qualitativa e quantitativa. O método para coleta de dados utilizado foi o questionário aplicado por meio de entrevista pessoal. A análise dos resultados foi apoiada pelas técnicas de orçamento de capital: valor presente líquido (VPL), taxa interna de retorno (TIR) e *payback* descontado. Para determinar o risco econômico de cada cenário, foi utilizado o método de Monte Carlo. Os principais resultados mostraram que houve uma produção mensal de 1.134 litros de OVR; a logística reversa de resíduos atinge um alto índice de destinação adequada, mas alguns problemas ainda precisam ser resolvidos, como a periodicidade da coleta; falta de retorno à comunidade local e incentivo à coleta do resíduo. Dentre os cenários propostos para uma melhor logística reversa, a produção de sabão artesanal por meio de parceria com a administração pública foi a que obteve o melhor desempenho. Nesse cenário, o tempo estimado de retorno do capital investido foi de 3 anos e 2 meses.

Palavras-chave: Lucratividade. Óleo de cozinha. Resíduos. Sustentabilidade.

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INTRODUCTION

In Brazil, the Solid Waste Policy (SWP) approved by Federal Law no. 12305/2010 (BRASIL, 2010c) deals with the integrated management of solid waste. This law includes a set of principles, objectives, instruments, guidelines, goals, and actions of the government, adopting the non-generation of waste as a priority, followed by reduction, reuse, recycling, treatment, and environmentally sound disposal (BRASIL, 2010c; ANTUNES, 2014; LIMA et al., 2016).

This legal diploma highlights the application of the concept of reverse logistics as an important instrument for the appropriate reuse or disposal of materials in line with environmental preservation (GARUTTI; SANTOS, 2010; SILVA et al., 2013). According to Rogers and Tibben-Lembke (1999), reverse logistics consists of the process of planning, implementation, and control of product flow (raw, finished, or unfinished), which goes from the point of consumption to the point of origin, with the goal of recovering value or achieving proper disposal. SWP provides for the implementation of post-consumer reverse logistics for the following industrial sectors: tires, lubricants, batteries, lamps, electronics, pesticides, and packaging made primarily of plastic, metal, and glass (GARUTTI; SANTOS, 2010; SILVA et al., 2013).

Brazil produces approximately nine billion liters of vegetable oils per year, with about 33% being edible oils, with a per capita consumption of 20 liters per year (DISCONSI, 2014). Generally, these oils are used in food preparation at commercial establishments and in homes. More than 200 million liters of waste oil are estimated to be discharged directly into rivers and lakes every month, compromising the environment (FRANÇA et al., 2016).

Improper disposal of residual vegetable oil (RVO) causes significant negative impacts on the environment (SANIBAL; MANCINI FILHO, 2002; WALLACE et al., 2017). Of the total vegetable oil consumed in Brazil, it is estimated that less than 4% is correctly disposed of, most of which are improperly disposed of in drains, in the soil, rivers, lakes, or sewers, or incinerated (THODE FILHO et al., 2014; SABESP, 2016; WALLACE et al., 2017; SINDHU et al., 2019).

Residual vegetable oil has been used for several types of reverse channels: animal feed production, putty, biofuels (WILDNER; HILLIG, 2012), transformer alternative cooling substance (LI et al., 2016; RAEISIAN et al., 2019; SINDHU et al., 2019), and even for hydrogen production through hydrothermal gasification (NANDA et al., 2019) or bio-hydrogen (RAFIEENIA et al., 2019). Wilner and Hillig (2012) and Melo and Castro (2014) recommended the use of RVO for soap and handcrafted detergent manufacturing as a way of strengthening the solidarity economy (LIMA et al., 2014). The transformation of RVO to biofuel production has environmental potential because, in addition to being renewable, biodegradable, and non-

toxic, it also emits smaller amounts of carbon than those from fossil fuels, such as diesel and gasoline (HAJJARI et al., 2017; ULLAH et al., 2017; UEKI et al., 2018).

