Industrial Symbiosis for Responsible Consumption in the Coffee Sector: Literature Review

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Abstract

The objective of this article is to present a review of the industrial symbiosis literature for responsible consumption in order to identify its relationship and by-products in the coffee growing sector. The type of investigation is documentary, and the method is deductive. The research was carried out in two phases: Systematic Literature Review (SLR) based on the SLR model of Garza-Reyes (2015) and the identification of the literature and relationships with other studies. The result that was obtained was that the reviewed literature maintains that industrial symbiosis is a way to get a sustainable world, because it supports the generation of jobs, additional income, lengthens the life cycle of products, uses waste as by-products and transfers it knowledge. In this sense, through this research, the bases of the relationship of industrial symbiosis with responsible consumption are laid, which can be applied in the coffee growing sector, where many benefits are obtained due to the amount of waste that is produced, during its production, and the properties that waste has, in order to be used as by-products of other processes, thus helping society, the environment and the economy of the sector.

Keywords
Industrial Symbiosis, Responsible Consumption, Coffee Sector, By-products, and Systematic Literature Review.

1. Introduction
Industrial symbiosis is a concept that was born in 1972, under the project developed in Kalundborg-Denmark (Cervantes et al., 2009). Whose experience confirms that through cooperation it is possible to reduce the indiscriminate use of natural resources, in addition to increasing the region's economy (Tudor et al., 2007). Among the most outstanding figures is the 60% reduction in water consumption in the power plant that is part of this symbiosis, by supplying it with surface water taken from a nearby lake and the water treated by the Kalundborg refinery (Pinzón, 2009). Later, the term would be used for the first time in an article whose main topic is production strategies (Frosh and Gallopoulos, 1989). According to Chertow (2000), industrial symbiosis merges traditionally separated industries in a collective approach to obtain competitive advantages including physical exchange of materials, energy, water and/or by-products. In this sense, to put this tool into practice, an exchange of resources must be given, whether by-products, infrastructure or the provision of services (Chertow et al., 2007).

Thus, currently the reuse of waste in food production chains is becoming one of the main areas of interest and study, with the aim of promoting the economy and processes in favor of the environment (Mansouri et al. 2017; Gunarathne et al. 2019; Pfaltzgraff et al. 2013; Udugama et al. 2019). In addition to generating additional income (Udugama et

al., 2017) and attracting those "interest groups" that seek to be responsible consumers (Duenas et al., 2014). On the other hand, Webster (1975), argues that a consumer who takes into account the public consequences of his private consumption and tries to use his purchasing power to achieve social change, which begins to have positive impacts worldwide, because the population increase has led to a higher consumption of animal proteins (Organization for Economic Cooperation and Development, 2018), which means a greater demand for production for the agricultural sector (Udugama et al. 2019).

In this context, waste, and by-products such as coffee can be the raw material to produce other products, for example in this case can be used to produce feed, beverages, vinegar, biogas, caffeine, pectin, protein, and fertilizer (Rathinavelu and Graziosi, 2005). Products that may be produced by other companies from an Industrial Symbiosis, which serves as a tool connected to sustainable invocation (Clift and Druckman, 2015). Particularly for this sector, a symbiosis would develop where agri-food chains are involved, that is, an "agri-food symbiosis" (Koppelmâki et al. 2019; University of Helsinki 2016; Burg et al. 2020). In this context, the reuse of these food resources, which are by-products, play a crucial and key role in seeking to reduce the number of resources used for food production worldwide (Udugama et al., 2019).

Evidently coffee is one of the main crops internationally (Canet et al., 2016) with which it is possible to prepare one of the most appreciated beverages by the commercial sector. In this sense, coffee has been positioned as one of the main products to generate sources of income in developing countries (Gole and Senbeta, 2008). Specifically, it is a product that can employ about 500 thousand coffee growers (Ministry of Agriculture and Rural Development, 2018), in Mexico by the end of 2019 there were 509,817 producers according to the Agrifood and Fisheries Information Service (SIAP) (Center for Studies for Sustainable Rural Development and Food Sovereignty, 2020). That generate profits that are above USD $ 15 billion annually (Canet et al., 2016). Particularly Mexico, according to the Secretariat of Agriculture and Rural Development (SAGARPA) produces 24% of coffee worldwide (Moscosa 2018), being Chiapas, Veracruz, Oaxaca, Puebla and Guerrero the States with the highest production in that order mentioned (Trusts Instituted in Relation to Agriculture, 2016).

