UNIVERSIDADE CATÓLICA PORTUGUESA

Towards the Circular Bio-economy Supply Chains: foresight and outlook

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2023

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Final Assignment in the form of Dissertation presented to Universidade Católica Portuguesa to obtain the Master's Degree in Business

by

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April 2023

Agradecimentos

Nesta secção quero expressar o meu agradecimento a todos que me apoiaram durante este projeto de mestrado pois sem eles nada seria possível. Primeiramente quero agradecer aos meus orientadores por toda a paciência, troca de ideias e conhecimento facultado durante o processo de investigação e escrita.

Quero expressar minha profunda gratidão à minha família - pai, mãe, irmã e avó - pelo amor incondicional, suporte emocional e incentivo constante durante todo o meu período académico. Pois, o apoio foi fundamental para que eu pudesse alcançar este objetivo.

Também gostaria de agradecer ao meu namorado pelo seu amor, carinho e compreensão, por estar sempre presente e por apoiar-me incondicionalmente. As tuas palavras de encorajamento motivaram-me todos os dias a tentar fazer o meu melhor.

Por último, os meus sinceros agradecimentos a todas os profissionais que me dispensaram momentos do seu precioso tempo para me facultarem conhecimentos, dos quais, eu empreguei para este trabalho.

Resumo

A bioeconomia é considerada como um meio para combater os desafios globais, a lógica para o fazer é substituir os recursos fósseis por sistemas renováveis e biológicos que otimizem o cultivo ou utilizem os resíduos biológicos por inovações tecnológicas que reduzam as emissões de gases verdes e dióxido de carbono, obtendo sustentabilidade. A motivação de alcançar a sustentabilidade através da bioeconomia surgiu como uma oportunidade para a promoção de sistemas e logísticas mais circulares. Para apoiar esta transição para um planeta mais sustentável, as Nações Unidas criaram 17 objetivos incorporados na Agenda 2030 para o desenvolvimento sustentável, não só centrando-se nos fatores económicos, mas também incluindo os direitos humanos e a responsabilidade ambiental.

Assim, a investigação atual trata da capacidade da bioeconomia para promover um desenvolvimento sustentável no decurso das cadeias de abastecimento, integrando visões coerentes sobre como a mudança para uma bioeconomia circular será afetada pelas cadeias de abastecimento a jusante. A abordagem metodológica para tentar preencher esta lacuna na literatura foi através da realização de uma revisão bibliográfica sistemática de 99 artigos, analisando tendências e lacunas nos estudos. Para apoiar a análise, realizou-se 9 entrevistas entre peritos no campo da bioeconomia e de operações logísticas para obter conclusões mais significativas. O estudo revelou uma série de lacunas no conhecimento, no que concerne ao desenvolvimento e implementação de sistemas eficientes entre académicos para atividades da bioeconomia. A análise demonstra que alguns dos motivos devem-se à tecnologia limitada para alguns materiais biológicos e à deficiência em adaptações regulamentares para a atividade económica.

Palavras-chave: Bioeconomia; cadeias de abastecimento; desenvolvimento sustentável; economia circular; gestão circular da cadeia de abastecimento.

Número de Palavras: 9 158

Abstract

Bioeconomy is considered to be a means to combat global challenges, the logic to do so it's by substituting fossil resources with renewable and biological systems that optimize the cultivation or use biowaste with technological innovation that will reduce green gas emissions, CO2 and achieve sustainability. The motivation to achieve sustainability through bioeconomy came as an opportunity for the promotion of more circular systems and logistics. To support this transition for a more sustainable planet the United Nations created 17 goals, the 2030 agenda for sustainable development, not only focusing on economic factors but also by including human rights and environmental responsibility.

So, the current research deals with the ability of bioeconomy promoting sustainable development in the course of the supply chains, integrating coherent views on how the shift towards a circular bioeconomy will be affected by downstream supply chains. The methodological approach to try filling this gap in the literature was by conducting a systematic literature review of 99 articles, analysing trends and research gaps. To support the analysis, it was conducted 9 interviews among experts inside the field of bioeconomy and logistical operations to draw further conclusions. The study unveiled a series of gaps in knowledge concerning the development and implementation of efficient systems for bioeconomy activities, due to the limited technology for some bio materials and the deficiency in regulatory adaptations for the economic activity.

Keywords: Bioeconomy ; supply chains ; sustainable development; circular economy ; circular supply chain management.

Number of words: 9 158

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Abbreviations:

BE – BIOECONOMY

CE – CIRCULAR ECONOMY

CBE - CIRCULAR BIOECONOMY

GHG EMISSIONS – GREENHOUSE GAS EMISSIONS

CO2 – CARBON DIOXIDE

UN – UNITED NATIONS

1. Introduction

Currently, there has been a shift to change behaviours of consumption and production due to the high rise of climate change. To achieve more efficiency and management of resources, bioeconomy is having a rise in the present-day policies and discussions to attain practices towards sustainable development.

Although bioeconomy is still regarded as a complex subject of conceptualization, Kardung et al. (2021) defines it as a sector and system that includes biological resources which in turn supports functions and principles. Inside the bioeconomy, the presence of the earth's ecosystems provides services necessary for the development of production sectors and biological resources. This definition alludes to most thoughts of the researchers such as the European commission (2012) that in the same way describes it to be the economy that produces renewable biological resources that allow the transformation of these into food, feed, products and energy.

Throughout history bioeconomy had been an essential component in the food industry, using fermentation to produce products that are consumed daily, such as bread, wine, cheese, kimchi and beer, allowing the conservation of food, simultaneously surpassing transportations constraints. With the current influence of technology for industrial development and economic growth bioeconomy transformed its primary use, now providing another aspect that can be retrieved to achieve maximum value from biomass, residues or waste (Zilberman et al., 2018).

Thus, is important to comprehend how to overcome the difficulties when producing a product that leaves a large amount of waste behind during its production, and in what way can that residue and waste be valued for another

good. For this to happen, there should be more coherent logistics that allow this transition.

It can be applied to many sectors of activity such as agriculture, forestry, aquaculture and fisheries which demonstrates the potential benefits it holds. Due to this public awareness and legal enforcement, the manufacturing and production of environmentally-friendly products and recovered goods, are receiving more attention from academia, media, consumers and policy-makers (Mobtaker et al., 2021).

This review aims to give a comprehensive overview of the academic studies of bioeconomy in the supply chains and the sustainable contribution to fill the gap regarding how the shift towards a circular bioeconomy will be affected by downstream supply chains, in particular the production of waste stream. Despite the importance of these issues, there is still a gap in knowledge regarding the concepts addressed. To explore this issue, was identified various definitions of the key underlying subjects and identified essential research gaps based on the analysis. With the execution of a systematic review of the literature, the gathering of perspectives and foresights allowed me to introduce coherent logistics and supply chains within the circular bioeconomy.