There are many options for destination and reuse of RVO. In order to contribute to a better environmental destination, this article sought to identify in the studied region the best way to structure the reverse logistics of the waste, proposing different scenarios and analyzing the feasibility of each one, respecting the local characteristics. The analyzes carried out here can help in the decisions of government and interested parties. This is an innovative, multidisciplinary study, which, after identifying the way in which reverse logistics of waste occurs, proposes scenarios for excellent reverse logistics, and analyzes them aiming at gains to the local community, respecting regional characteristics, and paying attention to sustainability in social, environmental and economic dimensions.

In this context, the objective here was to evaluate the reverse logistics of the RVO in restaurants located in the area of influence of the Visconde de Maua Park-Road, Brazil, by identifying their waste disposal methods and analysis of the economic and financial ratio of four reverse proposed channel scenarios: (1) private-sector transformation of RVO into biodiesel; (2) transformation of RVO into biodiesel by local cooperatives and public administration; (3) RVO reused for soap production by the private sector; (4) RVO reused for soap production by local cooperatives and public administration. We describe the type and volume of oil, its destination and potentialities, and limitations in reverse logistics, as well as analyzing the economic and financial ratio of several reverse channel scenarios.

2 MATERIAL AND METHODS

2.1 STUDY AREA

The study was conducted near the restaurants installed along the Visconde de Maua Park Road, RJ, which runs through the municipalities of Resende and Itatiaia, Rio de Janeiro state, Brazil (Figure 1). The region belongs to the Black River basin. Economic activity maintains local development and supports structured tourism, with micro and small businesses providing many jobs. The road is located on the border of the states of Rio de Janeiro and Minas Gerais, passing through important protected areas such as Mantiqueira Environmental Protection Area (APA), Pedra Selada State Park, and Itatiaia National Park (SALOMÃO et al., 2010; RIO DE JANEIRO, 2012), with valuable scenic attributes, such as rapids and waterfalls, symbolizing a relatively preserved nature. Park Road has many natural tourist attractions (FERREIRA, 2015).

