SUSTAINABLE VALUE AGGREGATION: A FRAMEWORK FOR ENVIRONMENTAL SOLUTIONS AND BUSINESS OPPORTUNITIES

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ABSTRACT

Objective: The objective of this study is to investigate the intellectual framework that enables the aggregation of sustainable value.

Theoretical Framework: The generation of value and businesses are at the core of the economic exchange process and have a direct impact on sustainability. In this regard, sustainable businesses have as their main characteristic the ability to maximize the efficiency of material and energy use. However, the factors necessary for the implementation of sustainable businesses are a phenomenon that has not yet received attention from researchers.

Method: The methodology adopted for this research comprises bibliometric techniques and content analysis. Data collection was carried out in Scopus database, covering a time horizon from 1995 to 2022.

Results and Discussion: The results demonstrate that the conducive environment for sustainable businesses can be identified and explained by four main factors: (1) sustainability issues exist in a particular context; (2) people are becoming aware of these issues; (3) viable solutions or technologies exist to address the problem; and (4) where possible, people change their habits in pursuit of sustainability.

Research Implications: by understanding the process of sustainable value aggregation, policymakers can create policies aimed at incentivizing these solutions, investing in research and development, creating financing mechanisms for companies, fostering businesses, etc. Legislators can adapt legislation to the new reality, favouring the development of sustainable businesses; in this regard, the awareness of the population regarding the need for sustainability is crucial. On the other hand, entrepreneurs can identify opportunities and develop interesting businesses from economic, social, and environmental perspectives.

Originality/Value: the present study initiates a discussion on the conditions that favour the emergence of so-called sustainable businesses.

Keywords: Sustainable Technologies, Business Models, Wicked Problems, Eco-Innovation, Innovation.

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RESUMO

Objetivo: O objetivo deste estudo é investigar o framework intelectual que possibilita a agregação de valor sustentável.

Referencial Teórico: A geração de valor e negócios está no centro do processo de troca econômica e tem um impacto direto na sustentabilidade. Nesse sentido, os negócios sustentáveis têm como principal característica a capacidade de maximizar a eficiência no uso de materiais e energia. No entanto, os fatores necessários para a implementação de negócios sustentáveis são um fenômeno que ainda não recebeu atenção dos pesquisadores.

Método: A metodologia adotada para esta pesquisa compreende técnicas bibliométricas e análise de conteúdo. A coleta de dados foi realizada na base de dados Scopus, abrangendo um horizonte temporal de 1995 a 2022.

Resultados e Discussão: Os resultados demonstram que o ambiente propício para negócios sustentáveis pode ser identificado e explicado por quatro fatores principais: (1) questões de sustentabilidade existem em um contexto específico; (2) as pessoas estão se conscientizando dessas questões; (3) existem soluções ou tecnologias viáveis para resolver o problema; e (4) quando possível, as pessoas mudam seus hábitos em busca da sustentabilidade.

Implicações da Pesquisa: ao compreender o processo de agregação de valor sustentável, os formuladores de políticas podem criar políticas voltadas para incentivar essas soluções, investir em pesquisa e desenvolvimento, criar mecanismos de financiamento para empresas, fomentar negócios, etc. Os legisladores podem adaptar a legislação à nova realidade, favorecendo o desenvolvimento de negócios sustentáveis; nesse sentido, a conscientização da população sobre a necessidade de sustentabilidade é crucial. Por outro lado, os empreendedores podem identificar oportunidades e desenvolver negócios interessantes sob as perspectivas econômica, social e ambiental.

Originalidade/Valor: O presente estudo inicia uma discussão sobre as condições que favorecem o surgimento dos chamados negócios sustentáveis.

Palavras-chave: Tecnologias Sustentáveis, Modelos de Negócios, Problemas Complexos, Eco-Inovação, Inovação.

RESUMEN

Objetivo: El objetivo de este estudio es investigar el marco intelectual que posibilita la agregación de valor sostenible.

Marco Teórico: La generación de valor y negocios está en el centro del proceso de intercambio económico y tiene un impacto directo en la sostenibilidad. En este sentido, los negocios sostenibles tienen como característica principal la capacidad de maximizar la eficiencia en el uso de materiales y energía. Sin embargo, los factores necesarios para la implementación de negocios sostenibles son un fenómeno que aún no ha recibido atención por parte de los investigadores.

