https://doi.org/10.22398/2525-2828.82252-67

# Circular economy and industrial symbiosis as strategy for the management of textile waste of the Beachwear Cabo Frio/RJ Local Productive Arrangement

## *Economia circular e simbiose industrial como estratégia para a gestão de resíduos têxteis do Arranjo Produtivo Local Polo Moda Praia de Cabo Frio (RJ)*

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## ABSTRACT

This article presents the preliminary results of an exploratory field research on the Beachwear Cabo Frio/RJ Local Productive Arrangement, which aims to investigate the flow of textile waste from the production of local factories, analyze the feasibility of transforming this waste into raw material to be reintroduced into production itself or to supply other production cycles. To this end, we conducted unstructured interviews to understand how companies manage this waste. We partially conclude that there is no textile waste management system. In most cases, textile waste is disposed of as common waste. Moreover, companies donate part of the amount to nongovernmental organizations and individuals, and, until the completion of this article, we found that only two out of the 40 companies that are part of the cluster perform the separation and storage of the material to negotiate the sale with a textile recycling company located in São Paulo state.

**Keywords:** Local Productive Arrangement. Circular economy. Industrial symbiosis.

## *RESUMO*

*Este artigo apresenta o resultado preliminar de pesquisa de campo exploratória do Arranjo Produtivo Local Polo Moda Praia de Cabo Frio (RJ), que teve como objetivo investigar o fluxo de resíduos têxteis da produção das fábricas locais, para analisar a viabilidade de reinseri-los no próprio ciclo produtivo de origem ou transformá-los em matéria-prima para outros ciclos produtivos. Para esse fim, realizamos entrevistas não estruturadas focalizadas com atores sociais do arranjo para entender como as empresas administram esses resíduos. Parcialmente, concluímos que não há um sistema de gestão e gerenciamento de resíduos têxteis no aglomerado. Na maioria dos casos, os resíduos têxteis são descartados como lixo comum. Em segundo lugar, as empresas doam parte do montante para organizações não governamentais e pessoas físicas, e somente duas das 40 empresas que fazem parte do aglomerado realizam a separação e o armazenamento do material para negociar a venda com uma empresa de reciclagem têxtil localizada no estado de São Paulo.*

***Palavras-chave:*** *Arranjo Produtivo Local. Economia circular. Simbiose industrial.*

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**Received on:** 12/28/2022 **Accepted on:** 03/14/2023

## INTRODUCTION

Local Productive Arrangements (LPA) are clusters of companies from the same sector or related companies located in the same geographical space with the presence of economic, political, and social agents with ties and interdependence in an environment of productive specialization (CASSIOLATO; LASTRES, 2003). These clusters enable and privilege the analysis of interactions, particularly those that lead to the introduction of new products and processes (LASTRES; CASSIOLATO, 2000).

LPAs are created by an endogenous system, that is, from inside out, as a consequence of a territorial logic that encompasses local specificities such as the past, culture, and relations between companies (MENDONÇA, 2008; OLIVEIRA; FRANÇA; RANGEL, 2019). There are several actors that stand out in an LPA, among which:

- economic actors (customers, partners and competitors; suppliers of inputs, components or equipment; suppliers of technical services);
- knowledge actors (consultants, universities and research institutes);
- regulatory actors (the governing body of the LPA, governments at its various levels);
- social actors (unions, business associations, support organizations, the so-called third-sector organizations, among others) (CASSIOLATO; LASTRES, 2003 *apud* SIMONETTI; KAMIMURA, 2017).

The Beachwear Cabo Frio/RJ Local Productive Arrangement is located in the Coastal Lowlands of the state of Rio de Janeiro, Brazil. This cluster forms a LPA in the form of *geographical arrangements* (random), which is characterized by occasional interfirm links, scarce cooperation experience, and weakly-developed local institutions. The arrangement has a high degree of productive specialization in the beachwear segment and governance is *somewhat* formalized by the Commercial and Industrial Association of Rua dos Biquínis (*Associação Comercial e Industrial da Rua dos Biquínis* – Acirb), currently without representation and activity.