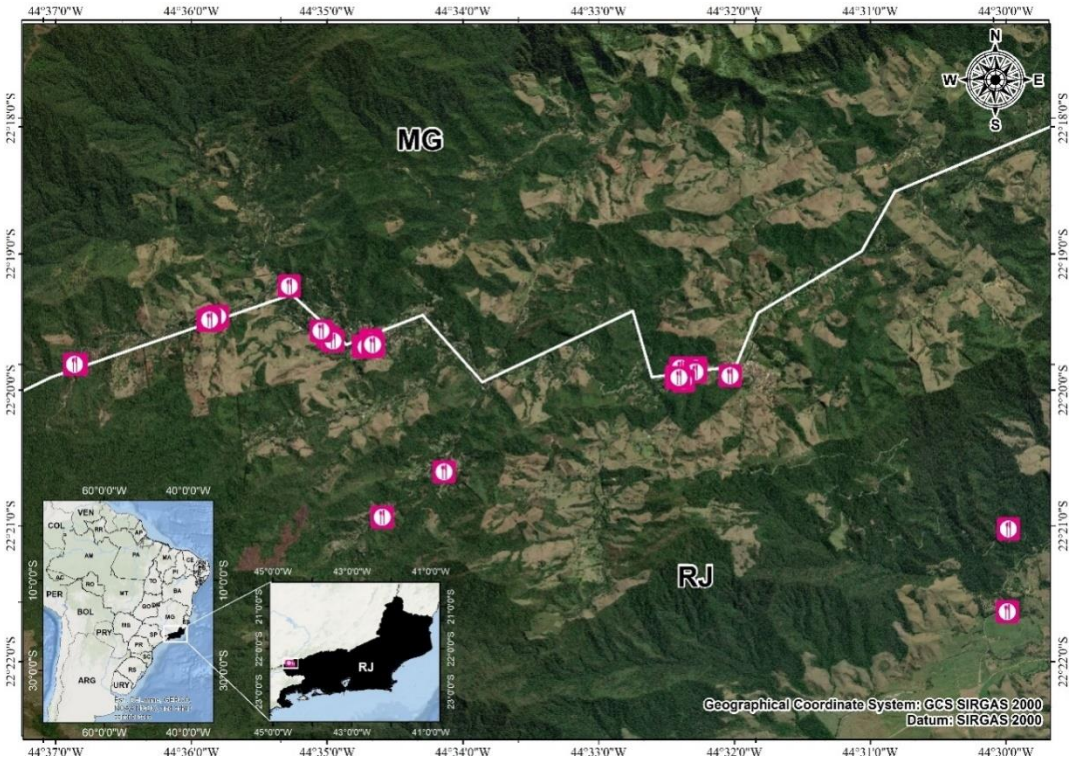

Figure 1. Visconde de Maua Park Road and the restaurants.
Font: Own elaboration based on Google Maps data.

2.2 METHOD OF INVESTIGATION AND DIAGNOSIS

The qualitative and quantitative approaches were used, featuring a mixed method (OLIVEIRA et al., 2018). Research can be classified, as to nature, as applied research (MARCONI; LAKATOS, 2017). As for the objectives, the research was descriptive, to discover how reverse logistics occurs in the locality; and exploratory, in order to know the best scenario for the disposal of the waste. According to the technical procedures adopted (GIL, 2018), bibliographic research, survey and field study were adopted, using the structured questionnaire applied through personal interview as a method for data collection, in a cross-sectional study. We adopted also the non-participant observation. Finally, as for the place of realization, it can be considered field research, in situ.

A descriptive census-type research (OLIVEIRA et al., 2018) was conducted, in person, using a semi-structured questionnaire, including 42 commercial establishments (restaurants), total according to information obtained from agencies in the municipalities of Resende and Itatiaia, Rio de Janeiro state, Brazil and with on-site observations. The interviews were conducted in 2016, preferably with the manager or restaurant's owner, or with an employee responsible for the waste. The questionnaire had a total of 26 questions, which addressed quantitative and qualitative variables, for example: the consumption of RVO, such as the amount of waste generated; form and frequency of destination; revenues and expenses involved in disposal; type of partnerships and covenants used for proper waste treatment; identification

of positive and negative aspects in the destination models practiced. With completed questionnaires, the answers were coded for analysis based on Arroyo and Orozco (2016).

2.3 CONSTRUCTION OF SCENARIOS FOR THE DISPOSAL OF RVO

Four scenarios were constructed based on the diagnostic results, bibliographic research, and observation, respecting local characteristics.

In all scenarios, the stages of the reverse flow of RVO were planned: from collection until transformation into a new product, returning to the consumer market in the study area.

For each of them were do economic and financial ratio economic profitability indicators, seeking greater real gain for the local community.

The scenarios evaluated were:

- Scenario 1: The generated volume collected and stored in the region, destined for biodiesel production and managed by a private company.
- Scenario 2: The generated volume collected and stored in the region, destined for biodiesel production and managed by local cooperatives in partnership with the public administration.
- Scenario 3: The volume generated, collected, and reused in the region for soap production, managed by a private company.
- Scenario 4: The volume generated, collected, and reused in the region for soap production, managed by a private company in partnership with the public administration.

Scenarios 2 and 4 were built using instruments regulated by SWP (BRASIL, 2010a; 2010b; 2010c), among them: a) application of the principle of shared responsibility; b) inclusion of local actors in the Solid Waste Management Plans; c) strengthening cooperatives for both selective collection and reverse logistics; and d) formalization of technical and financial cooperation between the public and private sector, including assignment of physical space. Thus, the public administration would assume a partner in the activity, allowing the management by any private initiative of public interest, through regulatory legal instruments, with a special interest in valuing the collector, the largest human figure in SWP. In these scenarios, it was admitted that the government would provide physical space for the activity, monitor the progress of the project and advertise it. Monthly inflows of money from the public sector were not admitted, although this could be possible through funding agencies, accessing public resources that would finance the project.

Four independent cash flows were prepared respecting the local characteristics, one for each scenario, considering the particularities of each activity. In the monthly cash flow, all admitted inflows and outflows were launched in each scenario, considering the prices already quoted and monetarily updated.