Método: La metodología adoptada para esta investigación comprende técnicas bibliométricas y análisis de contenido. La recopilación de datos se realizó en la base de datos Scopus, abarcando un horizonte temporal de 1995 a 2022.

Resultados y Discusión: Los resultados muestran que el entorno propicio para los negocios sostenibles puede ser identificado y explicado por cuatro factores principales: (1) las cuestiones de sostenibilidad existen en un contexto específico; (2) las personas están tomando conciencia de estas cuestiones; (3) existen soluciones o tecnologías viables para resolver el problema; y (4) cuando es posible, las personas cambian sus hábitos en búsqueda de la sostenibilidad.
1 INTRODUCTION

Some problems faced in the twenty-first century cannot be solved by modern scientific paradigms, nor can the classic economic system with the principle of minimal means allocate resources in a way to avoid the so-called "wicked" problems. Problems such as adjusting tax rates, combating crime, defining school curriculum contents, making society more sustainable, addressing climate change, and preventing ecosystem collapse are examples of wicked problems (Horst Webber 1973; McKibben 2010; Waddock 2011). Wicked problems are characterized by uncertainty, inconsistency of needs, diffuse preferences and values, little understanding of the consequences of actions, etc. (Carley and Christie 2000).

At the core of the economic exchange process, the generation of value, businesses, and sustainability are embedded in this context of wicked problems (Vargo et al. 2008). Motivated by sustainable consumption and production, new concepts such as eco-innovation, eco-efficiency, and social and corporate responsibility have become part of the industrial sustainability agenda. The industry that once relied on the extraction of non-renewable natural resources, businesses that were once strictly based on resource exploitation, need to transform. Redefining the purpose of businesses is necessary, considering beyond profit, the people and the planet (Elkington 1998). A sustainable business model is aimed at improving human life, generating value for the customer and the company, respecting a wide range of interests, and considering the environment and society as stakeholders (Garetti and Taisch 2012; Stubbs and Cocklin 2008).

More recently, this discussion has motivated the search for sustainable businesses.
Bocken et al. (2014) developed some archetypes describing groupings of mechanisms and solutions that can contribute to business sustainability. Sustainable businesses have as their main characteristic the ability to maximize the efficiency of material and energy use, reuse waste, use renewable resources and natural processes, and deliver functionality instead of ownership (Bocken et al. 2014; Stubbs and Cocklin 2008).

However, companies still lack an assessment system for the potential creation of economic, environmental, and social value of sustainable businesses. Additionally, this assessment involves multiple stakeholders with different interests, objectives, and skills. Different circular business models vary in complexity and value generation proposition (Evans and Gawer 2016; Geissdoerfer et al. 2018). Furthermore, developing countries still face other challenges, such as lack of funding, requiring the implementation of support programmes for the development of sustainable businesses, products, and services (Vasilescu et al. 2023). Moreover, the development of sustainable products and processes is crucial for the success of small and medium-sized enterprises adopting circular business models (Almeida and Wasim 2023).

Therefore, the development of sustainable products and processes requires, in addition to investment, a favourable business environment, composed of factors external to companies. According to Lewandowski (2016), the external factors to companies that enable the development of sustainable businesses still need to be explored. In this regard, it is necessary to understand the context and the factors that enable the aggregation of sustainable value. To address this gap, this article presents an underlying intellectual structure that is inherent to the process of sustainable value aggregation.

Sustainability requires a cultural change, which is inevitably holistic and local. Cultural changes go beyond individual ideas to encompass large groups, nationally or globally, involving policies, institutions, and laws. In this sense, understanding the factors that enable sustainable value aggregation can facilitate the development of strategies for sustainable business development. Therefore, delineating the intellectual structure inherent to the process of sustainable value aggregation is an important step towards the diffuse problem of business sustainability.

2 METHODOLOGY

Decision-makers constantly deal with wicked problems; entrepreneurs, politicians, legislators, administrators, are responsible for improving or worsening some characteristics of
the world in which people live (Horst and Webber 1973). To demonstrate the context in which sustainable business opportunities emerge, we need to unravel and describe a phenomenon of reality (Marconi and Lakatos 2010). Thus, we seek to construct a mental model that explains the context in which sustainable businesses thrive (Domingues and Fonseca 2021; Thiry-Cherques 2007).