To write the foundation of the thesis, it was chosen the most preeminent academic sources that are among the best journal rankings which enable an adequate analysis about the area of study.

The thesis is structured as follows. Chapter 2 explains the systematic method applied where was used Web of Science as the data source and Scimago as article quality reference. Chapter 3 presents the results, mainly focusing on discussing the samples outcomes as regards to bioeconomy as in different subjects. The implementation and application of the bioeconomy in the supply chains and the relation to sustainable development is also included in this section. Chapter 4

brings about the discussions and conclusion and Chapter 5 is the study limitations and future research.

Throughout the results there will be evidence of 7 main objectives, in order to understand the problem of study:

1. Define the term bioeconomy
2. Gather the characteristics and potential benefits of the bioeconomy
3. Identify common business practices in the bioeconomy
4. Discuss the relationship between the Circular Economy (CE) and the bioeconomy
5. How can bioeconomy promote a sustainable development – SDG's Goals
6. Identify ways and forms of logistics and supply chains to support the bioeconomy
7. Propose theoretical model that characterizes circular bioeconomy in supply chains.

Chapter 2- Methodology

2.1 Search Criteria

Systematic literature review was the selected procedure to identify the gaps in the literature, regarding the implementation of the bioeconomy in the supply chains to obtain a more sustainable development and how to obtain coherent logistics that can support CBE. Allows to identify and assess relevant research, helping to identify research gaps. Given the specification of the field, circular bioeconomy, the most useful information would be through academic reviews and articles. Although secondary data was collected for analysis this provided knowledge concerning gaps in the literature.

According to Tranfield et al. (2003) this review process enables to synthesize research in a transparent mean that provides the foundation of knowledge trying to reduce bias.

The literature search was performed in the database, Web of Science, the database was selected because it disposes of one of the largest abstracts and citation databases of peer-reviewed literature. The search terms employed needed to belong to my topics of interest such as, bioeconomy principles, supply chains, sustainability, sustainable development and circular economy. So, the keywords used in the database analysis were: “Bioeconomy”; ”Bioeconomy and supply chains”; “Bioeconomy and supply chains and sustainability”; “Bioeconomy and sustainable development” and “Bioeconomy and circular economy” .

To obtain relevant articles was filtered the results when introducing the keywords in the database, the first step was to refine articles according to the

wanted publication years from 2015 to 2022, then define the type of document, it was included both review and research articles, defined the web of science categories that should be included and excluded, according to each search term there were around 87 categories available to choose to refine results but it was select 17 of the 87 due to higher articles match and focus area of study. The citation topics (Meso) were changed as well, in a similar manner, to narrow research. Finally, the last step applied was the exclusion of three journals of very low quality, according to SJR, and had a large number of articles published in the results section, which in consequence would reduce the number of papers for analysis.

Table 1 below shows the number of correspondent papers found, after the criteria process was applied, demonstrating each result of each keyword introduced in the database.

Search engine	**Strings searched**	**Papers Found**	**Analysis**
Web of Science	"Bioeconomy"	1,986	Defined years of publications; Defined document types; Defined categories; Exclude papers according to quality
	"Bioeconomy AND supply chains"	137	
	"Bioeconomy AND supply chains AND sustainability"	43	
	"Bioeconomy AND sustainable development"	705	
	"Bioeconomy AND circular economy"	556	

Table 1- Adapted from: D'Amato et al. (2017) and M. Geissdoerfer et al. (2017)

2.2 Evaluation and selection

A first selection was made based on the content of title, abstract and quality of the journal, preferably Quartile 1 in Scimago journal rank requiring, at least, the

published date of the article to belong in the first quartile. Of the 3,427 papers identified, 200 were eligible for the analysis but after a second examination, full-text analysis, the remaining papers became 99 for the final evaluation.

Table 2 summarizes each step and process of the final data collection.

Step	**Process and Criteria**	**Papers Found**
1- Define analysis	Document type: Review and Research articles Publication Years: 2015 to 2022 Language: English	-
2- Identification of Keywords	About "Bioeconomy" AND "Supply chains" AND "Sustainability" AND "Circular economy"	-
3- Search in ScienceDirect	Filtering results according to publication years, document type and papers category	3,427
4- Refining the data based on the Title and Abstract	Read the titles, abstracts, keywords and journal quality that would be relevant to the thesis proposal	200
5- Refining the data based on full-text	Read the full- text paper that would contribute to the literature analysis	99

Table 2-Full process of data integration for analysis adapted from: Nematollahi & Tajbakhsh (2020).

To further validate the research approach, was adapted the PRISMA protocol along with scientific articles reviewed in the systematic analysis, which enabled the outlined of the 4 phases in a diagram flow reporting the numbers of articles screened at each stage. The diagram flow is primarily used as a tool, in scientific reports of systematic reviews and meta-analysis.

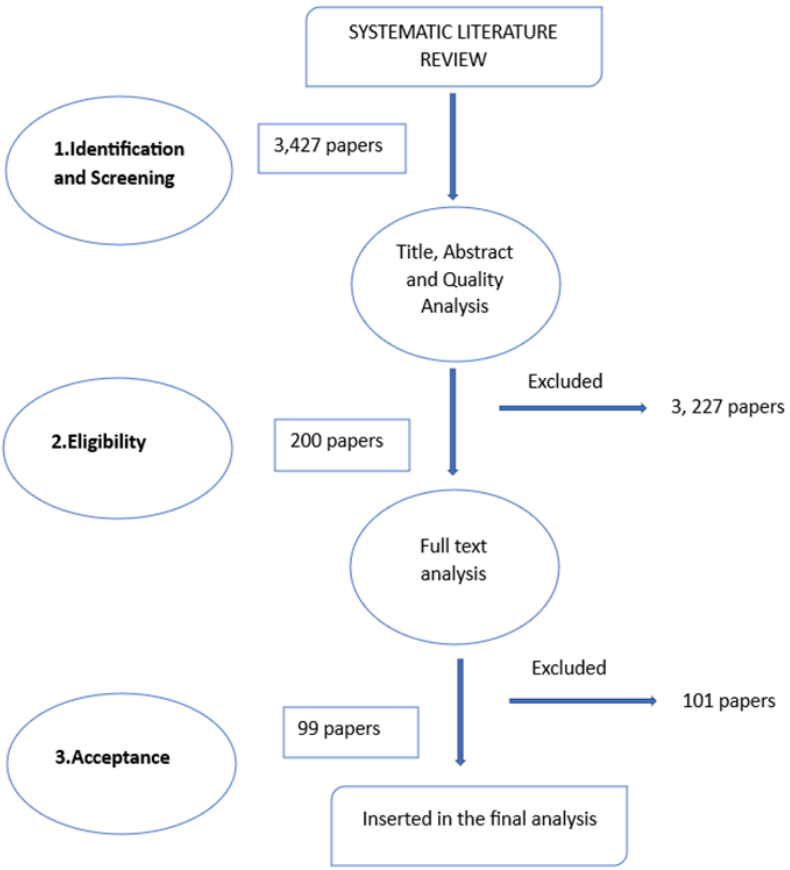

Figure 1- Adapted from: Steps for systematic literature review (PRISMA method) and Negri et al.(2021)