In the scenarios that considered the destination of the waste for biodiesel production, the sale of the RVO was admitted as input; for the scenarios that considered the destinationof the waste soap production, the inputs were the sale of the product, in bars of 250 grams. In all scenarios, the immobilized value of the land and the residual values of the machines, equipment, vehicle and furniture at the end of the considered time horizon were also considered as inputs.

In all scenarios, respecting the characteristics of each, the outputs related to civil works and installations, acquisition of machinery and equipment, acquisition of furniture and utensils, transportation, labor, social charges, cleaning material, office, overhead, maintenance, advertising and marketing and personal protective equipment. In the scenarios in which the activity would be managed by a private company, the outputs related to the acquisition of land in the region for the construction of a storage center, and the expenses resulting from the legalization of the company were also considered. In the scenarios in which the RVO would be destined for soap production, the ingredients for the soap manufacturing process, consumables and packaging were added to the outputs. In all scenarios, the replacement of machines, equipment, vehicles and furniture at the end of their useful life was admitted over the period analyzed.

2.4 ECONOMIC AND FINANCIAL RATIO OF RVO DISPOSAL SCENARIOS

The four scenarios had the production items identified and quantified for the construction of monthly cash flow, considering their particularities. A 12 year time horizon was considered. The prices were updated and monetarily adjusted by applying the IGPDI - General Price Index - Internal Availability (PORTAL BRASIL, 2021), having August 2016 as the reference month and year. In each scenario, an economic and financial ratio was performed, determining two economic indicators of profitability (BLANK and TARQUIN, 2008): net present value(NPV) and internal rate of return (IRR), applying discount rates of 2, 8, 14, and 20% per year, equivalent to 0.17, 0.64, 1.10, and 1.53% per month, respectively, on monthly net cash flow (LEMES JUNIOR, 2016).

The following formula was used to calculate NPV:

$$NPV = \sum_{n=0}^{N} \frac{CF_n}{(1+i)^n} \quad (1)$$

Where: N = total number of periods; n = the applicable period ($0 \leq n \leq N$); CF = Cash flow for the n^{th} period; i = required return or discount rate.

To calculate IRR, the following formula was used. The obtained IRR represents the value of "i" when NPV is equal to zero:

$$NPV = \frac{CF_0}{(1+i)^0} + \frac{CF_1}{(1+i)^1} + \cdots + \frac{CF_N}{(1+i)^N} \quad (2)$$

Where: NPV = Net present value; CF = Cash flow; i = required return or discount rate.

The minimum attractiveness rate (TMA) considered for 2016 was based on the difference between the return obtained on a low-risk investment available in the Brazilian market (savings account),which was in the order of 8.35% per year (BCB,2021) and inflation in the same period, which was around 6.29% per year (IBGE, 2021). The payback time of the invested capital was determined by the discounted payback technique (ASSAF NETO, 1992).

In order to identify the items of greatest influence on the results of economic indicators, a sensitivity analysis was performed (MACHADO et al., 2018). This analysis considers a 10% change in the average price of the item production, always in an unfavorable direction to investment, with a decrease in revenues and an increase in expenses.

To determine the economic and financial risk of each scenario, the Monte Carlo method was used (BLANK and TARQUIN, 2008), using the software MS-Excel®. The sequence of calculations used for the elaboration of the risk analysis was described by Blank and Tarquin (2008): to identify the probability distribution of each relevant cash flow items; randomly select a value for each item, based on its probability distribution; calculate the value of the choice indicator; and repeat this process until an adequate confirmation of the frequency distribution of the chosen indicator is obtained.