We used data from secondary sources and some scientific mapping tools to offer a comprehensive view of the phenomenon under study. In this regard, bibliometrics is a technique that can facilitate understanding the state of the art of a phenomenon addressed by the scientific community (Holton 2000). Bibliometric techniques introduce objective measures for evaluating publications that contrast with the potential bias embedded in subjective evaluation (Appio et al. 2014). Conceptual structure analysis and bibliometrics are applied by studies in various areas of knowledge with similar applications to this study (Belussi et al. 2019; Guleria and Kaur 2021; Mühl and Oliveira 2022a).

2.1 DATA COLLECTION

The Scopus database was chosen as it is the largest peer-reviewed journal database, and it is recommended by experts due to its extensive coverage (Zupic and Čater 2015). The search was conducted on January 3, 2023, and used the following search string: (Title (sustainab* AND "Add* value" OR "value add*" OR "value chain" OR "value creation") OR Keyword (sustainab* AND "Add* value" OR "value add*" OR "value chain" OR "value creation")). The search returned 3,488 documents, covering a time horizon from 1995 to 2022; 24 duplicate documents were excluded, leaving 3,464 documents.

2.2 DATA ANALYSIS

The Bibliometrix package, based on the R language, was used to perform the analyses. The tool has mechanisms for normalizing and standardizing data (Aria and Cuccurullo 2017). Bibliometrix integrates various bibliometric techniques, has open-source code, graphical and statistical features with flexibility, and frequent updates (Aria and Cuccurullo 2017). Specifically, the co-word technique was applied. This technique uses words to create a conceptual structure. The unit of analysis is concepts present in titles, keywords, abstracts, or full texts (Zupic and Čater 2015).

Word counts and bibliometric indicators were used as a starting point to retrieve, read
the documents, and develop the discussion of the results. Quantitative indicators are the starting point for creating the contextualization of the studied object. Therefore, different techniques are applied, generating results that corroborate with each other to represent the phenomenon under study, as presented below.

3 RESULTS

3.1 BIBLIOMETRICS

The search in the Scopus database resulted in a total of 3,366 documents, comprising 1,962 articles, 713 conference papers, 423 reviews, and 268 book chapters. Table 1 presents some general information regarding the research data.

<table>
<thead>
<tr>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>1995 : 2022</td>
</tr>
<tr>
<td>Sources (journals, books, etc.)</td>
<td>1535</td>
</tr>
<tr>
<td>Documents</td>
<td>3366</td>
</tr>
<tr>
<td>Annual growth rate %</td>
<td>12.78</td>
</tr>
<tr>
<td>Average citation per document</td>
<td>21.31</td>
</tr>
<tr>
<td>Plus keywords</td>
<td>15,341</td>
</tr>
<tr>
<td>Authors’ keywords</td>
<td>9021</td>
</tr>
<tr>
<td>Authors</td>
<td>9939</td>
</tr>
<tr>
<td>Authors with only one document</td>
<td>473</td>
</tr>
<tr>
<td>Documents with only one author</td>
<td>512</td>
</tr>
</tbody>
</table>

As mentioned in Table 1, a 27-year interval was considered (1995–2022). During this period, 1,535 journals and books addressed the subject. The main journals that published the articles are: Journal of Cleaner Production (42); Sustainability from Switzerland (27); Bioresource Technology (24); Sustainable and Renewable Energy Review (19); Resources, Conservation, and Recycling (19).

Similarly, some of the main research centres are Wageningen University, the Technical University of Denmark, the University of Cambridge, the University of Malaysia, among others. Furthermore, the countries with the highest number of citations are the United Kingdom, Germany, India, the United States, China, the Netherlands, Italy, Spain, Australia, among others.
Finally, we note that some authors are specialists and produce many studies on a particular subject; however, some studies have a greater impact, and others a lesser one. The h-index was a solution developed to characterize the scientific production of a particular author (Costas and Bordons 2007). By measuring the h-index of authors, Bocken N. (h12), Wang Y (h11), Jawahir I (h9), Liu J (h9), Badurdeen F (h8), and Chen X (h8), among others, appear at the top.