2.3 Interview Guide

To gather information on the bioeconomy, especially the applications in the supply chains, a set of experts were contacted for semi- structured interviews. Even though semi-structured interviews are time-consuming, they allow to understand the perspectives of individual opinions concerning a key issue (Adams, 2015).

Invitations were sent to company directors and teachers, that belong to the research area of study. The contacts were made using a wide range of strategies, (1) looking-up waste management and bioeconomy activities of companies on common search engines and who was a part of the research team, (2) searching

research projects of bioeconomy and finding the individuals in charge of the project and (3) recommended people from the interviewees. The interviews were conducted in February of 2023, resulting in a total of 9 interviews for the analysis. The questions for the interviews were derived from the knowledge collected from the literature review and based on the objective of understanding the processes and implications of bioeconomy in industries, to assemble an understanding that would perceive the supply chains of a CBE activity for sustainable development.

Figure 2 indicates the process led in the interviews to produce a more elaborate investigation.

Identification	- Interviewee's name and email address - Name of organization or institution - Main sector/ activity - Position
Topic-specific questions	1.Can you imagine the bioeconomy contributing to sustainable development? 2. What opportunities does the bioeconomy offer for businesses, consumers and the environment ? 3. To what extent does the shift to a circular bioeconomy require changes in supply chain processes, including material sourcing and procurement, logistics, production, end-of-life product management, etc. ? 4. If there is to be a transaction of the bioeconomy, will there need to be support not only operational and logistical but also sociological and political? 5. What additional factors would help develop a blueprint for organizations to integrate the bioeconomy into supply chains to transition to a circular economy ? 6. In your opinion, which logistics activities may represent the greatest opportunity for implementing the bioeconomy in a supply chain, production, goods processing or transport ?

Figure 2- Semi-structure interviews framework adapted from Salvador et al.(2022)

2.4 Data Handling

The research papers were stored, archived in the software Zotero, which has a similar design to Mendeley, Zotero collects the references and PDFs of each article if extracted with a chrome extension and using a VPN extension, of Catolica University, to be able to access important data. All data handling was in Excel, outlining the 99 articles chosen to organize research to simplify results.

Chapter 3 – Results

3.1 Descriptive Analysis

This section sets forth descriptive findings such as the distribution of the 99 articles over time and the journals published. Then, compared the methodologies of research used in each article in the context of the sampled data and the most predominant authors with more than one publication in the data sample.

The sample of the selected articles for the systematic literature review is available in Appendix A:.

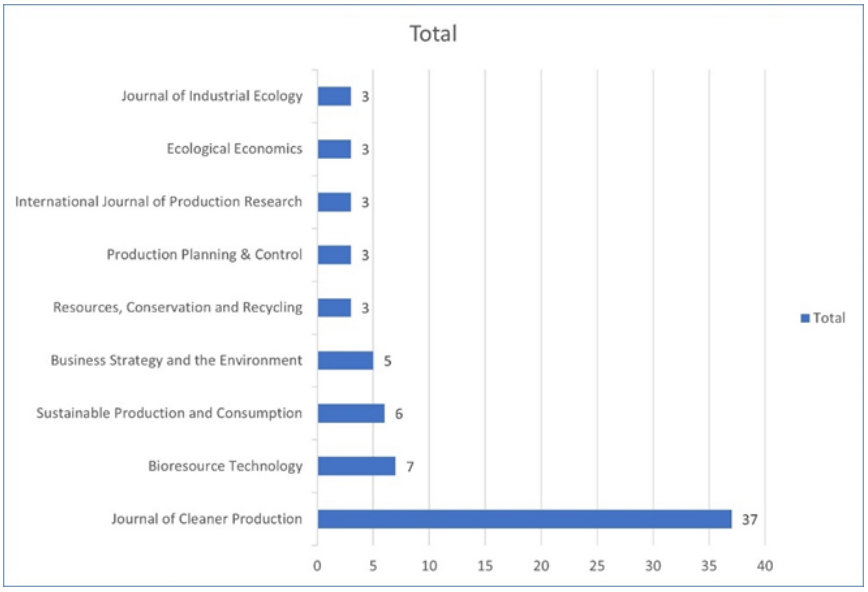

Figure 3- Number of articles per Journals (with at least 3 published articles)

The total number of articles per journals is in Appendix B :, but the Figure 3 shows that a large quantity of research within the topic of bioeconomy is employed by the journal of cleaner production.

Figure 4, below shows the distribution of the papers throughout the years. Although the research was performed to only include papers from 2015 to 2022, there was an exception of one paper published in 2014 that was considered as valuable for the research analysis.

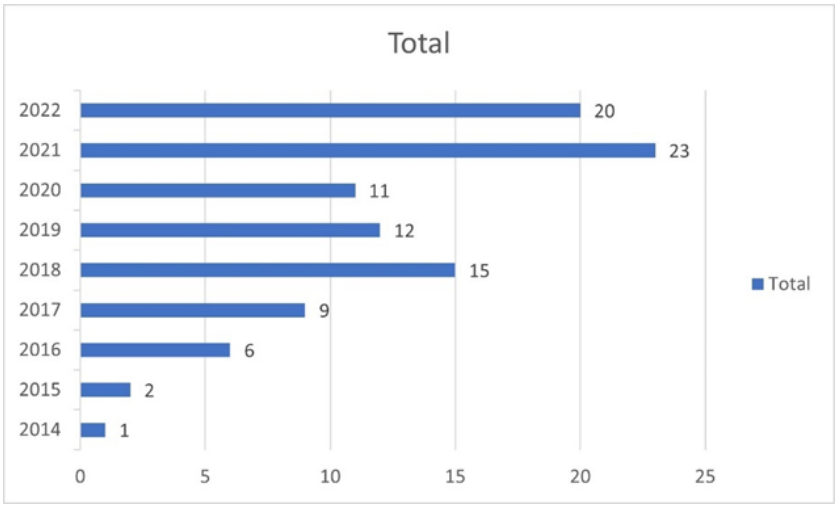

Figure 4- Distribution of papers by year of publication

Fig.4 illustrates the paper distributions over the years, the BE context is still an emerging area with an increasing number of publications in recent years (2021 and 2022).