However, in recent years this sector has continually faced collapses in grain prices, therefore, the international outlook is unfavorable, as many coffee growers have been forced to abandon their crops (Center for Studies for Sustainable Rural Development and Food Sovereignty, 2019). On the other hand, active coffee growers are directly affected and therefore face precarious lifestyles full of poverty (International Coffee Organization, 2019). This is a problem that concerns everyone, since this is one of the main causes of irresponsible consumption and production (Gunawan et al., 2019). Based on the above, through industrial symbiosis for responsible consumption, equitable prosperity can be obtained for all participants in the coffee sector.

The Industrial Symbiosis that has been studied by several authors, such as Chertow (2000); Araya and Luperfina (2019). Burg et al. (2020); Cervantes (2013); Clift and Druckman (2015); Frosch and Gallopoulos (2003). Jato and Ruiz (2021); Koppelmäki et al. (2019); Mansouri et al. (2017); Marchi et al. (2017); Macchiavelli (2008). Neves et al. (2019); Pinzón (2009); Ríos and Rodríguez (2021); Tudor et al. (2007); who establish elements about the implementation, experiences, and studies, which facilitate the understanding of this tool. While authors such as Bianchi et al. (2013); Duenas et al. (2014); Flowers (2019); Marchand and Walker (2007). Palafox et al. (2015); Ruiz and Almeida (2020); Salgado and Beltrán (2011); Webster (1975) focus the bases of responsible consumption.

In Mexico, the Industrial Symbiosis is carried out, as is the case of the "Corredor de Altamira" located in the State of Tamaulipas, where the main companies that work under this symbiosis are from the petrochemical sector (Carrillo, 2013), this project that was implemented in 1997 , being the first of its kind in the country (World Business Council for Sustainable Development, 2010) giving rise to different research groups such as the Grupo de Investigación en Ecología Industrial, GIEI-IPN; Grupo en la Universidad Tecnológica de León (UTL); Guanajuato Grupo en la Universidad de Guanajuato (UG); Grupo AGSEO-UAM-Xochimilco Grupo en la Universidad Autónoma de Querétaro (UAQ) among others (Cervantes y Turcott 2013). In this sense, carry out a review of the literature relating industrial symbiosis, responsible consumption is of great importance.

Systematic Literature Review (SLR), aims to collect and provide the best evidence on the policy and practice of any discipline (Tranfield, Denyer and Smart, 2003). There are models of literature review systems that are important to mention, the one developed by James Lind in (1753) which he named a randomized controlled trial (RCT) where the bases for the implementation of the SLR were obtained; in the medical sector (Dunn, 1997), and in publications where

the steps for the development of an SRL are mentioned, such as (Moreno et al. 2018). Garza-Reyes (2015), establishes the five phases for the development of the SLR, in a model that allows and facilitates the development of an adequate historical analysis in border studies.

Based on the above, this document presents a review of the literature, in two phases: phase 1: systematic review of the literature based on the Garza-Reyes (2015) model. Phase 2: Identification of the literature and relationships with other studies

1.1 Research Aim

The objective of this paper is to present the review of the literature, of industrial symbiosis for responsible consumption, adopting the systematic literature review (SLR) model of Garza-Reyes (2015) to identify their relationship and by-products in the coffee growing sector. To achieve this objective, the following steps are defined:

- Systematic review of the literature based on the Garza-Reyes (2015) model.
- Identification of the literature and relationships with other studies.

2. Literature Review

Industrial symbiosis is a tool that arises with the purpose of generating economic benefits for organizations. However, its positive impact on the environment and society was soon discovered, therefore since 2011, this tool is recognized by the International Community of Industrial Symbiosis as one that benefits in economic, social, and environmental aspects (Eco-industrial Development - Industrial Symbiosis Section, 2011). According to Chertow (2000), the key to symbiosis is collaboration, and the possibility of generating synergy offered by geographic proximity. In the current context, where the planet faces constant climate change, industrial symbiosis serves as a tool connected to sustainable innovation (Clift and Druckman 2015), which may involve chains of the agri-food sector, that is, developing as "agri-food symbiosis"(Koppelmâki et al. 2019; University of Helsinki; Burg et al. 2020) and energy systems that allow meeting the goals established by the Sustainable Development Goals of the 2030 Agenda (Food and Agricultural Organization of the United, 2014; United Nations, 2019; Burg et al., 2020).