3.2 THEMATIC ANALYSIS

The analyses below were also derived from the data described in Table 1. However, they result from more sophisticated analytical techniques, offering an interpretation of the themes addressed by researchers. Thus, to begin an immersion in the discussed themes, it is important to verify which works are most influential. A work that receives many citations becomes a reference for the field of study, as many authors rely on this study to develop their own ideas. Table 2 presents the 10 works with the highest number of citations.

Table 2

<table>
<thead>
<tr>
<th>Most cited works</th>
<th>Authors</th>
<th>Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of first- and second-generation biofuels: a comprehensive review</td>
<td>Naik et al. 2010</td>
<td>2122</td>
</tr>
<tr>
<td>A literature and practice review to develop sustainable business model archetypes</td>
<td>Bocken et al. 2014</td>
<td>1680</td>
</tr>
<tr>
<td>Recycling and recovery routes of plastic solid waste (PSW): a review</td>
<td>Al-Salem et al. 2009</td>
<td>1361</td>
</tr>
<tr>
<td>Status and perspectives of CO2 conversion into fuels and chemicals by catalytic, photocatalytic and electrocatalytic processes</td>
<td>Kondratenko et al. 2013</td>
<td>1251</td>
</tr>
<tr>
<td>Sustainable conversion of carbon dioxide: an integrated review of catalysis and life cycle assessment</td>
<td>Artz et al. 2018</td>
<td>1115</td>
</tr>
<tr>
<td>Opportunities of sustainable manufacturing in Industry 4.0</td>
<td>Stock and Seliger 2016</td>
<td>1024</td>
</tr>
<tr>
<td>Additive manufacturing and sustainability: an exploratory study of the advantages and challenges</td>
<td>Ford and Despeisse 2016</td>
<td>833</td>
</tr>
<tr>
<td>Biomass into chemicals: conversion of sugars to furan derivatives by catalytic processes</td>
<td>Tong et al. 2010</td>
<td>685</td>
</tr>
<tr>
<td>Sustainable management of coffee industry by-products and value addition: a review</td>
<td>Murthy and Madhava 2012</td>
<td>554</td>
</tr>
<tr>
<td>Thermolysis of waste plastics to liquid fuel: a suitable method for plastic waste management and manufacture of value added products: a world prospective</td>
<td>Panda et al. 2010</td>
<td>545</td>
</tr>
</tbody>
</table>

The most cited article reviews processes for converting biomass into useful liquid biofuels and other bioproducts. In this context, first-generation biofuels compete with food production for arable land use and have the potential to stress food chains, driving up food costs.
Conversely, second-generation fuels, based on biomass transformation, emerge as an alternative. Second-generation biorefineries can employ bioprocesses, pyrolysis, and catalytic processes to generate molecules and materials beneficial to society (Naik et al. 2010).

The second study in Table 2 presents a series of archetypes for generating more sustainable business models. Sustainable businesses are primarily characterized by their ability to maximize material and energy efficiency, reuse waste, utilize renewable resources and natural processes, and deliver functionality instead of ownership (Bocken et al. 2014).

As an alternative to waste reuse, the third most cited article reviews literature on recycling and recovery of solid plastic waste. Four waste treatment routes are presented: primary (re-extrusion); secondary (mechanical); tertiary (chemical); and quaternary (energy recovery). While primary and secondary recycling schemes are established and widely applied, tertiary and quaternary schemes require further research when the review was conducted (Al-Salem et al. 2009).

Panda et al. (2010) also propose alternatives to replace non-biodegradable plastics in various applications. Available alternatives include source reduction, reuse, recycling, and recovering inherent energy value through waste incineration into energy and processed fuel applications. Liquid fuel production would be one of the best alternatives, as the calorific value of plastics is comparable to that of fuels – around 40 MJ/kg.

Similarly, seeking solutions for waste, the study by Kondratenko et al. (2013) focuses on using carbon dioxide for sustainable energy and chemical production. Processes such as heterogeneous catalytic hydrogenation, photocatalytic and electrocatalytic conversion of CO2 into hydrocarbons and oxygenates, were discussed by the authors. Additionally, Artz et al. (2018) conducted a combined analysis of state-of-the-art methodologies and synthetic processes for sustainable CO2 conversion. The authors aim to identify opportunities and suggest using CO2 as a raw material that can avoid the use of fossil resources. CO2 can be converted to meet various needs, such as fuel generation, chemicals, or even specialty products.

