CIRCULAR VALUE PROPOSITION FOR THE COFFEE CAPSULE CHAIN FROM A SUSTAINABLE PSS SOLUTION DESIGN METHOD

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ABSTRACT

Product-service systems (PSS) are one of the business models that can promote circular economy and sustainability; however, to design this kind of solution, holistic approaches must be used, integrating different areas of knowledge. Thus, this study proposes a conceptual solution based on the PSS business model to the problem of reverse logistics of coffee capsules, through the application of the Requirements Engineering method for Sustainable PSS design, with a focus on the initial phase. With an emphasis on the business model and value proposition, a conceptual solution was developed to promote the circularity of the capsule chain based on the analysis of the main stakeholders' needs. The value proposition of the PSS solution for the issue of coffee capsules was described as the "cocreation of sustainable value to stakeholders to foster the circularity of the chain", considering consumer involvement through education and rewards in product disposal processes. The results reinforce the need to integrate critical stakeholders to add the desired value in creating a sustainable PSS solution and the need to pivot the business model during the solution development process.

Keywords: Product-Service Systems (PSS), Conceptual design, Circular economy, Design methods

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1 INTRODUCTION

In face of an ever more dynamic market, with harsh competition and the need to achieve higher and sustainable performance, organizations have been searching for alternatives to the traditional offer of products and services, which include new ways of creating, delivering, and harnessing value. An alternative lies in developing integrated solutions of products and services that can better meet clients' needs by relying on innovative business models that cause less negative environmental and social impact (Echeveste et al., 2020; Gaiardelli et al., 2021).

From a conceptual perspective, a product-service system (PSS) is a solution that integrates products and services from a network of actors and supports infrastructure, seeking competitiveness and the satisfaction of clients' needs while causing less environmental impact than traditional business models (Mont, 2002; Tukker, 2004). In this sense, a sustainable PSS is an innovation strategy in which the business core shifts from physical product design and marketing to the development of product and service-integrated solutions with higher added value to clients and which are marketed from innovative business models involving new forms of consumption and relationship between stakeholders. Sustainable PSS solutions are one of the business models that promote a circular economy through the dematerialization of consumption, the extension of the product lifecycle, and product recycling into its chain, creating value in the use and functional result of the solution (Kühl et al., 2022; Mont, 2002; Nag et al., 2021; Tukker, 2004).

In order to design and deliver this sort of solution and complex systems, one must consider holistic approaches to development and methods that integrate various tools from several areas of knowledge involved. In this sense, Echeveste et al. (2020) have proposed a Requirements Engineering approach for innovation in PSS from a structured design method that integrates several requirements engineering, design, and innovation tools. More specifically, innovation methodologies (Blank, 2013; Osterwalder et al., 2015), Design Thinking (Brown, 2008), Lean Startup (Ries, 2011), Requirements Engineering (Sharma and Kumar, 2016), and PSS Design (Geum and Park, 2011; Morelli, 2006; Vezzoli et al., 2014) were integrated, resulting in the Requirements Engineering method for Sustainable PSS design (R-PSS). The R-PSS method aims to assist in developing a sustainable PSS solution.

In this context, this study approaches the application of the R-PSS method in proposing a sustainable PSS solution for the disposition of coffee capsules produced by a Brazilian company. Thus, this study aims to present a sustainable PSS solution focusing on a circular value proposition for the adequate destination of coffee capsules, starting from the results of applying the first cycle of the R-PSS method.

2 REFERENCE METHOD OF REQUIREMENTS ENGINEERING IN PSS (R-PSS)

The Requirements Engineering method for Sustainable PSS design (R-PSS) proposed by Echeveste et al. (2020) results from real case experiences in partner companies approached by the graduate students of an Industrial Engineering course at the Federal University of Rio Grande do Sul (UFRGS) which follow the premise of delivering value (mainly sustainable) to various stakeholders. The R-PSS method was applied in several cases, demonstrating a flexible and customizable approach to different proposals aimed at sustainability and circular value (Dorigon et al., 2019; Lermen et al., 2020; Peralta et al., 2020; Sastre et al., 2019).