In the process of cutting beachwear garments, about 30% of raw material is wasted, in the form of scraps of various sizes, and most of this waste ends up in irregular landfills, causing a great negative impact on the environment. The National Solid Waste Policy (BRASIL, 2010), regulated by Law No. 12.305 of August 2, 2010, provides for principles, objectives, and instruments as well as guidelines related to the integrated management of solid waste. Among the principles established by the law is "the recognition of reusable and recyclable solid waste as an economic asset with social value, generating work and income and promoting citizenship" (BRASIL, 2010, free translation).

In nature, an ecosystem can be understood as the set formed by the interactions between living communities and the nonliving factors of the environment. It is a set of physical, chemical, and biological characteristics that influence the existence of species that interact with each other, forming a stable system. The interrelations that exist between the various types of consumers in the ecosystem form a food chain, in which the primary consumers feed on the producers; the secondary, on

the primary; the tertiary are at the top of the chain; and the decomposers are responsible for the decomposition of matter, transforming it into nutrients that will be available again.

When talking about a circular production model, this type of correspondence helps to think about how to change the way in which natural resources are produced and used. If a tertiary company connects with other secondary companies whose activities have an affinity, as well as the fungi that help trees to multiply their root surface and capture much more water and nutrients, it expands its capacity to make better use of resources compared with another that operates in isolation, with only its own roots. As long as the established relationship is beneficial to all stakeholders, this ecosystem can live in partnership for a long time, typifying an industrial symbiosis.

The expression "industrial symbiosis" represents cooperation between a group of companies that optimize waste flows to reuse raw materials in other production processes (WEETMAN, 2019). This practice is a way of minimizing the impacts caused by the generation of waste and, when performed in a structured manner, among different actors (academia, industry, and public authority), it broadens economic, social, and environmental advantages. This collective and simultaneous effort can result in benefits such as reducing material, logistics, and waste management costs.

Industrial symbiosis is an application of industrial ecology that aims to help companies understand how they use resources, how they monitor material, energy and water flows, and also how they are responsible for the product throughout its life cycle (WEETMAN, 2019). It consists of an approach that aims at the creation of open- or closed-loop production processes, in which waste is transformed and return to the value chain. The different industrial cooperation mechanisms that may be established are flexible and are subject to location, the types of industry involved, raw materials, and other aspects, and each circumstance will result in groups with specific characteristics (FERRÃO; JORDÃO; MENDES, 2003).

In order to increase cooperation between the companies that are part of the Beachwear Cabo Frio/RJ LPA, the general objective of this article was to analyze the flow of textile waste from the process of exiting the fabric cutting sector, to consider formulating strategies for recovering the value of this material. To this end, we use the concepts of LPA, circular economy, and industrial symbiosis as a theoretical framework.

## LOCAL PRODUCTIVE ARRANGEMENT

Based on Fuini (2013), Queiroz and Souza (2017) explain that the concept of LPA was initially systematized in Brazil by a group of researchers brought together in the Research Network on Local Productive and Innovative Systems and Arrangements of the Institute of Economics of Universidade Federal do Rio de Janeiro, based on research from the 1990s on innovative media and national and local innovation systems.

The main objective of a LPA is to unify the production chain with common activities, seeking the development of companies through joint and cooperative actions (CARDOSO, 2014). With the potential to generate an increase in internal capacity for innovation, competitiveness, and local development, the arrangements promote consistent articulations and ties that result in interaction, cooperation, and learning (OLIVEIRA *et al*., 2017).

The general meaning of the word "cooperation" is to work together, involving relations of mutual trust and coordination at different levels. In a LPA, two types of cooperation are identified: *productive cooperation*, aimed at achieving economies of scale and scope, as well as the improvement of quality and productivity indices; and *innovative cooperation*, which results in the reduction of risks, costs, time and, especially, in interactive learning, boosting innovation potential (OLIVEIRA *et al*., 2017).