Stock and Seliger (2016) aim to maximize material and energy efficiency through digitalization. The authors present the state of the art of Industry 4.0 based on recent developments in research and practice, as well as different opportunities for sustainable manufacturing in Industry 4.0. The Industry 4.0 paradigm is essentially delineated by: horizontal integration across the value creation network; end-to-end engineering throughout the product lifecycle; vertical integration; and networked manufacturing systems. A vast amount of information generated by sensors and digital integration enables the maximization of process efficiency, enhancing sustainability.
Similarly, Ford and Despeisse (2016) summarize the benefits and challenges, and analyse the sustainability implications of additive manufacturing (AM) in terms of innovation sources, business models, and value chain configuration. They consider how AM can enable more sustainable production and consumption models. Investigating AM adoption through a life cycle perspective, four main categories identify where AM achieves sustainable benefits: product and process redesign; input and material processing; custom component and product manufacturing; and closing the production cycle.

Increasing efficiency in the use of non-renewable resources is important, but the quest for alternative sources of energy and materials is essential. In the pursuit of using renewable resources and natural processes, biomass processing is an interesting alternative for energy and chemical production. Tong et al. (2010) primarily review catalytic pathways for the synthesis of 5-HMF, 2,5-FDCA, 2,5-DMF, and other furan derivatives from sugars. They discuss the possible reaction mechanism for hexose conversion and also suggest some promising research directions and catalysts capable of enabling the production of high-value chemicals.

Murthy, and Madhava (2012) also explore possibilities for value addition, but in this case, the authors focus on coffee production waste management. The authors review value-added explorations of coffee by-products achievable with the application of bioengineering principles in food processing and waste management. Waste processing-based solutions for generating high-value by-products can conserve the environment, address disposal issues, accelerate the use of ecological resources, and create opportunities for a new cycle of economic development.

Thus, the most cited or influential articles deal with topics such as biomass conversion, increased material and resource efficiency, plastic recovery or reuse, carbon dioxide utilization, Industry 4.0, additive manufacturing, and waste management bioengineering. These themes can be considered major areas with opportunities for sustainable business development. For example, biomass conversion, plastic recovery, and carbon dioxide use can only be adopted on a large scale with the refinement of technological solutions and the development of industries with high production capacity in strategic locations to meet waste management and material transformation needs. Additionally, with increased awareness related to climate issues, the institutional environment, legislation, and people's habits are likely to create a favourable business environment focused on sustainability solutions.

Another interesting resource for exploring the themes of a field of study, which can be useful in this instance, is keyword analyses. By analysing keywords in a particular field, critical relationships between concepts can be explored. Plus keywords are more interesting for
bibliometric effects and are generated by a database algorithm, with words extracted from article titles cited in a document. Figure 1 presents a keyword co-occurrence network, with terms grouped in a network according to the similarity of occurrences (Aria and Cuccurullo 2017; Guleria and Kaur 2021).

**Figure 1**
*Keyword co-occurrence network.*

![Keyword co-occurrence network](https://example.com/network.png)

The term sustainable development had the highest number of occurrences, with 1398 instances, followed by sustainability (472 occurrences), value-added products (369 occurrences), biomass (327 occurrences), value chains (280 occurrences), waste management (189 occurrences), environmental impact (183 occurrences), value creation (177 occurrences), among the top positions. It is important to note how the term sustainable development, which was not used in the search key, stood out by establishing a strong connection with value-added products, as represented by the line connecting the terms. On the other hand, the term sustainability, used in the search key, appears as the second most important term.

According to the similarity of terms, the algorithm formed two large clusters, with the strongest relationship established between sustainable development and value-added products. The group related to sustainable development consists of more generic, theoretical terms of broader scope, such as sustainability, circular economy, innovation, supply chains, and others. On the other hand, the second cluster related to value-added products presents more technical aspects, technologies for waste management and transformation, such as bioconversion,
fermentation, catalysis, biorefineries, and others. This second group presents some interesting technologies, concepts, and areas where sustainable businesses can be developed.

Still exploring the keywords, another approach is possible – that is, considering the terms that were most present in publications each year. In a scientific field, subjects gain and lose importance at different times, according to society's needs and researchers' focus. Figure 2 represents the evolution of terms over the years.