The R-PSS is a reference model composed of three learning cycles. The first cycle (phase 0) refers to the value proposition, the second one (phase 1 and 2) is dedicated to requirements engineering, and the third (phase 3) integrates the proposed solution's processes. In each phase, the actors suggest tools based on Design, Lean Startup, Requirements Engineering, and PSS Design literature. This tools' integration into the design process of PSS allows for the alignment of consumer and stakeholder needs, leading to more sustainable solutions and higher added value to those involved (Carreira et al., 2013). Figure 1 presents the R-PSS method.

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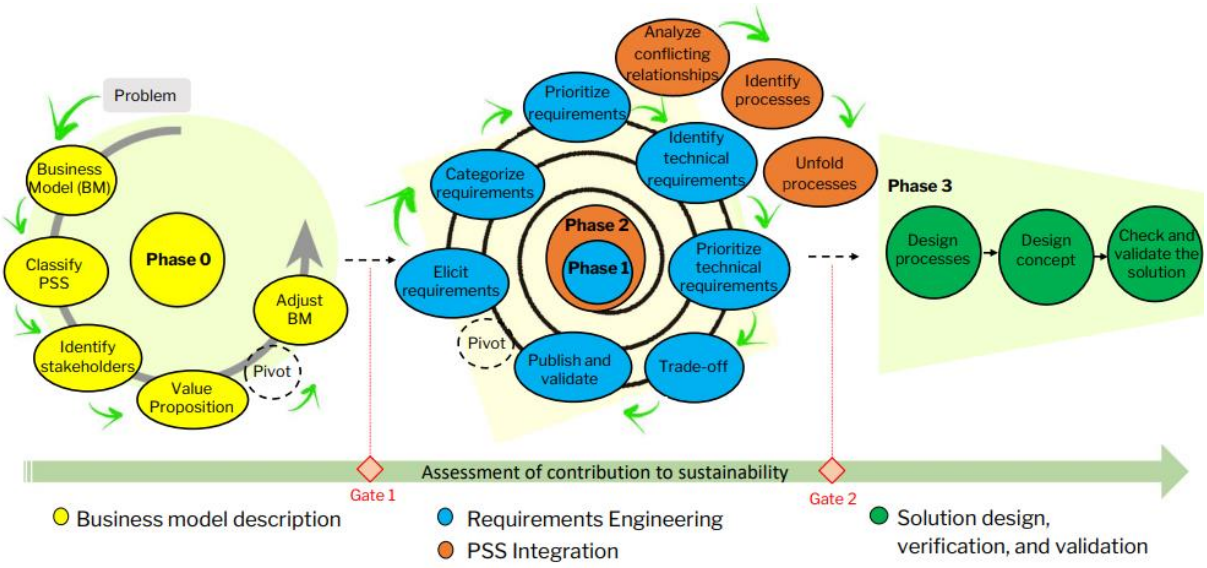

Figure 1. R-PSS method

The first cycle, which is the present study's focus, is based on Design Thinking principles. Specifically, this stage aims to deliver a creative and innovative solution for the issue, which must be centered on the human being (critical stakeholders), their needs, and preferences (Brown, 2008; Shapira et al., 2017). Furthermore, this early stage is exploratory, for it consists of a series of iterations that aim to discern the demands of various stakeholders and project the value proposition of the solution that best meets the needs of critical stakeholders. The concept of the solution generated in the first cycle is detailed in terms of requirements in the following phases of the method. Therefore, the method begins with the definition of the business model with the company involved, adopting the consideration of sustainable value as a premise. Subsequently, the classification of the PSS type based on Tukker (2004) is performed.

The method involves understanding what value is for each critical stakeholder, besides comprehending the stakeholders' needs using market research tools and Value Proposition Canvas (VPC) (Osterwalder et al., 2015) to create the value proposal statement. Information is chained as of the business model, with learning cycles to pivot it whenever necessary (Ries, 2011). The following phases apply requirements engineering tools according to the PSS type. Finally, the process is developed based on the Product-Service Blueprint and System Map tools (Geum and Park, 2011) for the company to visualize and validate the proposed solution's concept and scalability. The evaluation of the service or contribution to the sustainability of the PSS solution is performed throughout the phases of the method with qualitative and design tools that highlight the value of sustainable aspects (Morelli, 2006; Silveira et al., 2022; Vezzoli et al., 2014).