One of the most outstanding characteristics that has been discovered is that the industrial symbiosis supports these objectives without damaging the economic growth of the parties involved (Daddi et al. 2017; L Dong et al., 2014; Fan et al. 2017; Martín and Harris 2018; Neves et al. 2019a) together with the possibility of lengthening the life cycle of critical natural resources, thus making production processes more efficient and eliminating pollution caused by waste (Chertow, 2007). Even through it, the foundations for the transition to a new circular economy can be centered (Fraccascia and Giannoccaro, 2020; Wadstrôm et al. 2021). Well, its focus is the exchange of resources between different sectors either through mutuality (services), substitution (water) or genesis (sub-products) (Marchi et al. 2017), the same classification proposed by Chertow (2007), under the name of joint provision of industrial, utility or infrastructure services and reuse of by-products respectively. Its purpose is to be able to close cycles, minimize losses, dematerialize the economy and balance activities (Erkman 2004; Macchiavelli 2008), in addition to generating mutual benefits for the network of companies that work under these synergies (Cutaia and Morabito 2012; Marchi et al. 2017).

Mainly, as is the case in Colombia, the companies that are most involved in this type of industrial symbiosis are the manufacturing companies and those that are mainly dedicated to the collection of materials and waste. Well, regularly these are the industries that are dedicated to making products through raw material that comes from waste (Ríos and Rodríguez, 2021). Also at present, the recovery of waste in the agricultural industry is gaining strength, under two main types of practices: the separation of valuable material from food waste and the treatment of waste that is used as a by-product for the creation of valuable compounds through of some type of treatment (Pfaltzgraff et al., 2013; Ravindran and Jaiswal 2016; Daufin et al. 2001; Udugama et al. 2019). These recovery practices have a strong positive impact worldwide, since the population increase has led to a greater consumption of animal proteins (Organization for Economic Cooperation and Development - Food and Agricultural Organization of the United, 2018) which means a higher production load for the entire agricultural sector. In this context, the reuse of these food resources plays a crucial and key role in seeking to reduce the number of resources used for food production worldwide (Udugama et al., 2019).

Based on this situation, companies currently play a very important role since they are capable of contributing to people having a better lifestyle and incorporating actions that are directed towards socially responsible consumption (CSR)

(Palmer and Flanegan, 2016; Gunawan et al. 2019). However, consumers must also have a change in their mind, for example, currently food production systems have been migrating towards more sustainable systems, which has been a great challenge, therefore, in social discourse, the consumer has the responsibility of directing their consumption choices towards products made under a sustainable scheme, fostering a phenomenon of cause and effect, since this situation will lead to an environmental change (Halkier 2009; Tuscano et al. 2021), since day by day It is more evident that the world cannot continue to function under a production scheme based on a consumerist economy where the idea is that natural resources are infinite (Cavanagh et al. 2002; Hutton and Jones, 2005; Marchand and Walker, 2007).

In this sense, a responsible consumer will be one who considers the consequences and effects of their decisions when choosing a certain product for private consumption, as this will have a direct impact, in terms of changes in food systems (Lockie 2009; Tuscano et al. 2021), the term "responsible consumption" goes beyond just the involvement of food systems, since from a literary review it comes from the so-called green consumers that had their peak during the sixties (Hendarwan 2002; Duenas et al. 2014). Which according to Elkington and Hailes (1989) are those that avoid "products that put the health of the consumer or another at risk; cause significant damage to the environment during manufacture, use or waste; consume a disproportionate amount of energy; cause unnecessary waste; use materials derived from endangered species or environments; as well as those that imply the unnecessary mistreatment of animals or that adversely affect other countries. Conceptually, the term "Responsible consumption" involves two aspects, the ethical and the moral, that appear in consumers once they analyze the type of product they will buy (Mintel Research 1994; Duenas et. Al. 2014), however, over time it has been observed that it goes beyond just these two aspects. Since then, the concept has been in continuous evolution, but the concept established in the 1970s by Webster (1975) and Brooker (1976) continues to prevail; (Roberts, 1996).