**Figure 2**

*Key topics, annually.*

![Figure 2: Key topics, annually.](image)

Figure 2 depicts the evolution and changes in terms over the years. The term paper industry starts to be discussed in 2003 and gains emphasis in 2004. Then, terms like environmental engineering, value chain, etc., emerge. The term pulp industry stands out as the most temporally broad term, which was a prominent subject for 16 years. In the middle of the analysed period, terms such as knowledge-based systems, industry, cost–benefit analysis, technology transfer, and information management stand out. In recent years, terms like valorization, value-added, biofuels, carbon, greenhouse gases, biomass, waste management, value chain, and life cycle, among others, have emerged.

The terms valorization and value-added can be considered synonymous. Similarly, the terms carbon and greenhouse gases are related, given that carbon is a greenhouse gas. Likewise, value chains, biofuels, and life cycle primarily concern carbon and energy issues. We delve into this observation in the discussion.
4 DISCUSSION

Additionally, Chu and Majumdar (2012) argue that clean, accessible, and reliable energy is a necessity for prosperity and economic growth. Some examples of developing alternatives are solar and water-based energy generation and microbial engineering for biofuel production, among others. These new alternatives represent opportunities for sustainable businesses.

Secondly, Mata et al. (2010) state that when it comes to renewable energy, first-generation biofuels, derived from food crops, specifically oilseeds, have limited capacity to mitigate climate change. However, second-generation biofuels from non-food raw materials, such as microalgae, offer greater long-term opportunities. In the meantime, microalgae use sunlight to produce oils, but do so more efficiently than cultivated plants. Moreover, cultivating microalgae has another advantage as it does not directly compete with food production for land use. The oil productivity of many microalgae far exceeds that of the best oilseed crops (Chisti 2007). The current state of microalgae use for biodiesel production, including cultivation, harvesting, and processing, is reviewed in Mata et al. (2010). Further potential applications and products of microalgae, such as biological CO2 sequestration, wastewater treatment, animal and human food additives, pharmaceutical production, and other applications, are also presented. In summary, a value chain can be structured around microalgae as an alternative to fossil fuel use. Ultimately, this represents various opportunities for new sustainable businesses.

In Tilman et al. (2011), discussions focus on terms such as global food demand and environmental impact, agricultural intensification, and greenhouse gases. Similarly, Searchinger et al. (2008) address the issue of greenhouse gases and changes in land use. Additionally, Cox et al. (2000) write about the carbon cycle, where the relationship between "carbon", environmental impact, gas emissions, businesses, and climate change becomes clear.

In this context, there is still a diversity of articles related to waste management, biomass, and biorefineries (Mohan et al. 2016; Ubando et al. 2020). This demonstrates the potential that waste holds as an alternative to replacing traditional, mineral, or fossil-based materials and energy. Therefore, waste management itself can promote the circular economy. From this perspective, opportunities for sustainable businesses are related to biorefineries and waste management technologies. For example, in Brazil, anaerobic digestion plants for agribusiness waste management, biogas, and biofertilizer production have shown significant growth in recent years (Mühl 2022; Mühl and Oliveira 2022b).
However, according to Cao et al. (2020), one of the cleanest forms of energy production is hydrogen production from biomass. Although biomass gasification, including steam gasification and supercritical water gasification, shows high potential in field-scale applications, the selectivity and efficiency of hydrogen production need to be improved to ensure profitable industrial applications. Therefore, research and investment in the development of this type of solution are necessary to truly foster opportunities for sustainable businesses.

Thus, we observe a series of concepts, problems, technologies, or solutions related to sustainable development as shown by bibliometric results and the discussion developed by various authors. The same applies to the most influential studies and the most popular keywords in the research field; it is always possible to identify sustainability problems and related technologies. This dynamic provides some insights into the emerging trends and models of sustainable value aggregation businesses.

Therefore, we sought to classify and organize the main keywords from Figures 1 and 2 into categories. The most abstract concepts were classified as sustainability paradigms; these concepts represent a shift in understanding the relationship that humans must establish with nature and the fundamental resources for their own survival. However, this new understanding is the result of identifying environmental problems such as waste and climate change. However, a series of practical and technological innovations arise in response to environmental issues. Finally, the adoption of these new practices and technologies allows for a change in the human relationship with the environment. Humans understand that natural resources are finite, and from this, they establish a new understanding of reality that will guide their future actions. See Figure 3.
Therefore, the intellectual framework of sustainable value aggregation can be understood through four fundamental elements: i) there are sustainability issues; ii) people are undergoing a shift in thinking, meaning they are concerned about environmental issues; iii) there are solutions, techniques, technologies, and viable possibilities to address sustainability issues; iv) people are willing to change their habits in pursuit of sustainability.