To determine the probability of failure of the activity, 5,000 random combinations of market prices were simulated, considering the triangular distribution (PONCIANO et al. 2004). There are several types of probability distributions, but due to the difficulty in identifying the specific distribution of each of the variables involved in all cash flows, the triangular distribution was used. The triangular distribution is defined by the most likely average level or mode (m), a minimum level (a) and a maximum level (b) of prices obtained in the market and is often used when there is insufficient knowledge about the variables (PERES, 2006).After generation of several NPV values, a count was made to know how many times the activity obtained negative NPV, in relation to the total number of simulations performed, being possible to classify the risk according to its probability of occurrence. Thus, the risk analysis here shows the probability of negative NPV in each scenario analyzed, with different discount rates, through the simulations performed.

3 RESULTS

The monthly consume of vegetable oil was 1,955 liters and the monthly production of RVO was 1134 liters, which accounts for 58% of the total oil consumed. The restaurants generated, on average, 29.84 liters of RVO per month. In 97% of the restaurants, it was observed that the disposal was done correctly and consciously, demonstrating the commitment of the owners to the correct disposal of the waste and respect for the environment. Most respondents who donate the waste to companies (63%) were unable to provide the name of the company responsible for the collection, nor what is done with the waste after collection (59%).

Donation of the waste to private companies was the reverse route to the disposal of RVO to biodiesel production, a process that usually occurs through the transesterification reaction. On the other hand, RVO was donated to individuals, and then went through a recycling process to produce cleaning products (soap and detergents).

Only one establishment claimed to have any kind of revenue from the disposal of RVO, and the vast majority (96%) donate RVO without receiving any financial or material benefit. However, it was found that 93% of respondents would be more motivated to seek a private company destination if there was a donation program for gifts and/or everyday products (e.g., cleaning products).

Among the establishments that donated the waste to companies, 33% stated that the collection has no defined periodicity. The destination of residual vegetable oil for the production of artisanal soap proved to be financially viable when considering the application of a discount rate of 8% per year, over a 12-year time horizon (Table 1).

Table 1. Net present value (NPV) results in Dollar (US$) for the different RVO destinations at the Visconde Maua Park Road, RJ, Brazil, for cash flow subject to discount rates of 2, 8, 14, and 20% per year

Discount rate	Waste disposal			
	Biodiesel		Handmade soap	
	Private company	Waste pickers; Partnership	Private company	Waste pickers; Partnership
2%	- US$ 79,444	- US$ 62,926	US$ 60,738	US$ 96,507
8%	- US$ 92,711	- US$ 55,359	US$ 10,292	US$ 57,148
14%	- US$ 96,419	- US$ 49,621	- US$ 16,830	US$ 33,948
20%	- US$ 96,634	- US$ 45,306	- US$ 32,323	US$ 19,424

*Amounts monetarily restated by the IGP-DI for February 2021.
Font: Own elaboration.

The proposal for the production of handmade soap was attractive for investment, whether implemented through private initiative or through the promotion of public initiative, where the yields obtained were above the minimum attractiveness rate considered (2.06%), which is obtained by calculating the difference in return (8.35% per year) obtained in a low-risk investment (savings account) and inflation in the same period (6.29% per year) (Table 2).

Table 2. Internal rate of return obtained (%) for the production of artisanal soap in the Visconde de Maua Park Road, RJ, Brazil

Private Company	Waste Pickers; Partnership
9.89%	35.71%

*Amounts monetarily restated by the IGP-DI for February 2021.
Font: Own elaboration

The scenario that presented the highest profitability was the one that admitted the partnership between local cooperatives and the public administration in the production of handmade soap, which would help the exploration of the activity, providing subsidies to the business.

When evaluating the cash flow components, it was observed that the selling price (US$ 0.43) of handmade soap (bar of 250 g) was the one that most influenced the results of the economic indicators of profitability, that is, in the NPV (Table 3).

Table 3. NPV results in Dollar (US$) resulting from an unfavorable 10% variation in the prices of items in the production of handmade soap at Visconde de Maua Park Road, RJ, Brazi.