Figure 5, displays the distribution of research methodologies employed.

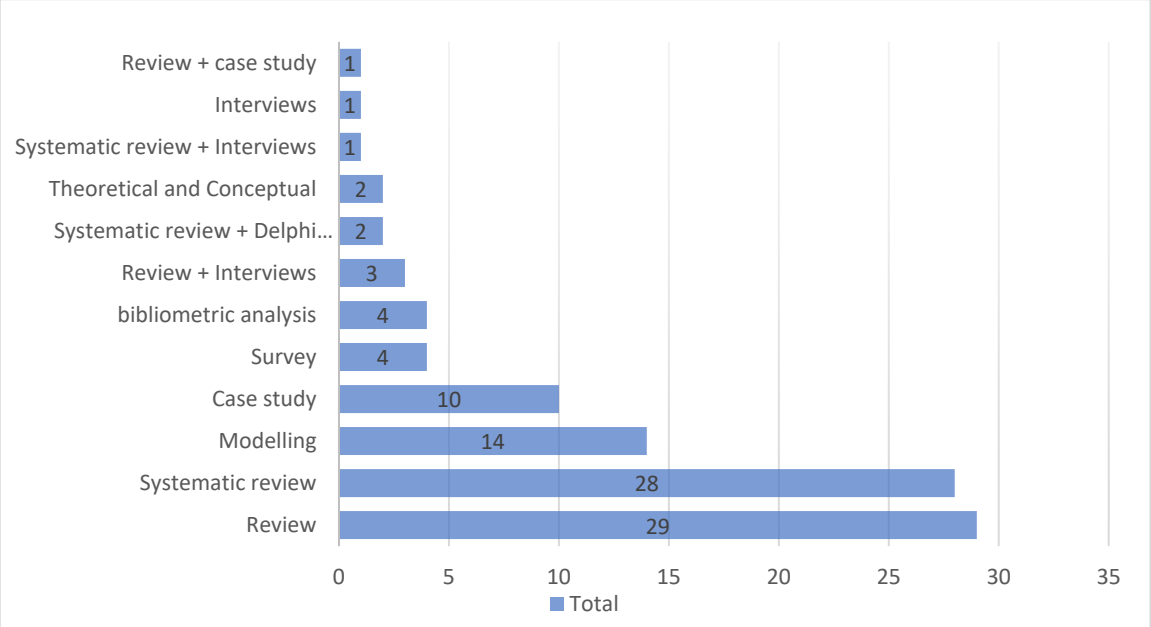

Figure 5- Distribution of research methodology

Most of the studies published in bioeconomy include literature reviews, case studies, conceptual frameworks and modelling. The research methodology that focusses on case studies provides a detailed analysis of a subject and the relations associated with contextual conditions, modelling is the creation of mathematical model that describe the behaviour of a system and reviews or systematic reviews, summarize previous published literature. The most common methodology employed, as shown in the figure above, are reviews and systematic reviews in the studies gathered. Although a large portion of articles is of qualitative data, a significant number of articles included in the sample are of quantitative data, both methods of collecting data were important to consider, to understand the opportunities and limitations of bioeconomy in the supply chains.

In the data sample, authors have more than one publication so Table 3 shows the most predominant authors in the research. Represented are the authors which have more than 1 publication, the complete Table of authors can be accessed in Appendix B :.

Authors	Number of articles
Geissdoerfer	4
Zilberman	2
De Lima	2
Cristóbal	2
Bressanelli	2
D'Amato	2
Total	14

Table 3- Most predominant authors (with at least 2 publications)

The Table 3, demonstrates that Geissdoefer has 4 different publications included in the data sample and 5 other authors have 2 publications included in the final analysis.

3.2 Characterization of the bioeconomy

3.2.1 What is the Bioeconomy: concepts, opportunities and limitations

Through the examination of the sample data the conceptualization of the definition of bioeconomy was difficult to comprehend due to the different adaptions from the authors. Most studies refer to it simply by its functions and others complement their understandings by adding the implications that the activity brings to the environment and society.

It's easy to recognize there is a wide scope of the concept in the literature, so to simplify the definition of bioeconomy according to its characteristics, the term should be referred to as a collective effort to convert the renewable carbon pool of agricultural biomass and organic waste into value-added products, including food, bioplastics, bio-based chemicals, biofuels, and bioenergy and as consequence provides more innovation and new technologies.

At this stage, bioeconomy studies mainly focused on the transformation of biomass into bio-based products with sustainable regeneration led by biotechnology and the sustainable development of agricultural systems against the background of climate change. Policy responses to and theoretical research on bioeconomy have been gradually systematized (Wei et al., 2022).

Bioeconomy allows for research and development and new technology to develop while using effectively biomass from alive organisms or it's residues. Provides an ecological and socio-cultural sustainable economy as it decreases the government control and increases the power of others, for example customers and non-profit organizations. It requires the participation of citizens,

communities, stakeholders and government leaders, it needs public and private support for the promotion of regulations (Takala et al., 2019).

To further extend the analysis, bellow is demonstrated a table of definitions by the most predominant authors systematically reviewed, as it will be clear, each author has his own perception of the concept, creating a vast understanding in the current literature.

Definition of Bioeconomy:	**References:**
The application of a new knowledge that allows the production of multiple products that come from living organisms and their waste, which demonstrates a big component of sustainable development.	Zilberman et al. (2018); Leandowski, (2015)
The replacement of fossil by renewable resources such as biomass extracted from marine, forestry and agricultural activities.	Mak et al. (2019); Heimann, T. (2019); Befort (2020); Bröring et al. (2020)
Path to reduce dependence on non-renewable resources (fossil), ease climate change and have the capacity to obtain the full capacity of natural resources. But at the same time has to fulfil social and economic factors such as responsible development, sustainable consumption, innovation and job opportunities.	Ubando et al. (2020); Mobtaker et al. (2021)
The operations that contain biotechnology, bioprocesses and bioproducts. Which produce new products and services.	Urbaniec et al. (2021); D'Amato et al. (2020) ; Parobek et al. (2019)

Table 4- Definitions of Bioeconomy according to the systematic review

Bioeconomy employs a number of renewable energies and products that are essential in turning over the economic dependence on limited resources such as

fossil fuel, nuclear energy and others that are producing GHC emissions. Biomass is at the core of bioeconomy and has a huge potential, currently being used for feed and food, bioenergy and biomaterials representing a more sustainable and viable substitute (Popp et al., 2021).