The R-PSS method focuses on the initial stages of the PSS development process through a holistic requirement engineering approach that integrates several tools and methodologies commonly found in a dispersed and disaggregated way in the literature. One of the main differentials of the R-PSS method related to models in the literature (Kim et al., 2015; Lee et al., 2019; Song and Sakao, 2017; Sutanto et al., 2015) is the consideration of the integration of products and services and sustainable value for different stakeholders from the initial stages of the method. Specifically, while some methods propose the development of the package of services and products in parallel (Kim et al., 2015; Marques et al., 2013), the R-PSS method proposes the integrated development of products and services from the beginning.

Additionally, the existing models focus on the ideation of the concept or the solution requirements without detailing the operationalization and tools in the development stages (Doualle et al., 2016; Song and Sakao, 2017). On the other hand, the R-PSS method integrates innovation and requirements engineering methodologies and suggests tools at each stage. Furthermore, some methods were designed for specific types of PSS (Cong et al., 2020; Kim et al., 2015; Lee et al., 2019), while the R-PSS method is flexible and has its application tested and validated in different types of PSS.

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3 METHODOLOGY

This study is applied research based on university-company interaction projects in the course "Requirements Engineering for the development of a product-service system" taught in the Industrial Engineering Graduate Program of a Brazilian university and follows the stages of requirement integration in sustainable PSS solutions, called R-PSS (Requirements for Product-Service System) (Echeveste et al., 2020).

The R-PSS method was applied in the case of a Brazilian start-up responsible for handling capsule packaging waste of a coffee manufacturer to create a conceptual solution for the circularity of the capsule chain, which must be implemented by the start-up with the capsule manufacturing company, aiming to abide by the applicable Brazilian legislation related to reverse logistics.

The following stages have been performed: i) understanding the issue at hand; ii) defining the business model and PSS type of the current solution of the company; iii) identifying the life cycle of the coffee capsules and the stakeholders; iv) defining the value proposition of the sustainable solution; and v) assessing the contribution of the proposed solution to sustainability. Figure 2 presents steps methodological adopted.

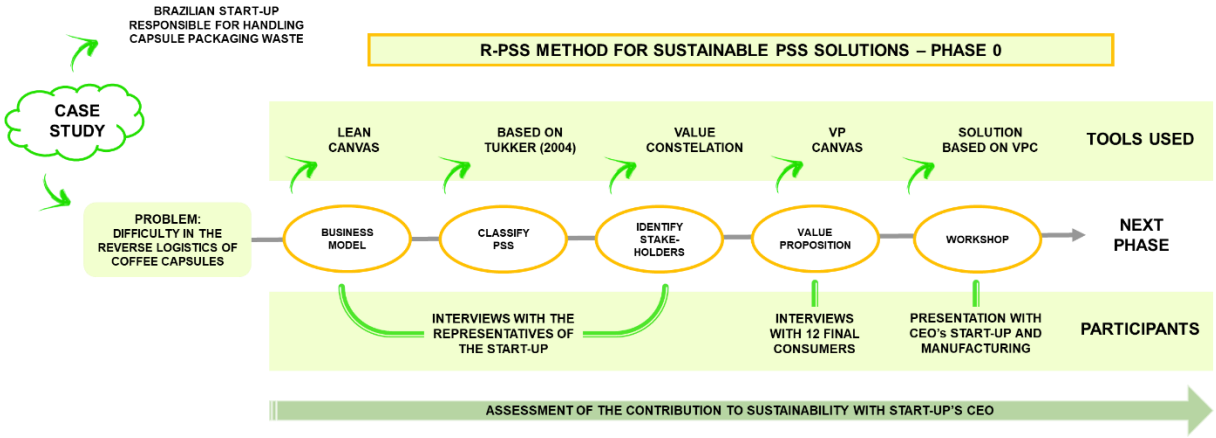

Figure 2. Methodological procedures

The first three stages were conducted employing interviews with the representatives of the start-up responsible for handling capsule waste and of the capsule manufacturer. Each interview lasted nearly one hour, was conducted via conference call, and was recorded with the participant's consent. The questions were guided by the elements that compose the tools employed in the R-PSS method (e.g., Lean Canvas, Stakeholder map, etc.) to be described in section 4.