Artisanal soap production	Item description	Variation
Private company	Selling price of handmade bar soap	- US$ 24,636
	Employee salary	- US$ 7,641
	Land acquisition	- US$ 3,948
	Purchase sodium hydroxide	- US$ 3,909
	Construction of the manufacturing unit	- US$ 1,299
	Taxes	- US$ 1,232
	Accountant fees	- US$ 1,201
	Fuel	- US$ 1,067
	Internet and phone	- US$ 885
	Essences shopping	- US$ 675
Waste pickers; Partnership	Selling price of handmade bar soap	- US$ 24,636
	Employee salary	- US$ 7,641
	Purchase sodium hydroxide	- US$ 3,909
	Construction of the manufacturing unit	- US$ 1,299
	Fuel	- US$ 1,067
	Essence shopping	- US$ 675
	Office building	- US$ 649
	Social charges	- US$ 611
	Electricity	- US$ 611
	Vehicle acquisition	- US$ 554

*Amounts monetarily restated by the IGP-DI for February 2021.
Font: Own elaboration.

The economic-financial risk (5.31%) of artisanal soap production, when considering the partnership with the waste pickers, through public policy was unlikely to make the NPV negative, when it was subjected to the discount rate of 8% per year. As long as artisanal soap is

produced, the economic and financial risk (36.53%) for the private company can be considered high (Table 4).

Table 4. Probability of a negative NPV or result of the risk analysis in the production of handcrafted soap on the Visconde de Maua Park Road, RJ, Brazil

Discount rate	Artisanal soap production	
	Private company	Waste pickers; Partnership
2%	13.96%	2.77%
8%	36.53%	5.31%
14%	65.25%	9.37%
20%	85.91%	15.26%

*Amounts monetarily restated by the IGP-DI for February 2021.
Font: Own elaboration.

4 DISCUSSION

The low monthly volume of residual vegetable oil produced in the restaurants located on Visconde de Maua Park Road is justified because the establishments operate on weekends and holidays, when there is a greater presence of tourists. In addition, some establishments seek to avoid fried recipes due to customer appeal for healthier products. Logistics can be a determinant for the viability of the RVO reverse chain, as it requires planned collection, which in certain cases, can make this action costly (ARAÚJO et al., 2010; WALLACE et al., 2017; SINDHU et al., 2019).

The volume collected below 60% of the total oil consumed can be explained by the absorption of the frying oil by the food (that can reach up to 60% of its total value). The proportion of oil absorbed is influenced by multiple parameters, such as the characteristics of the food itself, the oil used, and frying conditions (JORGE and LUNARDI, 2005).

According to the Resolution of the National Council of Environment (CONAMA, 2011), the release of RVO directly into water bodies above 50 mgL^{-1} has the capacity to modify the quality of freshwater, that is, each liter of RVO can modify 11,440 liters of freshwater (CONAMA, 2011). Thus, the in-natura disposal of RVO from restaurants in the study region could compromise the quality of more than 340,000 liters of freshwater each month.

All restaurants in the region of Visconde de Maua, RJ, dispose of the waste correctly, but most of them are unaware of the final destination and the potential reuse of the waste generated. This fact can become an aggravating factor, as the establishment does not receive the reuse information, thus losing the incentive to promote the correct disposal of this waste generated. In some cities in Brazil, there are already positive experiences regarding the disposal of oil, as observed in this study, with over 90% of the disposal carried out with environmental responsibility. In the city of Santa Maria, RS, authors have reported a 95% correct-waste-destination rate for restaurants (MEDEIROS and DELEVATI, 2016). In Volta Redonda, RJ, all

participating establishments collect the residual vegetable oil and transfer it for reuse, whether in the production of biodiesel or soap (SANTOS et al., 2018). However, this behavior is not yet done at the national or global level. In the city of Belo Horizonte, MG, approximately 80% of the assessed establishments (restaurants, pizzerias, patisseries, bars, and snack bars) reported discarding of the RVO in the sink drain or toilet (MASCARENHAS and SILVA, 2013). While in Beijing, China, an additional 20% of the restaurants surveyed dispose of the waste oil in kitchen waste, and another 6% indicated dumping the waste directly down the drain (LIU et al., 2018).