According to Cristóbal et al. (2016) there are different types of biomasses that can be used for bioeconomy purposes, industrial waste, agricultural waste, municipal solid waste, energy crops, forestry wood, forestry residues and micro algae. Sustainable biomass is one of the products more produced through the act of bioeconomy.

Generally, biomass is referenced as organic material used for energy production and for other purposes not related to food such as the biogenic materials and chemicals (Lewandowski, 2015).

There are different value chains of biomass, each having their benefits, such as food and feed, bio-based products and bioenergy (Blair et al., 2021 ; Brandão et al., 2021; Cristóbal et al., 2016).

To obtain the different consumptions of the biomass, it requires different applications of transformations through, fermentation, hydrolysis, direct combustion, gasification and anaerobic digestion (Cristóbal et al., 2016 ; Liu et al., 2021 ; Sherwood, 2020).

Figure 6, represents the types of biomasses in the bioeconomy outlook and the Figure 7 represents the biomass value chains.

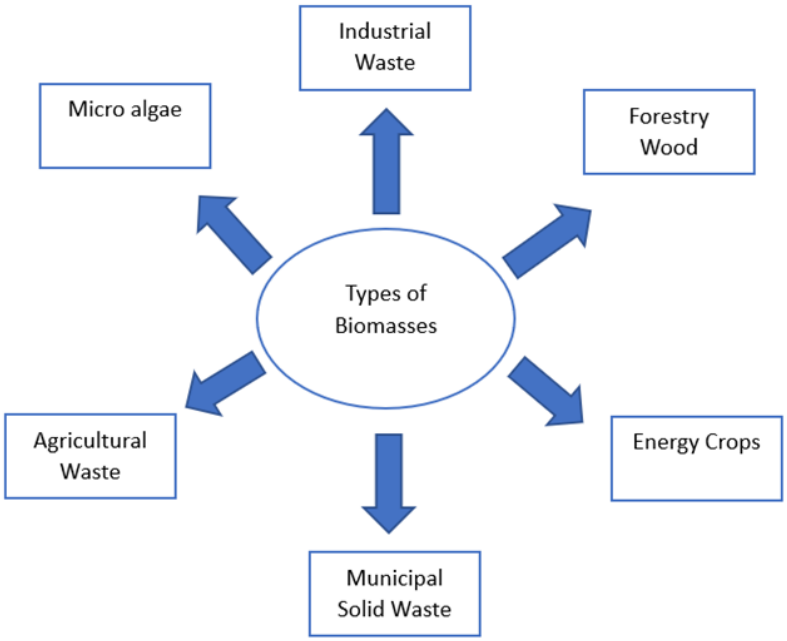

Figure 6- Own illustration: Types of Biomasses

Comparing biomass to the current feedstock used as the foundation of the existing economy, linear economy, it reveals that biomass has lower carbon densities, greater moisture contents, and is more diverse (Schipfer & Kranzl, 2019).

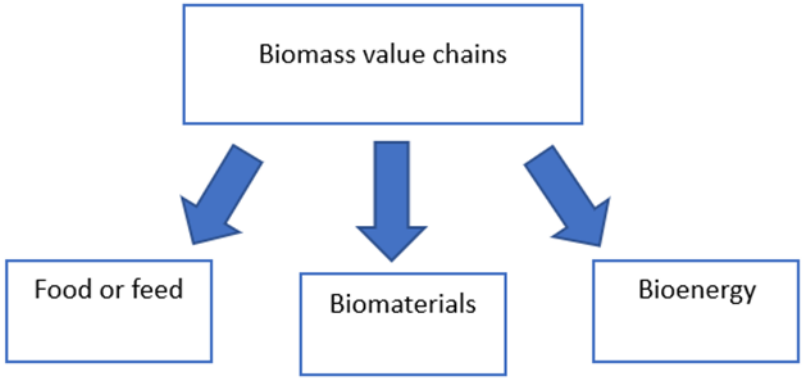

Figure 7- Own illustration: Biomass Value chains

Bioeconomy reveals various types of innovation, such as bio-based substitution products that aren't fossil based, this represents new resources from biomass such as chemicals and energy, choosing a process that allows to convert the by-product into new products. Fermentation is often used and the new

products can be inserted into pharmaceuticals, cosmetics and medicine (Bröring et al., 2020).

Zilberman et al. (2019) mentioned that the evolution of the bioeconomy reinforces the design of supply chains in a way to take the most advantage of feedstock, such as its residues[1], derivatives. Some examples are the livestock producers that also use residues for animal feed, pet food, gelatine and others. Not to mention that Brazil is the largest producer of sugarcane-based ethanol, producing mostly their own feedstock, using the residue bagasse as a source for energy production. The agri-food sector is a part of the bioeconomy, being capable of producing multiple products ranging from food, fuel, fibre and fine chemicals that come from living organisms.

In the light of these authors bioeconomy can lead to a path of success for modern bioeconomy, capable of producing multiple products from renewable feedstocks that replace products produced from non-sustainable sources and by not only achieving environmental goals but also trying being cost-competitive with other industries.

While analysing the overall message and vision of bioeconomy, most articles focused predominantly in dividing it in categories, for example Urbaniec et al. (2021) defined two principles of the concept into the sector of science / technology and other representations. The field of science and technology is considered as strategic, which implements behaviours of multifaceted planning and innovation research with human resources. The other representation of bioeconomy is perceived as new knowledge, the urge of innovation and creativity for agricultural purposes such as forestry, fishery, bioenergy and waste reuse. Wei et al. (2021) created a similar segmentation to conceptualize

[1] The European Commission (2008) divided residues into four categories, agricultural, forestry, aquaculture, fisheries and processing residues. Processing residues is a material that is not deliberately produced in a production process that can or not be considered as waste. By-products are processing residues that are not considered as waste.

bioeconomy in multiple areas of application, such as the whole, biotechnological, bioindustry, policy and sustainable vision.

To demonstrate the most articulate and coherent results, Table 5 below shows the aggregated perspectives on bioeconomy by dimension according to the literature reviewed.

Dimension	**Agenda**
Technological	Breakthrough of innovation carried by biotechnology and modified genetics to implement fossil substitutes and more advanced logistics
Environmental/ sustainability	The role of bioeconomy to contribute to the achievement of SDGs and contribution to environmental restoration and climate change mitigation
Economic and Political	Creation of regulatory policies for the intervention of regulators and stakeholders. The integration of more legislations that allow a more controlled practice that's beneficial for the economy.
Social	Improvement of social conditions through job creation and regional development

Table 5- Characterization of Bioeconomy by dimension

There are several critical factors and drivers related to the practice and implementation of bioeconomy, such as economic viability, technological development, public and private funding, policies and regulations, public acceptability and trade-offs with various stakeholders (D'Amato et al., 2020).