Each arrangement presents its own characteristics in relation to origin, economic context, sociocultural environment, level of complexity of the production chain, among other aspects. According to Cardoso (2014), with regard to the degree or stage of development, arrangements can be classified into three levels:

- incipient arrangements, disjointed and lacking legitimate leadership;
- developing arrangements, which attract new companies and encourage entrepreneurs to invest in competitiveness;
- developed arrangements, which enable innovations in products, processes and organizational formats, generating greater competitiveness.

The main characteristics of each level of arrangement are listed in Chart 1.

In addition to the evolution of the development stage, the LPAs have distinct characteristics that differentiate them from other types of local clusters, such as the territorial dimension; the space where productive, innovative, and cooperative processes take place; the diversity of activities and of economic, political, and social actors; the participation and interaction of companies, class entities, public and private institutions, and the community; tacit knowledge, sharing and socialization of knowledge by generations; innovation and learning assets, fundamental to the exchange of knowledge and expansion of productive and innovation capacity; and governance, which is the mode of coordination between agents (CARDOSO, 2014).

According to Cardoso (2014), other characteristics contribute to defining the degree of maturity of the arrangement, such as local development, leadership, level of cooperation between actors, financial incentives, process and development management, investment in innovation and technology, market and competitiveness.

Addressing LPA means, above all, to address cooperation, and this joint association, as we shall see next, intersects the purposes of the circular economy and industrial symbiosis. The articulation of these concepts promotes sustainable actions in the arrangements, reducing the impact of production processes on the environment.

Chart 1. Classification and profile of local productive arrangements according to the stage of development.

| Classification of the local productive arrangement | Profile |
|---|---|
| Incipient arrangements | • individual focus;<br>• low business performance;<br>• isolation between companies;<br>• lack of interaction from public authority;<br>• lack of support/presence of a class entity;<br>• restricted trading market;<br>• simpler productive base. |
| Developing arrangements | • sectoral focus;<br>• possible narrowing of the links in the production chain;<br>• difficulty accessing services;<br>• interaction with class entities;<br>• local/state/national market. |
| Developed arrangements | • territorial focus;<br>• narrowing of collective commercial demands;<br>• interaction with the community;<br>• state/national/international market;<br>• more advanced proximity finance;<br>• diversified and comprehensive local institutional base;<br>• broad and complex productive structure. |

Source: developed by the authors based on Cardoso (2014) and Simonetti and Kamimura (2017).

## CIRCULAR ECONOMY AND THE RECYCLING OF TEXTILE WASTE

Circular economy (CE) is an economic model based on separating growth and development from the extraction, production, and consumption of finite resources (KIRCHHERR; REIKE; HEKKERT, 2017; MODEFICA; FGVCES; REGENERATE, 2020). Resulting from the evolution of the concept of various schools of thought — service/performance economy, natural capitalism, blue economy, cradle to cradle, and industrial ecology —, it consists of "a restorative and regenerative system based on intention and design, which seeks to maintain products, components, and materials at their greatest utility and value for as long as possible" (ELLEN MACARTHUR FOUNDATION, 2017, free translation).

The CE-based approach broadens the value chain perspective to cover all stages of supply, manufacturing, distribution, sales, and final destination of what is produced (WEETMAN, 2019). The transition from the linear model of production to a circular model involves reinventing the design and processes (WRIGHT, 2019).

CE has a system-level perspective (GHOSH; GHOSH, 2021) and is based on some basic principles (ELLEN MACARTHUR FOUNDATION, 2013; MUTHU, 2018; WEETMAN, 2019):

- Designing waste: there is no waste when a product is designed, intentionally, for dismantling, renovation, and remanufacturing;

- Resilience through diversity: modularity, versatility, and adaptability are resources that must be prioritized. Natural systems must serve as a model in the search for sustainable solutions;
- Renewable energy: every circular process must analyze the energy involved in the production process, and all elements must prioritize renewable energy sources;
- Thinking about systems: understanding how the parts influence each other on the whole is crucial. Systems thinking emphasizes flow and connection over time and has the potential to comprise regenerative conditions;
- Waste as a nutrient: the ability to reintroduce products and materials into technical or biological cycles through nontoxic restorative loopings.