From this study, we observed the need for more aggregating work and marketing and visibility actions by the collectors to form a recycling network with various tools, such as promotional material and lectures to raise awareness about environmental issues, as well as to ensure excellence in partner service (GARUTTI and SANTOS, 2010; WILDNER and HILLIG, 2012; ZHANG et al., 2017b; SINDHU et al., 2019). Liu et al. (2018) and Wallace et al. (2017) suggest implementing mandatory regulations and economic incentives, which, combined with the supervision and education of those involved, can promote the proper disposal of the RVO.

Biodiesel production from RVO is a viable option in many regions of the world (KULKARNI and DALAI, 2006; TALEBIAN-KIAKALAIEH et al., 2013; ZAREH et al., 2017; KATARIA et al., 2019; SINDHU et al., 2019). Using RVO in this process might decrease the production costs compared to the use of other vegetable oils (ENCINAR et al., 2005; TORRES et al., 2013). Similarly, the manufacture of handmade soap can become a complementary activity for communities (WILDNER and HILLIG, 2012; LIMA et al., 2014), or even be used in conjunction with education and environmental awareness (MELO and CASTRO, 2014).

On the one hand, there is a lack of investment by the private sector to turn RVO into a source of income (BILCK et al., 2009). Otherwise, the practice of transforming RVO into hygiene products is a way of connecting people to the recycling network, and encouraging waste separation, saving pollution from their drainage network. However, although most restaurants on Visconde de Maua Park Road prefer the switch to hygiene products, this is not the most common practice, since 96% of the restaurants donated the waste without receiving any benefit or bonus in exchange for initiative and the correct disposal of the waste.

Contrary to what happens in the Visconde de Maua region, waste reuse programs in other Brazilian locations, such as Reóleo, from Florianópolis, SC, Bioleo, from São Paulo, SP, Eco Oil, from Volta Redonda, RJ, PROL from the state of São Paulo, PROVE from the state of Rio de Janeiro and Papa Oil from the state of Bahia are examples of success in generating some kind of return to the restaurants or the community involved, either through exchanges for cleaning products, support for waste pickers' cooperatives, support for social projects, or environmental education actions in schools and associations (CHIEREGATTO and CLARO, 2011; LAGO, 2013; SABESP, 2016).

Another relevant aspect observed in the research is the lack of collection periodicity that needs to be adjusted to make the reverse logistics of this waste more efficient. Zhang et al. (2017a), Avinash et al. (2018), Liu et al. (2018), Hatzisymeon et al. (2019) and Khan et al. (2019) all stressed that, in addition to considering incentive mechanisms in the collection of RVO, it is also necessary to raise awareness of risks (storage, transportation, among others), managed collection service, strengthening of inspection processes in establishments, and regulation in the sector. They have already warned of the importance of introducing and improving the deployment of RVO reverse logistics.

Due to negative results for NPV, at different discount rates, the allocation of RVO was not sufficient to make biodiesel production viable, being financially unfeasible. The unfeasibility of the destination for biodiesel production can be explained since the sale of the volume of residual vegetable oil collected in the area covered by the Visconde de Maua Park Road was insufficient to cover all production costs involved in the activity. A volume of 5,000 liters/month of waste was estimated to make the activity destined for biodiesel production financially viable. Samad et al. (2018) were able to achieve economic viability and an internal rate of return equal to 17.8% by analyzing a portable biodiesel production plant. However, in the case of the study, there would be too much production (of 60,000 liters per month) of fuel. Therefore, it is essential to consider the supply of raw material, in this case, residual vegetable oil, when considering investing in biodiesel production.

Given these favorable results, both for the waste pickers' association and for the private company, it is recommended to conduct market research that evaluates whether the handmade soap would have a consuming market and if it would be well accepted by the local community, so that the production flow was not compromised and allowed the generation of income, making the business viable.

Both scenarios would contribute to the preservation of the region's ecosystems, such as social welfare, generate employment and income, and provide environmental awareness. The destination of the residue for the production of artisanal soap was identified as the best option for public managers, entrepreneurs, traders, and the local community, in order to seek excellence in reverse logistics and increase the volume of oil collected, thus decreasing the negative impacts on the environment that improper disposal could have.