3.2.2 Connection and relation between CE and BE

As pointed out by Ghisellini et al. (2016), Kennedy and Linnenluecke (2022) and Sarkar et al. (2022) CE aims at reducing the amount of waste and improve the wellbeing of humans. However, CE mainly promotes the perspective of reduction and recycling to improve waste management practices. It aims at implementing better systems through preventive design of reuse and recycle, reduce the production of unnecessary goods through participatory strategies. But only using circular economy as way to break waste management and environmental pollution isn't sufficient, so it is necessary going a step further than CE towards bioeconomy.

Geissdoerfer et al. (2018) also identified that circular economy as a recycling system that minimizes resource use and waste, emissions and energy loss. By slowing, closing, and limiting the cycles of matter and energy.

The authors performed systematic reviews of the literature identifying important elements of circular economy that clearly differentiate it from the bioeconomy.

Recognized, primarily, that CE is concerned with economic actors and should favour the economy and the environment also benefiting the society that come from environmental improvements and social advantages, fairer taxation, and endorsing the economy. But Ghisellini et al. (2016) also argue that CE cannot be confirmed to support economic growth due to market competition where efficiency is not the first concern, not being very useful for economic systems. While CE goal is to generate economic prosperity while promoting more environmental quality and social equity, the concept doesn't have many connections with the topic of sustainable development (Kirchherr et al., 2017).

An interesting view from Mak et al. (2019) explore the thought that bioeconomy is more complex than circular economy, contributing to areas of

product innovation and service performance. Of course, it benefits from circularity, recycling and reuse that allow a better management of waste, but the concept also focuses on knowledge and innovation for better efficiency, mechanisms on biotechnology create new applications of waste into bioenergy and biochemicals.

Based on Giampietro (2019), circular economy is interpreted as the desirable outcome of using resources efficiently but bioeconomy is the different processes needed to achieve that result.

Loiseau et al. (2016) described that bioeconomy focuses on substituting natural capital with human-made capital by using biotechnology, new technologies to meet the human needs in a world where the natural resources are limited. But circular economy attempts to find solutions to overcome climate change and our safety by changing entirely human behaviours.

BE and CE practices help intervene in sustainability challenges and planning. The operations are supported by individuals or companies at a national and international level (D'Amato & Korhonen., 2021).

Within the CE and bioeconomy there is a foundation of circular business models, the cycling in which materials or energy are recycled through the use of the four R's, the extending is a concern regarding durable design and maintenance (Geissdoerfer et al., 2020).

Despite having independent terms and different applications both have the shared objectives of reconciliation of the economy, environmental and social goals.

The illustration, Figure 8, created shows the main characteristics between the three concepts of the study, such as CBE is between bioeconomy and circular economy to bring balance and adopt both behaviours.

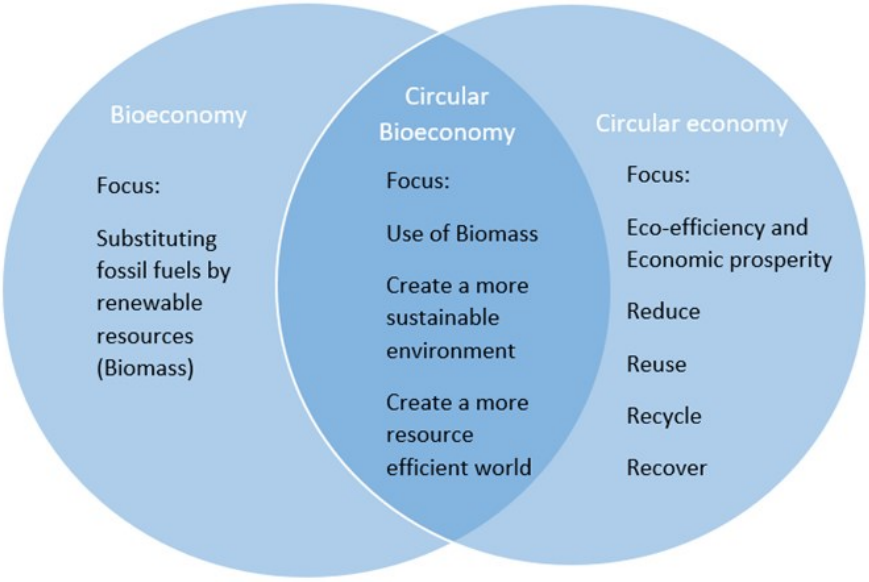

Figure 8- Own illustration: Diagram of BE, CBE and CE

3.3 How does Bioeconomy promote Sustainable Development

To determine if bioeconomy can promote a sustainable development, it was required to analyse the 17 sustainable development goals (SDG) of United Nations from the 2030 Agenda for Sustainable Development. Examining if the literature recognized the benefits of implementing BE could develop more sustainable practices including environmental, social and political. To consider bioeconomy as sustainable is important to determine if the products being used such as biomass, are following sustainable principles such as biodiversity, human and working conditions, pollution and others (Sherwood, 2020).

The analysis indicates that in most articles, bioeconomy and sustainable development have a clear relationship between both concepts, due to the goals that bioeconomy focuses on fulfilling, such as waste and side-stream use, waste

minimisation, carbon sinks, clean energy and resource efficiency and replacement of fossil resources which many of these examples are connected to environmental sustainability. But the concept of sustainable development and sustainability not only focuses on ecological actions but also socio-cultural, which demand to ethically sustain working practices (Takala et al., 2019).

Although there are different opinions throughout academic scholars, some didn't inherently correlate both concepts as linked, explaining that many practices of bioeconomy if not regulated can lead to negative repercussions in the environment, for instance the destruction of the biodiversity of a particular land because of inefficient land management (Egea et al., 2021; Lewandowski, 2015 ; Moktadir et al., 2022 ; Roy & Tu, 2022).

The survey of Devaney et al. (2018) a study of value chains opportunities for sustainable bioeconomy, respondents perceived bioeconomy not inherently sustainable specially if adopted at large scale, which can negatively affect biodiversity, habitat, ecosystems. But emphasized that bioeconomy suggestions are much better than the linear value chains, and by combining approaches of inputs, different feedstocks in agriculture, food, marine and forestry it can reach a balance. Using crossing functions can create high value biochemicals and biomaterials, such having the best of both worlds, while using waste and residues and creating energy and materials.