A holistic perspective of the project is essential to consider possible innovations and strategies for redesigning business models, based on shared value. Based on Michael Porter and Mark Kramer, Weetman (2019) explains that this shared value must be understood as "a management strategy to create measurable business value, by identifying and addressing social problems that entangle the business" (WEETMAN, 2019, p. 431, free translation).

CE proposes that waste from one industry serve as raw material for itself, returning to the production cycle, or to another industry, even if not from the same sector (MURRAY; SKENE; HAYNES, 2017). Many researches on materials development have investigated, for example, the transformation of agroindustrial waste, which would be discarded or incinerated after harvest, and post-consumer food waste into a high value-added raw material for the textile industry, such as the Orange Fiber, an Italian company that patented and produces sustainable citrus-fruit by-product fabrics; Piñatex, from the United Kingdom, which developed a natural textile made from pineapple leaf fiber waste; and Desserto, a vegan leather made of Mexican nopal cactus.

CE focuses on creating continuous cycles, technical or biological, to maintain the maximum value of materials, products, and services. These cycles consider the design of the product, the process, and circular flows (WEETMAN, 2019). At each stage of the cycle, it is possible to think of ways to recover all materials so that they are not destined for the landfill.

In a survey conducted by the Brazilian Association of Special Waste and Public Cleaning Companies (ABRELPE, 2020), it was found that 5.6% of the urban solid waste generated at the national level falls under the *textile, leather and rubber* group, which includes scraps of fabric in general, clothing, shoes, backpacks, and sneakers.

According to the National Solid Waste Policy, "recycling is defined as the process of transforming waste, involving the alteration of its physical, physicochemical, or biological properties, with a view to transforming it into inputs or new products" (BRASIL, 2010, free translation). The study conducted by Amaral (2016) highlights that the logistics of the collection and transportation of waste, as well as obtaining

waste separated by composition, in an organized manner, are common difficulties faced by textile recycling companies, which end up opting to import this type of waste to guarantee the quality of the input. Solid waste management is the set of regulatory, operational, financial, and planning actions by organizations to optimize the handling of solid waste, non-generation, reduction, reuse, recycling, treatment, and adequate final disposal of waste, in this respective order of priority (BRASIL, 2010; FLETCHER; GROSE, 2011).

In living systems, there is no waste, i.e., what is not good for one becomes a nutrient for another, and it is at this point that CE is inspired by nature. Garbage began to be considered a design error (BRAUNGART; MCDONOUGH, 2009). According to Stahel (2019), CE is the last possible solution to the problem of garbage and waste, as it expands the value chain and the sustainability of production processes, in addition to keeping materials and resources in the economy for as long as possible, minimizing waste generation. According to Weetman (2019, p. 154), cooperation between companies and suppliers, between companies from the same sector or from different sectors, between companies and organizations and other articulations is considered an external factor that provides conditions for the progress of circular economy models.

## INDUSTRIAL SYMBIOSIS

The process of trading or exchanging waste and other resources from one company to another is increasingly common and is based on the concept of industrial ecology. It is a way of assigning value to what would be discarded by identifying untapped opportunities, allowing companies to generate new revenues with alternative businesses and reduce costs by improving processes (FERRÃO, 2009).

The new innovation paradigm, in addition to the use of new technologies, is related to new forms of interaction, and this is one of the main agendas related to the transition to a circular production model. The steps necessary to promote initiatives of this type include raising awareness, analyzing resources and possible synergies to create forms of cooperation that can positively influence both the growth of the actors involved and the increase in the innovation capacities of each company (WEETMAN, 2019).

Cooperation can strengthen purchasing power by making it possible to share resources; enabling the convergence of skills, gathering different competencies; and guaranteeing investment in research and innovation, with the division of costs between the parties (CHERTOW; PARK, 2016). The benefits of this articulation can be observed in three dimensions: economic, with the increase in efficiency in the use of resources; social, with the creation of jobs in sectors such as recycling; and environmental, with the reduction of the use of untapped raw materials.