The fourth stage was performed after an exploratory study with semi-structured individual interviews (Malhotra, 2019) with a sample of twelve final consumers chosen by convenience. Again, the interviews were conducted via conference call and recorded with the participants' consent. The interview involved the questions from the first stage of the VPC (Osterwalder et al., 2015).

With the data collected during the interviews with the final consumers, we organized a workshop with the two CEOs of the start-up and two representatives of the capsule manufacturer (an environmental coordinator and an environmental analyst) aiming to propose the products and services for the solution, alternatives to soothe problems and the assets to add value required to meet the demands of the final consumers and the manufacturer. The workshop was conducted with questions used in the second stage of the VPC tool (Osterwalder et al., 2015), resulting in a value proposition statement.

In the last stage, the development team and the CEO of the start-up assessed the contribution to the sustainability of the proposed solution for the capsules based on the principles catalog for the creation of sustainable PSS as proposed by Silveira et al. (2022). For every aspect of sustainability (environmental, social, and economic), the tool considers various analysis categories that represent the heuristic principles related to the characteristics of sustainable PSS solutions (network of players, integration of products and services, reduction of environmental and social impacts) (Silveira et al., 2022). In order to assess these principles, a five-point Likert scale was implemented, where 1 means full disagreement and 5 means full agreement. Each sustainability dimension generates a radar by adding the score of each category.

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4 APPLICATION OF THE R-PSS METHOD FOR THE SUSTAINABLE SOLUTION OF FINAL DISPOSITION OF COFFEE CAPSULES

The issue faced by the coffee capsule manufacturer is related to the reverse logistics required by the National Policy for Solid Waste (Law no. 12,305/2010), under which 22% of the total capsules sold by the company must return to the cycle (Brazil, 2010). The capsule manufacturer hired a solid waste management start-up to collect, separate and pre-recycle the capsules. The start-up presented the challenge to the discipline's students, seeking assistance in developing a sustainable PSS solution for the case.

The R-PSS method was employed to structure a conceptual solution from the business model, based on Design Thinking principles, to the design of PSS processes for the start-up to implement at the capsule manufacturer and other stakeholders in the chain. Therefore, the application of the method advances toward correct environmental solutions for the end of the capsule lifecycle, prioritizing the circularity of the chain. Due to the limitation of words in the required format, this paper presents only the results obtained with the application of stage 0 (first cycle) of the method, whose objective is to develop the business model and the value proposal of the solution via learning cycles. However, the complete PSS solution, including the results of the application's main phases of the R-PSS method, can be accessed at the link: https://miro.com/app/board/uXjVPk6sNM8=/?share_link_id=542837846338.

4.1 Business model and PSS type

A representative of the capsule manufacturer, the founder of the start-up hired to develop a solution, and a team of five specialists (graduate students) conducted this stage. Firstly, a brainstorming session generated potential ideas for the solution of the capsule reverse logistics issue. Then, Lean Canvas was used to define the solution proposed initially through the agile development of the business model (Peralta et al., 2020), identifying value for the customer (capsule manufacturer) and developing other important elements for later experimentation and validation (Maurya, 2012).

From the problem (high amount of waste generated after the consumption of coffee capsules and, more specifically, high incidence of incorrectly disposed of capsules by the final consumer, which possibly ends up in landfills), the solution originally designed contemplated the collection of capsules via recycling and screening programs at cooperatives and recycling for the production of tiles. For that, we found that the value of the proposal centered on promoting the circularity of the capsule chain and, therefore, integrating the relevant stakeholders would be necessary.