A significant analysis and discussion on the subject were presented by D'Amato et al. (2020), which explored systematically the connection between bioeconomy, the ecosystem and the challenges that both subjects face. The results showed that there were emerging themes concerning both concepts. The themes approached are more macro focused, such as ecological, economic and socio-cultural dimensions are considered. The conflicts that may arise between stakeholders that can damage environmental sustainability due to competing interest of management should be recognized. The management of resource-

intensive bioeconomy and the food security risks. But conclude the paper by saying that the bioeconomy community hold potential for a future more sustainable.

All end use types (heat, electricity, transportation) in the biomass supply chain type contribute towards SDGs (Blair et al., 2021).

Biomass production can be integrated within existing farming and forestry operations to improve ecosystem function, enhance the sustainability of farming and forestry practices, and improve waste management.

Figure 9 represents the 17 SDGs elected, with the respective objective.

Figure 9- Sustainable Development Goals. Source: https://www.un.org/sustainabledevelopment/news/communications-material/

3.3.1 SDGs and the Bioeconomy

Considering the SDGs suggested by the UN, is important to correlate such factors of ambition with the bioeconomy and how both can be accomplished though the merging of the sustainable practices. Bioeconomy can lead to a more successful future if taken seriously with government action with the implementation in diverse industries that allow the usage of the residues and waste. The use of the residues and waste will enable to create a prosperous present and future that fulfils human rights, environmental responsibility and economic improvement.

Table 6 suggests the direct link between bioeconomy and SDGs, reflecting actions that could contribute to the fulfilment of the goals, referencing the authors in the literature that supported the connection between concepts to achieve more sustainability.

SDG's	Description	Bioeconomy involvement	References
1	No poverty	The development of bio systems in rural and indigenous communities indirectly supports jobs and economic opportunities for those people.	Heimann(2019); Blair et al.,(2021)
2	Zero hunger	By introducing bioeconomy practices the agriculture could benefit from the principles enriching more adequate and healthy food for the global population	Barcelos et al.,(2021); Heimann,(2019); Blair et al.,(2021)
3	Good health and well-being	Reduces the use of fossil which are health risks due to air pollution and environmental contamination by switching to bio resources, helping increase quality of life.	Heimann,(2019); Lewandowski (2015); Blair et al.,(2021)
6	Clean water and sanitation	Removal of residues from crops can increase the susceptibility of soil to wind, water erosion and fires. Also reforesting areas for biomass use can help treat wastewaters.	Heimann,(2019); Lewandowski 2015; Blair et al.,(2021)
7	Affordable and clean energy	Using waste as a source for bioenergy can create more renewable energy especially to rural areas and by integrating bioenergy into energy systems can contribute towards more accessible and affordable energy.	Barcelos et al.,(2021); Heimann,(2019); Blair et al.,(2021); Moktadir et al.,2022; Takala et al.,(2019)
8	Decent work and economic growth	The increase of biomass uses for e.g., bioenergy can create community-scale projects which contribute for local and rural employment which in consequence supports municipalities, strengthening financially the areas.	Heimann,(2019); Lewandowski 2015; Blair et al.,(2021); Moktadir et al.,2022
9	Industry, innovation and infrastructures	Bioeconomy provides innovation in products, services and infrastructures.	Barcelos et al.,(2021); Heimann,(2019); Lewandowski (2015); Blair et al.,(2021)
11	Sustainable cities	Creates more sustainability inside cities by using waste and improving circularity systems for example recycling and reducing.	Barcelos et al.,(2021); Heimann,(2019)
12	Responsible consumption and production	Use of residues results in more efficient use of resources, and lower material footprint than extracting and burning fossil fuel which enables more environmentally waste management.	Barcelos et al.,(2021); Heimann,(2019); Lewandowski (2015); Blair et al.,(2021); Takala et al.,(2019)
13	Climate action	The supply of biomass supports and promotes local economy by producing energy with waste and developing more sustainable operations.	Barcelos et al.,(2021); Heimann,(2019); Lewandowski (2015); Takala et al.,(2019)

14	Water life	Management of waste streams for energy or food /feed use can reduce marine pollution.	Heimann,(2019); Lewandowski (2015)
15	Land life	Can restore degraded agriculture land, reduce pollution and develop management plans of land use.	Heimann,(2019); Lewandowski (2015); Blair et al.,(2021)

Table 6 - SDGs linked with Bioeconomy according to literature

Bioeconomy can reflect sustainability as is seen by the table 6 above due to the fulfilment of most of the goals presented in the UN providing respect for human rights, protection of biodiversity, wildlife, environmental responsibility and responsible business practices that improve economic growth for communities . Although if not regulated and respect it can affect negatively the biodiversity.

3.4 Bioeconomy in the supply chains

3.4.1 Logistical Applications

There were identified several limitations and gaps regarding the frameworks necessary to implement bioeconomy in the supply chains, among researchers and academics. Even though there is a common reference to biorefineries[2] which manage, predominantly, by-products and residues offering systems of optimization of resources and maximization of benefits.

There is an absence of current methodologies, in the literature, that need to be applied in the supply chains (from production to distribution) in order to obtain circular practices. The common supply chain components present to apply bioeconomy practices are: (1) feedstock supply which there are multiple sources previously reviewed; (2) biomass conversion; (3) market demand; (4) distribution and (5) use (Christensen et al., 2022).

[2] Biorefineries focus on producing fuels, solvents, plastics and food for human use that are made from waste biomass. In the Biorefinery the main processes involve fermentation (Ohara, 2003).

The CBE concept is an alternative to the dominant linear take make-dispose industrial model.

To sustain a shift of fossil-based economy to a bio-based there needs to be more efficiency in the use of biomass. That can be attained through the cascading methodology which enables the use of biomass and offers the potential of producing more value by developing new and enhanced products (Scheiterle et al., 2018).

Raimondo et al. (2021) also suggested that by using the cascading method, it will optimize the environmental footprint of a product by increasing the value of the biomass while reducing their consumption and waste production while maintaining quality. The goal is to primarily apply in fine chemicals and pharmaceuticals, second food-feed, third bulk chemicals and materials, fourth is energy and in last biomass.

Bröring et al. (2020) acknowledge a great cascading example, such a crop of fruit where a part can be used to commercialize fruit, while the remaining could be used for the pharmaceutical industry due to high values of antioxidants compounds. In the transformation process there would be waste biomass that could be transformed into bio-based substitutes (bio-chemicals) and into energy production.