The Ellen MacArthur Foundation defines industrial symbiosis "as the exchange of materials or waste flows between companies, so that the waste from one company becomes another company's raw material" (WEETMAN, 2019, p. 97, free

translation). In other words, it is a productive arrangement in which different industries, not necessarily close, mutually exchange products, waste, and inputs, improving their environmental, social, and economic performance in the face of their individual actions (VEIGA, 2007 *apud* BORSCHIVER *et al*., 2018).

The origin of the nomenclature "symbiosis" lies in ecology, in which it is used to describe the beneficial and reciprocal association between two or more living beings from different species (BORSCHIVER *et al*., 2018). As in nature, industrial symbiosis can result in favorable interactions between companies from different industrial sectors, by CE practices that help closing cycles and that disconnect the growth of companies from the consumption of resources (STARLANDER, 2003).

The main premises associated with industrial symbiosis focus on mutualism, cooperation, and sharing, and the obtained benefits include the reduction of the ecological footprint, the optimization of resources, and the use of clean energy sources (SEHNEM; PEREIRA, 2019). Starlander (2003) classifies industrial symbiosis into two types: *co-located*, when industries are located in the same cluster; and *virtual*, when they are distributed in different areas, municipalities, or countries. In both cases, gains can be shared between all links in the chain, generating results for companies, society, and the environment (MIRATA, 2004). Hence, the notion of value is expanded with the idea of shared value, whose level of delivery will depend on the connections that are established between the actors.

The Brazilian Industrial Symbiosis Program, represented by the Industrial Symbiosis Program of the state of Minas Gerais, is an example of virtual symbiosis and is motivated by the reduction of costs for companies and the improvement of environmental performance (correct waste disposal and resolution of environmental problems) (PAULA; ABREU; SOUSA, 2015). Borschiver *et al*. (2018) report that, from 2009 to 2015, the Industrial Symbiosis Program of the state of Minas Gerais enabled the recovery of 140 thousand tons of waste; 200 thousand tons of natural resources ceased to be used; carbon emissions decreased by 90 thousand tons; over 13 million $m^3$ of water were reused; and the costs of recycling materials from participating companies were reduced by BRL 8.7 million.

According to Weetman (2019), traditional linear-based industry models must be transformed into industrial ecosystems to optimize energy and material consumption, minimize waste generation, and ensure that the leftovers from one process become the raw material of another. Industrial symbiosis, as an application of industrial ecology, is a way to face sustainability challenges and achieve CE, through responsible processes.

## FIELD RESEARCH METHODOLOGY: BEACHWEAR CABO FRIO/RJ LOCAL PRODUCTIVE ARRANGEMENT

To recognize, map, and understand the dynamics of the arrangement; diagnose the textile waste; and investigate the current flow, the identification of the origin, volume, characterization, and forms of destination adopted, an exploratory

field research was conducted to obtain qualitative information on the destination of textile waste when exiting the fabric cutting sector.

As a data collection procedure, in addition to direct non-participant observation, focused unstructured interviews were conducted via telephone in the month of March 2022 and in person in April of the same year, with three actors from the arrangement:

- an *economic actor* (A), represented by the person responsible for the production of one of the factories;
- a *regulatory actor* (B), responsible for the Board of Urban Services of the Cabo Frio Services Company (*Companhia de Serviços de Cabo Frio* – Comsercaf);
- a *social actor* (C), the vice chairwoman of Acirb and also entrepreneur from the group.

To define the actors participating in this first stage of the research, the authors considered the importance of obtaining statements from people with different points of view about the textile waste generated by the arrangement.

Based on experimental manipulation studies (LAKATOS; MARCONI, 2003), the aim was to understand the activities of the arrangement with the purpose of formulating strategies for recovering the value of textile waste based on CE principles and the industrial symbiosis model.