Obviously, sustainability creates new opportunities for designers to be able to develop new innovative concepts in terms of "material culture" (Cooper 2000; Marchand and Walker 2007), therefore, we must not forget that sustainable consumption involves all those processes necessary for the creation of products and the way in which the need was created for the consumer to acquire that product (Carley and Spapens, 1998; Marchand and Walker, 2007), thus directly involving Industrial Symbiosis as a sustainable innovation (Clift and Druckman, 2015; Wadstrôm et al. 2021), although its implementation is hampered by the lack of regulations and policies that strengthen the creation of these relationships (Neves et al. 2019b). In this sense, the funds to be able to break down those latent economic barriers are insufficient (Mauthoor, 2017), finally, the lack of information and mistrust makes their application difficult; However, alternatives should be kept in mind for their implementation such as: the introduction of facilitators workshops (Bacudio et al. 2016) and tools that facilitate decision-making (Álvarez et al., 2017) to break down these barriers (Jato and Ruíz, 2021).

3. Mehtodology

This research is a documentary type, and the deductive method was carried out based on the SRL model proposed by Garza-Reyes (2015), which has been adapted and modified according to the needs of this research. However, the phases were not altered, which are: (1) Formulation of the research questions; (2) Studies location; (3) Studies selection and evaluation; (4) Analysis and synthesis; and (5) Reporting and use of results.

After carrying out the SLR, the identification and relationship between the concepts was carried out: industrial symbiosis for responsible consumption in the coffee growing sector. That is, the research was carried out under the following two phases:

1. Systematic Literature Review using the Garza-Reyes (2015) model as a basis.
2. Identification of the literature and relationships between industrial symbiosis and responsible consumption for the coffee sector.

3.1 Systematic Literature Review (SLR)

The RSL was carried out according to the steps stipulated in *figure 1*: the (1) formulation of questions was carried out, What are the characteristics that responsible consumers demand when choosing a product ?; subsequently; (2) studies were found in different scientific databases and on the web, referring to responsible consumption and industrial symbiosis; (3) in the selection of studies and evaluations, only those where there were populations interviewed or surveyed about the characteristics sought by responsible consumers when buying a product were taken into account;

(4) in the analysis and synthesis, the main characteristics that responsible consumers demand were extracted; (5) to finally dimension these characteristics with the relationship of the industrial symbiosis for the coffee sector.