With this new understanding of reality, environmental problems caused by human action begin to be identified (Brundtland et al. 1987). In response to these environmental problems, researchers and society begin to seek solutions that provide sustainability for human activities (Elkington 1998; ONU 2023). Ultimately, awareness of sustainability and the implementation of sustainable solutions are reflected in a change in how people and society use natural resources (Bugge et al. 2016; Carus and Dammer 2018; Ellen Macarthur Foundation 2017). Finally, sustainable business models emerge (Geissdoerfer et al. 2018; Lewandowski 2016). Figure 3 summarizes the development of this intellectual framework.

The concept of value aggregation from the United States Department of Agriculture (USDA) and value creation from Sadovska et al. (2020) would align with the same holistic logic consolidated in Figure 3. In this regard, the implementation of environmentally friendly
technologies for biomass transformation, plastic recovery, carbon dioxide utilization, and other technologies represent opportunities for implementing sustainable businesses.

A set of enterprises should be structured in strategic locations to meet waste management and material transformation needs. These "bioeconomy industries" should gradually replace old facilities from the old linear economy. Furthermore, a wide range of services can develop around this "bioeconomy industry". Additionally, with increasing awareness related to climate issues, the institutional environment, legislation, and people's habits tend to create a favourable business environment focused on solutions that provide sustainability for society. Researchers, entrepreneurs, government, and lawmakers must be vigilant and help develop this new reality.

5 CONCLUSION

The intellectual framework of sustainable value aggregation can be understood through four fundamental elements: i) there are sustainability issues; ii) people are undergoing a change in thinking, meaning they are concerned about environmental issues; iii) there are solutions, techniques, technologies, and viable possibilities to address sustainability issues; iv) people are willing to change their habits in pursuit of sustainability.

In summary, opportunities for sustainable businesses are related to the application of environmentally friendly technologies and solutions. These technologies and solutions must necessarily be aligned with the principles of bioeconomy and circular economy. However, all of this is only possible if people are willing to change their habits to make society more sustainable. In practical terms, if an entrepreneur aims to explore a market with some new sustainable technology, they must bear in mind that they will be competing with traditional technologies. This entrepreneur must first identify the level of "environmental awareness" among people in a particular community.

This study was limited to discussing the statistically most important topics based on the bibliometric techniques employed. Thus, these results were limited to constructing a framework representing the main ideas related to sustainable value aggregation. Synthesized results are useful tools for addressing problems and can benefit entrepreneurs, policymakers, or legislators in decision-making processes.

Future research can create constructs and instruments to measure whether the environment in a particular region is favourable for the development of sustainable businesses based on the identified results. For example, if people believe that sustainability is not
important, investment in awareness is needed. On the other hand, if there are no technologies or solutions that enable sustainability, it may be necessary for a particular region to develop or import these technologies. In the same vein, it is essential to identify the social and economic variables that influence the process of sustainable value aggregation.

We hope that these results help decision-makers to think about sustainable businesses. In this regard, where there is an environmental problem, it is possible to apply a technology or solutions, and this is an opportunity for sustainable business. By understanding the process of sustainable value aggregation, policymakers can create policies aimed at incentivizing these solutions, investing in research and development, creating financing mechanisms for companies, fostering businesses, etc. Legislators can adapt legislation to the new reality, favouring the development of sustainable businesses; in this regard, the awareness of the population regarding the need for sustainability is crucial. On the other hand, entrepreneurs can identify opportunities and develop interesting businesses from economic, social, and environmental perspectives.

Finally, we have found that sustainable development is also an intellectual challenge. People need to assimilate the paradigms of sustainability to understand that waste production, carbon emissions, and other similar problems have a negative impact on their lives. After this initial awareness moment, environmentally friendly solutions become valued, leading to a change in mindset. This new mindset turns problems into opportunities, and thus a circular-based economy emerges, powered by biofuels, biofertilizers, and other value-added products.

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