Based on the elements of Lean Canvas, the initial PSS solution was classified as result-oriented. According to Tukker's (2004) classification, a result-oriented PSS generates functional results both for the producer and the consumer. More specifically, the customer and supplier agree with a result, and the focus is not on a pre-determined product but on management activities (Tukker, 2004). Therefore, since the initial solution involves reducing the number of capsules directed to landfills and supplying inputs to other companies for reuse or recycling, aiming at the circularity of the chain, we see a common result sought for involving more than one stakeholder.

4.2 Lifecycle and stakeholder analysis

Using as reference the proposition of a solution that adds value to various actors of the chain, the lifecycle of the capsules was mapped to identify the main actors involved along the product cycle (from the purchase of raw materials to the disposal stage in landfills or recycling).

Subsequently, the group of direct and indirect actors identified was placed in a value constellation (Figure 3). The relationship between the stakeholders was highlighted to facilitate the understanding of their roles in the value network (Speed and Maxwell, 2015). Furthermore, conflicts between the actors and interactions that add value were identified, indicating key stakeholders (Patrício et al., 2011), who were then heard about the structuring of the value proposition. Diagnosing the previously existing value constellation (presented to the left of Figure 3) allowed for identifying opportunities to reorganize relations and potentialize value for the actors (Figure 3 to the right).

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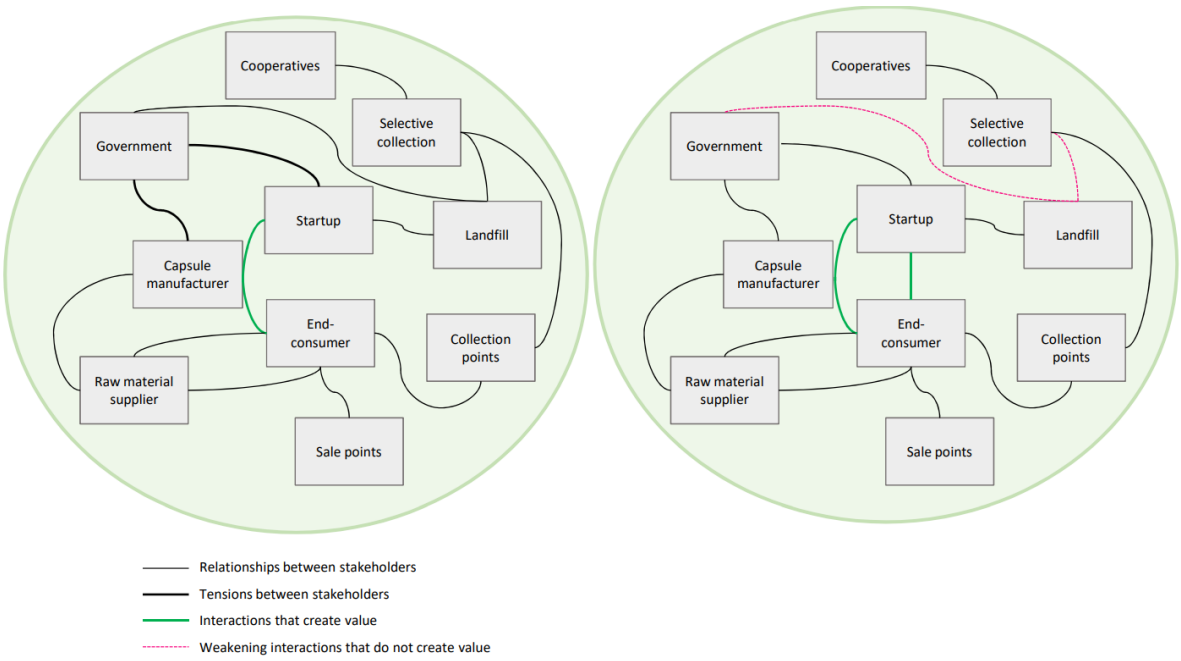

Figure 3. Value constellation

Figure 3 shows three main actors in the coffee capsule chain in structuring the solution: capsule manufacturer, start-up responsible for handling capsule waste, and consumers. The relationships to be strengthened to create a virtuous cycle that fosters environmentally correct disposal and the relationships that must be weakened (for instance, the interaction between consumers and the landfill) were highlighted.