In the case of the manufacture of artisanal soap with subsidies from the government, as provided by SWP, the initial investments would be recovered in 3 years and 2 months, a period classified as short term. To ensure the success of the activity, it is necessary that the product is traded at around US$ 0.43, considering the sale of the total produced.

It was observed that it would take 11 years and 5 months for the initial investments to be recovered based on the determination of the discounted payback, when the manufacture of artisanal soap was managed by a private company, a period classified as long term. Considering the investments, the acquisition of the area, construction, and improvements, the period

estimated by the discounted payback are justified by the high fixed financial value belonging to the company and necessary for the execution of the proposal.

When a private company managing the artisanal soap manufacturing activity from the collected residual vegetable oil was admitted (Table 4), the probability of negative NPV at a discount rate of 8% per year was high (36.53%).This condition might be justified by the low volume of RVO available for the production of artisanal soap by a private company, as the fixed asset as well as the fixed cost of production are high and, allied to the small scale of production, leave the undertaking with an idle production capacity.

Considering the destination of the waste collected in restaurants for the production of artisanal soap, through a public incentive policy for the pickers' cooperative, the activity subsidized by the public administration showed a low economic risk (5.31%) financial activity becomes financially unviable at a discount rate of 8% per year.

The scenario with the lowest probability – waste collected in restaurants for the manufacture of artisanal soap and subsidized by the public administration – had a net present value of less than zero (NPV <0), thus being considered a low-risk investment activity.

The risk analysis showed that changes in market prices might lead the activity to a situation of unfeasibility, so in both scenarios, to reduce the risk of failure, it would be necessary for managers to constantly monitor the progress activity, especially with regard to the most impactful items in the result, controlling the initial investments, the purchase of inputs, and the sale price of the product, so that the venture becomes solid and produces the expected financial return.

5 CONSIDERATIONS

The amount of RVO generated in the restaurants in the area covered by the Visconde de Maua Park Road, RJ, corresponds to 1,134 liters per month, indicating the potential for economic activities aligned with environmental guidelines. Currently, the main reverse channels of this volume of waste are legal entities, which collect it to be sent to production of biodiesel in other municipalities, or individuals, who use it in the manufacture of handmade soap.

Reverse waste logistics achieve a high rate of adequate disposal, but some problems remain to be solved, such as periodicity of collection by the responsible company; lack of return to the local community and incentive for waste collection; and ignorance of the actors of reverse logistics and the destination of waste by restaurants.

Among the possible scenarios for better reverse logistics of waste in the study area, the destination of vegetable oil residue for the production of artisanal soap is financially viable and presents greater financial profitability for the actors involved in the reverse logistics of the waste.

The recovery time of capital invested in the manufacture of artisanal soap occurs in the long run for private companies and for cooperatives / associations of collectors with government subsidies is classified as short term.

The financial risk of artisanal soap production is low when considering a discount rate of 8% per year for production in partnership with the government.

The analyzes carried out here can be used for decision by local actors and can serve as a model for other locations, in order to obtain a reverse logistics model that brings benefits to environment and society. The study can serve as a reference for other tourist spots in search of sustainable development, as it highlights the possibility of financial and environmental gain with possibilities of using and correctly disposing of waste. The study also demonstrates the importance of mutual involvement to achieve a good result: government and society together can promote ecological, environmental and financial gains for the local community, generating income in a sustainable way, promoting environmentally correct disposal, sustainability and environmental awareness.

The present study had limitations, such as the difficulty of comparing the data of the financial analysis with other studies and the difficulty of finding articles that studied the waste in Visconde de Maua Park Road.

As a suggestion for future works, the expansion of the present work could occur, using the same methodology with restaurants in other districts near Visconde de Maua Park Road, thus it would be possible to achieve other values, other volumes, and other scenarios could be admitted or economically viable. Other studies could be carried out involving environmental valuation, considering the externalities in each admitted scenario. There is also the possibility of studying the environmental education and initiatives with an emphasis on conserving the ecosystem for continued tourism and protection activities in the region.

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