The choice of this LPA as a research sample was mainly due to the type of raw material used in the production of this segment, considering the impact that synthetic textile waste causes when improperly disposed of. Another relevant fact was that, although there was much research on the dynamics of this arrangement, the authors found none that focused on the issue of waste generated by the manufacture of this cluster.

## Characterization of the Beachwear Cabo Frio/RJ Local Productive Arrangement

Cabo Frio is a Brazilian municipality located in the east of the state of Rio de Janeiro. It is the seventh oldest city in Brazil (CARDOSO, 2006), with a territorial extension of 410,415 km$^2$ and a population density of 453.75 inhabitants/km$^2$ and, according to the Brazilian Institute of Geography and Statistics (IBGE, 2020), an estimated population of 234,077 inhabitants for 2021.

The city's main economic activities are tourism, fishing, beachwear, oil extraction, agriculture, livestock, and handicrafts; but, currently, tourism and, consequently, beachwear are the most significant activities according to the City Hall of Cabo Frio (Prefeitura de Cabo Frio, 2022). The production of beachwear is of great economic relevance — with a strong contribution to the city's gross domestic product — and social relevance — as it employs a large part of the female population of Cabo Frio (CARDOSO, 2006).

The manufacture of beachwear garments in the city began in 1953 with the seamstress Nilza Rodrigues Lisboa, who later became an entrepreneur and supporter

of other seamstresses in the region. Her work in the Gamboa neighborhood, where she lived, was decisive for the formation of the Beachwear Cabo Frio/RJ LPA (CARDOSO, 2006). Located in Gamboa Mall, on the traditional Rua dos Biquínis (which could be translated into "Street of Bikinis"), formerly Rua José Rodrigues Povoas (Figure 1), the LPA consists, for the most part, of micro and small enterprises (PEIXOTO, 2005).


Source: Google Earth (2022).
Figure 1 – Overview of the Gamboa neighborhood (highlighted in yellow) and Rua dos Biquínis (highlighted in red).

Built in 2002, the Gamboa Mall is the largest beachwear chain in the Americas, with over one hundred stores specialized in the segment (MOURA, 2012). Cooperation and associations, the market and entrepreneurship are the factors that most influence this LPA (VALLE, 2007).

Brazil is a world reference in the production of beachwear, and the city of Cabo Frio is one of the largest producers in the country. According to Prado (2021), 221 million garments from this segment were sold throughout the Brazilian territory in 2020, a reduction of 50 million compared with the previous year. According to the statement of the vice chairwoman of Acirb[1], Fabrícia da Costa, about five million garments are manufactured annually, generating thousands of permanent and temporary jobs. However, it is worth highlighting that seasonality has a strong influence on job creation, causing high employee turnover between high and low seasons (PEIXOTO, 2005; CARDOSO, 2006).

1 Verbal information provided in March 2022.

The strengthening of Acirb, which was the main social actor in the cluster, has already resulted in some desired advances in the arrangement, such as the revitalization of Rua dos Bikinis, the inauguration of its own headquarters, and the launch of the book entitled *Biquíni: duas peças que mudaram a rua e o mundo* ("Bikinis: two pieces that changed the street and the world"), which tells the story of the street and the development of the Beachwear Cabo Frio/RJ LPA, published in 2015. Nevertheless, the association is currently inactive, and the headquarters was deactivated due to the lack of engagement of the entrepreneurs that compose the cluster.

## Challenges and potentialities of the Beachwear Cabo Frio/RJ Local Productive Arrangement

Considering the attributes of Cardoso (2014) and Simonetti and Kamimura (2017), we can classify the Beachwear Cabo Frio/RJ LPA as a *developing arrangement*. The potential for the formation of an industrial symbiosis in the cluster for the management of textile waste is evidenced by the identification of technical, political, economic, informational, organizational, and motivational aspects.

The LPA major challenge is to encourage the engagement of entrepreneurs to enhance the search for solutions to improve the arrangement. The group of about 40 retailers communicates entirely by a messaging application. Face-to-face meetings have low attendance, which makes it difficult to make decisions.