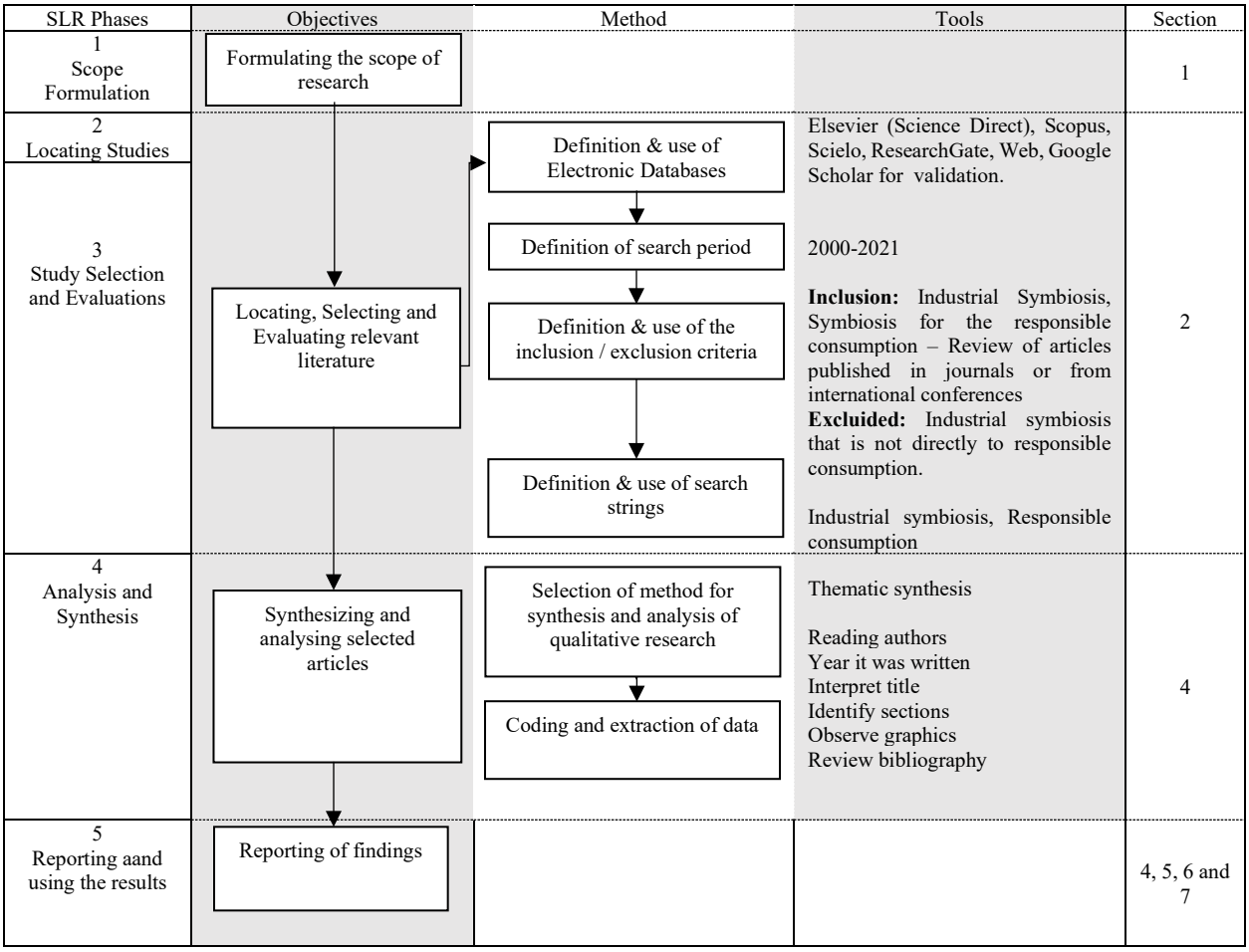

Figure 1. LSR methodology adapted based on Garza-Reyes, (2015)

All the information obtained was carried out by searching for articles online, using high-impact databases, including in the searches the keywords "Industrial Symbiosis", "Agri-food Symbiosis" and "Responsible Consumption". In Scopus, Elsevier Science Direct, Scielo, Research Gate, Google Scholar, and high-impact publications found on the web. In this way, the border publications were analyzed, to later extract the most relevant data that allow identifying the main characteristics to use the industrial symbiosis for responsible consumption in the coffee growing sector.

3.2 Identification and relationships

An analysis of the results obtained in the selected investigations that are shown in *table 1* was carried out, with this it was possible to extract the main characteristics that a responsible consumer demands once they go to buy a product. Then these characteristics were related to the main advantages and characteristics provided by the application of industrial symbiosis, see *figure 2.* Finally, it is related to the coffee growing sector for its implementation, due to the potential that coffee residues can provide to be used as by-products and as alternative to attract responsible consumers and generate additional income to the sector.

4. Data Collection

Ten publications from *Table 1* were analyzed, where the main characteristics that a responsible consumer studies before buying a product are exposed. The publications that were selected are those where the research instruments are

surveys and interviews whose main objective was to investigate the characteristics that responsible consumers analyze when buying a product.

Table 1 Literature Reviewed on Responsible Consumption

No	Author	Title	Paper type	Featurs
1	Araya, S. y Rojas L. (2019)	Responsible consumption and purchase intention of staple food in popular sectors: a multivariate approach.	Journal	Socio-environmental responsibility; Transparency; Business ethics; Equity and Justice; How was the product produced?; Certificate.
2	Bianchi, E., Ferreyra, S., y Kosiak, G. (2013)	Responsible consumption: Diagnostic and comparative analysis of Argentina and Uruguay.	Journal	Who made the product?; Business ethics; Care of living beings; Ecological identity; Protection of the environment; Origin of the product; Ecological pack.
3	Palafox, C., Elizalde, D., y Espejel, J. (2015)	Socially responsible consumer behavior in Sonora.	Publication in congress	Intrinsic Satisfaction; Health; Local consumption; Who and how was the product made?; Origin of the product.
4	Flores, A. (2019)	Responsible consumption and status.	Journal	Intrinsic Satisfaction; Equity and Justice; Protection of the environment.
5	Kunchamboo, V., Lee C., and Brace, J. (2017)	Nature as extended-self: Sacred nature relationship and implications for responsible consumption behavor.	Journal	Intrinsic satisfaction; Equity and Justice; Care of living beings; Ecological identity; Protection of the environment.
6	Marchand, A. and Walker, S. (2007)	Product Development and responsible consumption: designing alternatives for sustainable lifestyles.	Journal	Equity and justice; Better world; Protection of the environment.
7	Severino, P., Acuña, O., Astete, K. y Medel, J (2020)	Social responsibility and sustainable consumption: the case of higher education students from Talca (Chile).	Journal	Equity and justice; Who and how do I make the product ?; Business ethics; Local consumption; Care of living beings; Origin of the product.
8	Ruíz, D. and Almeida, R. (2020)	Analysis of the Behavior Of The Socially Responsible Consumer.	Journal	Intrinsic satisfaction; Protection of the environment.
9	Salgado, L. y Beltrán LF. (2011)	Factors that influence Sustainable consumption of organic products in the Northwest Mexico.	Journal	Intrinsic satisfaction; Health; Ecological identity; Protection of the environment.
10	Estrada, J., Cantú J., Torres F., y Barajas, E. (2020)	Factors that influence the consumer to purchase sustainable products	Journal	How the product was produced; environmental protection.