4.3 Value proposition

The value proposition was developed through the VPC tool (Osterwalder et al., 2015) based on the interviews with final consumers and the workshop with representatives of the capsule manufacturer and the start-up. Based on the data collected from the two groups of stakeholders, the VPC assisted the specialist team in ensuring that the PSS offer fit the customer's values and needs, as shown in Figure 4.

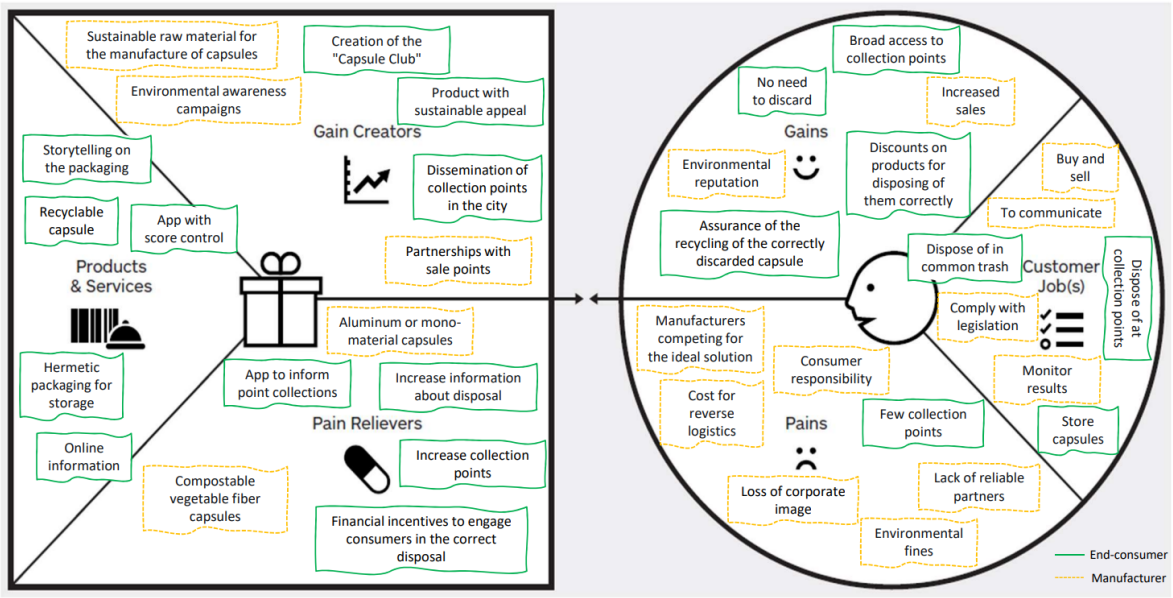

Figure 4. Value proposition canvas

Starting from understanding the critical stakeholders' problematic issues, gains, and activities (capsule manufacturer and final consumers), the specialist team and the start-up proposed creators of gain and "painkillers" for where it hurts. For instance, for the pain of "few points of the material collection", an

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increase in the number of points and information on environmentally adequate disposal was proposed. These painkillers generate benefits, such as collaboration between points of sale and environmental awareness about product disposal.
From this information, the team suggested products and services such as the development of airtight packages (to prevent bad smell from storing the capsules until disposal, mapped as a "pain" by the consumers interviewed), the elaboration of storytelling with information on adequate disposal and the cycle of the coffee capsules on their package, and the development of an app by the start-up aiming to manage scores and discounts to be obtained by disposing of the capsules in points of sale or collection. The VPC also evidenced the need to alter the composition of the capsule to two types of materials, at the most, for currently, the capsule is composed of four types. Therefore, the proposal is that the capsule is reprojected to facilitate recycling.
Considering that the value proposition arises from soothing the pains of the clients, value creators and products and services identified to facilitate the more critical client activities, healing the most intense sources of pain and providing gains expected by them (Peralta et al., 2020), the business model was reassessed to align the elements of the initially proposed solution with the results obtained empirically. By observing divergences regarding the aspects initially proposed, the business models pivoted to encompass coherent aspects of the reality at hand through interviews with critical stakeholders and the applying the VPC. Figure 5 presents the pivoted Lean Canvas.