## Textile waste management in the Beachwear Cabo Frio/RJ Local Productive Arrangement

We first spoke with C, who gave us an overview of the textile waste flow from the LPA. We found that only two out of the 40 companies that are part of the cluster properly dispose of most of the textile waste they produce. According to C, most entrepreneurs are not responsible for the textile waste from their productions: "*The majority leave the garbage on the street as if it were ordinary waste.*" This fact was confirmed by B, who points out that textile waste is discarded mixed with common waste, making the recovery process of this material unfeasible. As there is no selective collection program aimed at this type of waste, it ends up in the city's landfill.

A is responsible for production and has been working for nine years at one of the companies in the arrangement that uses a process for discarding part of the textile waste generated during production. One of the most interesting points in her statement is the fact that the textile waste management initiative did not come from managers (*top-down*), but from the head of the cutting sector (*bottom-up*). Bothered by the large volume of unused raw materials discarded every day, the employee decided to research alternatives for reusing the material and found a textile recycling company located in the state of São Paulo that offers compensation for the waste of unused mesh fabric. The condition for such negotiation is that the scraps must be separated by composition (100% polyamide, of higher value, separated from other proportions, for example, 90% polyamide/10% elastane, 98% polyamide/2% elastane, etc., of lower value) and in disposable bags. The waste is stored

for a period of six months to one year (depending on the accumulated volume), to justify the logistics costs of the recycling company.

It is estimated that the volume accumulated in the last year was around seven tons, considered by her to be a reduced volume, due to the drop in production during the last biennium. The amount received for the sale of the waste is divided by the team responsible for the initiative (manager, cutter, and cutting assistant) and, in the words of A, "it *represents a good extra income.*" The practice has been carried out by the company for six years, which is equivalent to saying that at least over 43 tons of synthetic textile waste destined for the landfill were forwarded to the recycling process.

Despite the relevance of the LPA, there is no textile waste management program or any guidance on how to properly dispose of this type of material.

## PROPOSAL AND DISCUSSION: CIRCULAR FLOWS AS A STRATEGY FOR MANAGING TEXTILE WASTE FROM THE BEACHWEAR CABO FRIO/RJ LOCAL PRODUCTIVE ARRANGEMENT

In the CE structure proposed by Weetman (2019), circular flows are at the end of the process. The scope of this stage involves the requirements to reuse, remanufacture, and recycle. In this research, we sought strategies to incorporate the open-loop recycling into the second stage of product development, namely the production.

In identifying the gap in textile waste management in the LPA, we seek to outline a design model for the waste management process based on the experience identified in the arrangement, to expand the scale of the existing initiative through the formation of an industrial, cross-sectoral, virtual symbiosis (Figure 2). Even with the objective of considering only the textile waste in the arrangement, we deemed necessary to consider alternatives for the paper and plastic that are used on the cutting table.