According to the European Institute of Sustainability, Employability and Innovation ISEieurope (2012), some of the acts that can be carried out to be considered a responsible consumer are: reusing water, consuming ecological products, mainly those that need less industrial processing and that are produced through fair trade like coffee. There is even Guatemala as an example where, through the certification of Utz Kapeh "good coffee" coffee, it is possible to identify where the coffee was produced, its marketing route and the conditions under which it was produced (Pérez, 2009). Characteristics that can be covered through industrial symbiosis, because through the exchange of products the amount of emissions of pollutants to the environment will be reduced, due to two reasons, first because the material will be reused, thus avoiding its disposal, and in second, because it will no longer be necessary to use transportation to take the waste to a specialized place (O'Carroll et al. 2017), in terms of the economic part, the costs that are normally used for the elimination of waste will be reduced (Burström and Korhonen, 2001; Ríos and Rodríguez, 2021). It will even be possible to increase the income of companies, thanks to the introduction of new products (Fraccascia et al., 2019; Ríos and Rodríguez, 2021)

Finally, with regard to the social part, jobs can mainly be created (Neves and Magrini, 2018), promoting the transfer of knowledge (Laybourn and Morrisey, 2009). That is, through Industrial Symbiosis it is possible to satisfy the demands of responsible consumers and help the coffee growing sector to obtain additional income and reduce costs, it is estimated that approximately only 5% of the coffee biomass is what It is used for the production of coffee, while 44% of the coffee made up of the pulp and 15% of the mucilage are wasted, when at present it has been shown that these can be used for the production of biethanol or biogas (Rodríguez and Zambrano, 2010) caffeine, pectin, protein and fertilizer (Rathinavelu and Graziosi, 2005) among others, as research continues to expand the range of manufactured products.

5. Results

Next, the revised literature listed in *table 1* is presented, which is categorized in *figure 2*, whose objective is to illustrate the relationship between industrial symbiosis and responsible consumption, taking as a basis the characteristics analyzed by a responsible consumer exposed in the research carried out, in addition to relating these two variables with the coffee sector.

In this sense, the industrial symbiosis acts under a set of characteristics, the main objective of which is to positively impact the social, environmental and economic axes, thus helping any economic entity that works under the bases of this tool, in this case with a focus on the coffee sector. Thus, the industrial symbiosis is found in the upper part of *figure 2*, emphasizing these activities and their relationship with the three axes already mentioned, the same axes that in turn have a direct impact on responsible consumption and the main characteristics that responsible consumers demand that they have the products they are going to buy. Which can be seen through the interconnections that are formed in the figure. Later, in the lower part, some numbers are shown that refer to the number of paper in *Table 1* from where these data were obtained thanks to the SLRs.