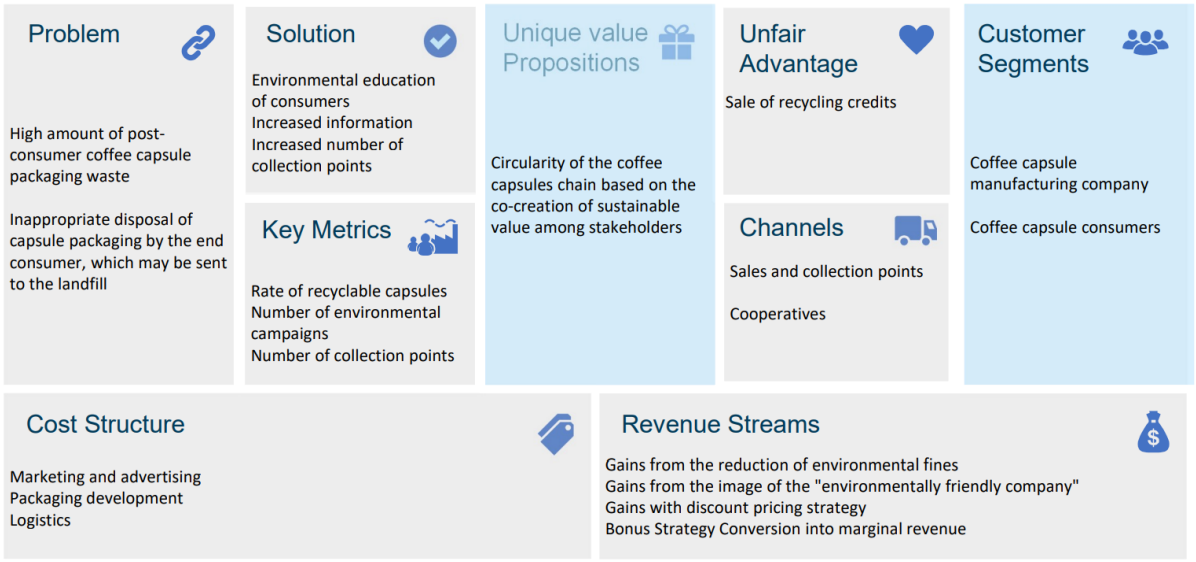

Figure 5. Lean Canvas pivoted

The application of the VPC revealed that most consumers do not know how to adequately dispose of the capsules after consumption and dispose of them in the common garbage. For consumers with such knowledge, inconvenient access (few points of collection) makes environmentally correct disposal difficult. Therefore, the solution that initially involved reusing the capsules to manufacture tiles was pivoted to contemplate consumer education, as they are fundamental actors in the reverse logistics process (Sangwan, 2017).
More specifically, we found that consumer commitment to the disposal process is essential to collect sufficient input for the promotion of the circularity of the chain (for instance, to contemplate the manufacturing of tiles at a later stage). This way, communication intensification and an increase in the points of the collection were added to the solution. Lastly, considering that consumer involvement in product disposal processes often requires giving rewards (Sangwan, 2017), the value offer should also be extended to the final consumer. This is related to the Evolutionary Theory, more specifically to the propensity for one's gain (Griskevicius et al., 2012). Only by receiving personal gain do individuals retribute with an environmentally friendly action. Therefore, the value proposition of the PSS solution for the issue of coffee capsules after consumption became the "cocreation of sustainable value to stakeholders to foster the circularity of the chain".

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4.4 Assessment of the contribution to sustainability

Based on the value proposition of the capsule issue solution, the specialist team and the supplier start-up employed the principles catalog for the creation of a sustainable PSS, as postulated by Silveira et al. (2022), to assess the contribution of the proposed solution to sustainability. The result of the assessment of each category in each dimension of sustainability is presented in Figure 6, based on the radars of contribution to sustainability.