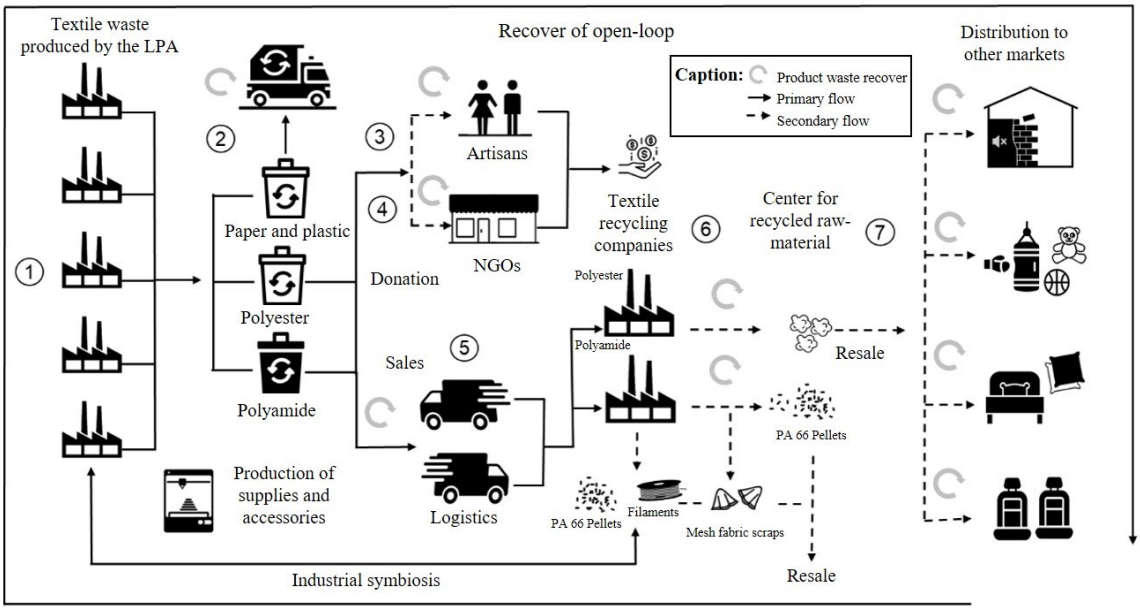


Figure 2 – Proposal for a circular, cross-sectoral, open-loop flow for the local productive arrangement.

Thus, we propose that the factories in the arrangement separate the generated waste, paper and plastic, polyester and polyamide; paper and plastic be collected by Comsercaf, through the current selective collection program; polyester, due to its low sales value, should be sent for donation to artisans and to the nongovernmental organization Comunidade dos Sinos, which maintains a social project with the local community; polyamide is collected by reverse logistics service companies and distributed between two textile recycling companies, the company A (city of São Paulo, state of São Paulo), which transforms textile waste into shredded textile waste, and company B (city of Londrina, state of Paraná), which recycles the material by converting it into pellets to be used as engineering plastic and filament for three-dimensional (3D) printers and other markets, which purchase the by-products of the recycling process from company A. Part of company B's production must be re-forwarded to the companies in the arrangement, so that they can produce the supplies and accessories used in production using additive manufacturing technology (3D printing).

After the implementation stage, it will be possible to obtain performance indicators that can:

- demonstrate the results obtained from the industrial symbiosis proposal for the arrangement;
- verify and understand limiting factors of the process;
- estimate the costs of operationalizing this system.

Considering that environmental preservation is not a motivating objective in the current economic model, Weetman (2019), based on Stahel, encourages that the focus of the proposal for a circular economy model in companies should be on the concept of total income instead of zero waste, considering that the expectations of entrepreneurs are always linked to profit.

As aforementioned, the destination of textile waste for artisans alone, which is carried out by some companies in a disorganized and unregular manner, is not enough to dispose of the waste generated by the arrangement. Thus, we identify the great difficulty reusing this material in the arrangement itself and, therefore, we propose the industrial symbiosis model.

## FINAL CONSIDERATIONS

Industrial ecology proposes industrial systems that work as natural ecosystems. The symbiotic relations provided between companies involve the creation of a culture of cooperation between different social actors.

CE is an instrument in this change and can act as an integrator of actions through practices based on its principles, to grasp the opportunities that arise from this context. There are numerous challenges, but collective practices can implement innovative links through the coordination of actions to create an environment conducive to symbiosis and the advancement of the CE.

In the second stage of the research, we intend to develop initiatives to engage entrepreneurs in workshops and lectures that clarify how cooperation between

companies, based on CE principles and on the concept of industrial symbiosis, can generate value in the management of textile waste in the arrangement.

## ACKNOWLEDGEMENTS

The authors would like to thank the support of the Three-Dimensional Experimentation Center and the Design Management Laboratory, which are part of the Graduate Program in Design of Pontifícia Universidade Católica do Rio de Janeiro.

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**Conflict of interests:** nothing to declare – **Financial support:** Coordination for the Improvement of Higher Education Personnel – Financing Code 001.
**Authors' contributions:** Conceição, M. E.: Conceptualization, Data curation, Formal analysis, Methodology. Magalhães, C.: Supervision. Lopes, J.: Supervision.