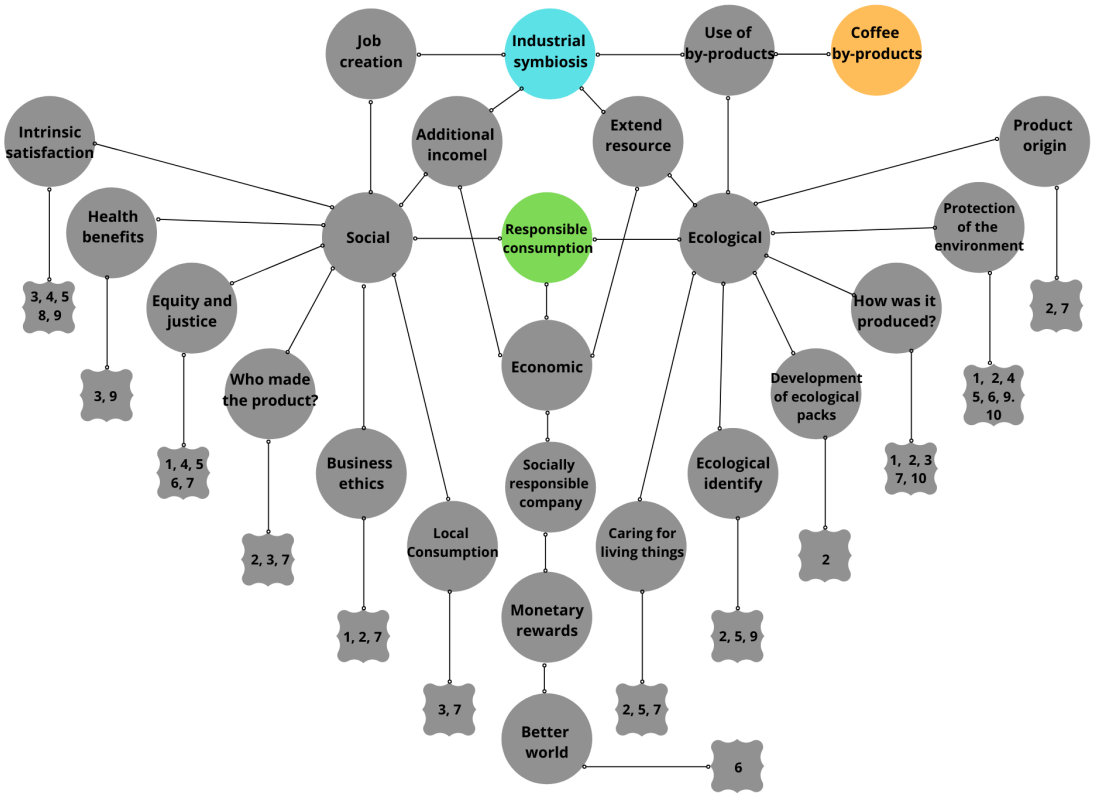

Figure 2. Explored characteristics of responsible consumption and its relationship with industrial symbiosis for the coffee sectors

6. Discussion

The implementation of industrial symbiosis involves a set of characteristics necessary for it to be functional, mainly this tool must be dynamic, use state-of-the-art technology and adapt to price fluctuations. In other words, once this tool is implemented, its limitations and barriers must be considered to overcome them (Macchiavelli, 2008). These barriers can be classified as internal and external, the former refer to those inherent to the company, for example, the lack of information or resources available within the company, and the persistent trend towards irresponsible consumption (Instituto Tecnológico Metalmecánico , Mueble, Madera, Emabaja y Afines, 2017) and the second mainly refers to those legal and administrative barriers that require a specific treatment of waste (Instituto Tecnológico Metalmecánico, Mueble, Madera, Emabaja y Afines, 2020). There may even be mistrust between companies that makes its implementation difficult (Ríos and Rodríguez, 2021).

Based on the above, this research opens a thread for future research where industrial symbiosis can lay the foundations for a transition towards a sustainable society and seek the best strategies for a correct implementation of this tool, for example, workshops (Bacudio et al., 2016) facilitators (Park et al., 2018) and decision-making tools (Álvarez and Ruiz, Puente, 2017). Well, the advantages that this brings is evident, such as the bases for the transition towards responsible consumption and the generation of more jobs and income for the coffee growing sector.

7. Conclusion

Industrial symbiosis is a powerful tool that well implemented, lays the foundations for a sustainable world, among its main qualities, is the generation of jobs, additional income, lengthening the life cycle of products and using waste as by-products. In this sense, the industrial symbiosis fits those of responsible consumption, as this will meet the requirements that responsible consumers ask for when buying a product, it can also be applied in sectors such as coffee, which has many benefits, due to the amount of waste produced during its production, and the properties that these wastes have to be used as by-products of other processes, thus helping society, the environment, and the economy of the sector.

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