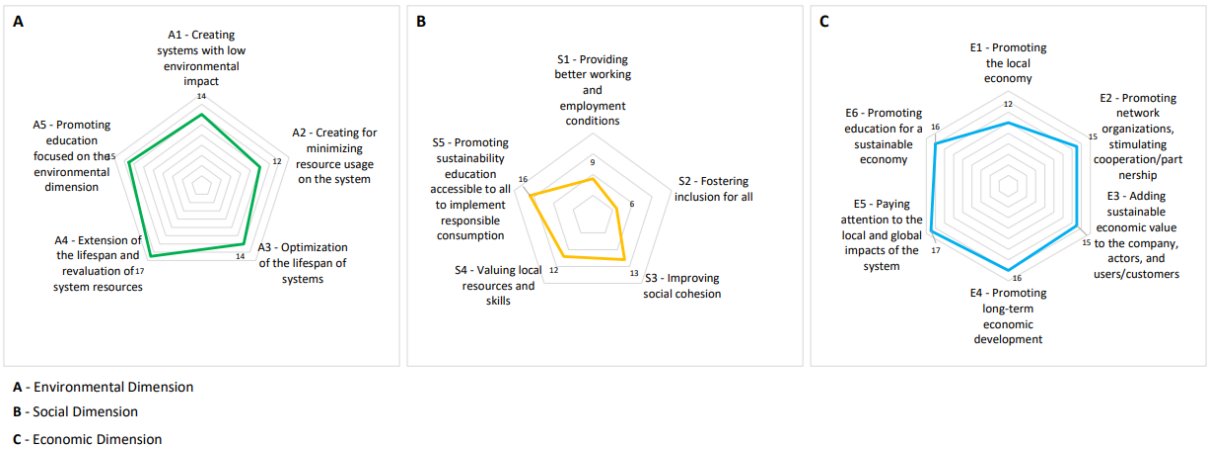

Figure 6. Sustainability radar

Based on Figure 6, it is possible to infer that, in general, the conceptual solution developed contributes to sustainability. The solution stands out in the environmental dimension, especially for prioritizing the extension of the lifespan of the capsules and promoting education focused on the environmental dimension. Emphasis is assigned to the economic dimension due to the proposal of a system that presents greater eco-efficiency, promotes network organizations, and stimulates cooperation and partnership. The PSS solution also contributes to sustainability from a social perspective, mainly through promoting sustainability education accessible to all to implement responsible consumption. However, future studies could better address the social aspects, including local resources and skills.

5 CONCLUSIONS

This paper aimed to propose a conceptual solution based on the PSS business model to promote the circularity of the coffee capsules chain, through the application of the R-PSS method, with a focus on outlining stage 0. Particularly, the design method supported the development of a solution for the difficulty faced by a coffee capsule manufacturer in reverse logistics. As contributions, we highlight the delivery of a conceptual solution (from the business model to the description of the PSS concept) for managing capsule waste after consumption, integrating critical stakeholders to foster the circularity of the chain through the creation of sustainable value. This solution, which encompasses the early stages of the development of PSS-type offers, provides subsidies for the start-up to advance in implementing the proposed elements towards the conception and marketing of the offer.

Applying the initial stage of the method resulted in learning for the development team. We highlight the following aspects: (i) the importance of taking into consideration the various stakeholders and their needs in the creation of the sustainable PSS solution to add the desired value to all critical stakeholders; (ii) the need to pivot the business model during the solution development process to incorporate new demands identified while implementing the required tools; (iii) the relevance of the flexibility and customization of the method to several types of PSS and contexts, allowing for the incorporation of new tools whenever necessary.

Considering that PSS business models are complex solutions whose design requires the appreciation of multiple factors such as technology, innovation, and interested stakeholders (Morelli, 2002, 2006), the description of the method application process can assist designers and engineering teams in the creation of other PSS offers that add value and adequate experience to consumers. Despite that, we highlight that the method's applicability is not limited to professional designers. The demonstration of the steps of stage 0 supports the development of offers PSS by any professional since it is based on Design Thinking, an approach that attempts to turn creative minds into "design thinkers" (Brown,

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2008). Lastly, for future research, we suggest including high-fidelity prototyping tools in the method to assist in verifying and validating the proposed solution with the stakeholders.

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