Zilberman et al. (2019) proposed meaningful insights into the perspective of the application of bioeconomy in food supply chains in order to become more efficient , analysing the farm stage, feedstock production, processing stage and conversion of feedstock into final products. The processes from pre-farm input supply to wholesale and retail of the final goods, that focuses on distribution of final goods to differentiated markets. The simplest supply chain comprises of a two-stage supply chain, which is based on the production of feedstock to then process it and create a final good, the main decisions consider the quantity of feedstock produced in-house and how much should be purchased from the

suppliers. The three-stage supply chains contemplate the input suppliers, production of the feedstock and processing/refining. This could be a vertical integration by controlling the inputs, production and processing. The fourth-stage supply chain is more complex, touching the subject of allocation of the output and the distribution channels, due to the wide variety of differentiated products that come from feedstock, so is important to decide the quality of goods, needed to balance between costs and resources.

Thus, is important to design supply chains tailored to local contexts, taking into account factors such as resource availability, consumer preferences and regulatory frameworks. The development of innovative practices includes interdisciplinary collaboration between different actors. Geography also must be addressed when designing supply chains, because the quality of the products, the service and transportation costs of the output are important. The producers can choose from depending on franchise or selling the goods directly, determining the total output and distribution of sales between the company and the franchise.

In research conducted by Devaney et al. (2018), they developed eighteen opportunities in the supply chain for the Irish bioeconomy and reflected positive feedback for more sustainable practices through bioeconomy development. But there are challenges for the implementation in the value chains such as short-medium term and further awareness. The main arguments were questions of scale, fragmentation of feedstock, the investment required for technological research and development and consumer approval.

The agri-food supply chains have the capacity to progress to biobased and circular value chains as is discussed by Egea et al. (2021), the solution for this translation is to focus on waste valorisation and management, new inputs set on technological innovations, build different delivery partners inside the sector and incorporate social awareness of bioeconomy.

In a research of sustainable agricultural supply chains by Nematollahi and Tajbakhsh (2020) it's suggested the implementation of reverse logistics and closed-loop systems for economic benefits and also environmental sustainability. The systems are capable of reducing waste and if designed to create efficiency, they can reuse materials across agricultural supply chains.

Throughout the systematic analysis there was a gap identified around the different methodologies that are used currently in order to quantify bioeconomy practices in the supply chains. If there would be more scientific development in the progress of implementing more closed-loop systems to create less waste, more product and biomass valorisation, there wouldn't be so much doubt regarding economic feasibility, cost implications and food safety.

The Table 7, identifies methodologies commonly mentioned among academics and researchers to quantify impacts along bioeconomy value chains.

Methodologies	**Description**	**References:**
Life-Cycle- Assessment Most common mentioned	LCA is an international standardized method to evaluate the environmental impacts of a product, process, or activity throughout its life cycle	Lewandowski (2015) ; Talwar et al. (2022); Pomponi & Moncaster (2020); Fiallos-Cárdenas et al. (2022); Cristóbal et al. (2016); Santagata et al. (2021)
Cascading	The cascading principle of biomass represents the use of biomass resources should be prioritize, high-value products (e.g. biochemicals and pharmaceuticals) over low-value ones (e.g. bioenergy).	Raimondo et al. (2021)

Material flow analysis (MFA)	The analysis of the throughput of process chains comprising extraction or harvest, chemical transformation, manufacturing, consumption, recycling and disposal of materials.	Pomponi & Moncaster (2020) ; Loiseau et al. (2016)
Biomass Value Chain Model (BVCM)	Considers the effects on the economy and environment of a pathway's end-to-end components, including crop production, conversion technologies, transportation, storage, local purchase, import (from abroad), sale, and disposal of resources,	Talwar et al. (2022)
Closed-Loop Supply Chain (CLSC)	Focused on simultaneous optimization of forward and reverse supply chain operations	MahmoumGonbadi et al. (2021); Lahane et al. (2020)
Substitution Share Indicator (SSI)	Compares products made from bio-based substitutes to those made from fossil resources and takes indirect fossil resource flows into account. These flows are estimated using a bottom-up approach based on data from life-cycle inventories and a top-down approach based on input output data.	Jander & Grundmann (2019)
Life Cycle Costing (LCC)	Is the process of calculating the total cost of ownership for an item over the course of its useful life. The costs associated with an asset from the point of purchase to the point of disposal are covered by whole-life costing.	Mak et al. (2019)
Reverse logistics	The practice of returning goods from end users back through the supply chain to either the manufacturer or the retailer.	Mobtaker et al. (2021); Lahane et al. (2020) ;

		Burke et al. (2021); Larsen et al. (2017)
Continuous material flow	Continuous evaluation and improvement initiatives ultimately call for integration of all production system components.	Lavelli (2021)
Techno-economic analysis (TEA)	Used to compare the economic viability between technological alternatives through metrics such as net present value (NPV) and payback period.	Roy & Tu (2022)
Decentralized biowaste management system (DBMS)	The system treats food waste in a micro-scale network, producing biogas and organic solid and liquid fertilizers in a closed-loop	Tsorochidou et al. (2021)

Table 7- Methodologies discovered to quantify impacts along bioeconomy value chains

Most studies focus mainly on the life-cycle assessment (LCA) research of the bioeconomy as is also pointed out by Wei et al. (2022). The reason behind it is that academic research and implementation of this methodology is being used more often than the others identified. Reverse logistics are as well a critical component, that create a backward flow of resources and produce the related information to achieve circularity in supply chains (Larsen et al., 2017). The circularity can be a closed loop, where firms working at the same supply chains collaborate to recover the value of wastes and biological nutrients.

The circular supply chain management (CSCM) is an emerging research topic, that has great potential enhance efficiency and sustainability for organizations. Is an alternative solution to linear supply chains of production, if implemented it can improve economic growth, value propositions, end of life strategies and competitiveness (Lahane et al., 2020).

These circular approaches are focused on the circulation of resources flow and waste management, which can reduce the demand for virgin resource extractions

by circulating biological materials in regenerative cycles and technical material for restoration creating a zero-waste vision (Burke et al., 2021).

3.4.2 Examples of sustainable applications

Correl et al. (2014) explored the application of bioeconomy in the supply chains, particularly the diversification of feedstock. The model included three different types of crops which optimize the harvest windows throughout the year and reduces the minimum amount of feedstock that must be held on-site. Also, by including a high-yield variability, mitigates the costs of crops. So, the re-design of the supply chain for biobased product that employ multiple crops as feedstock, could reduce costs of logistical equipment and feedstock inventory, making a dramatically impact in practitioners and communities engaged in the bioeconomy, showing that is a very beneficial practice. The results demonstrated that the strategy saved 38% of costs in feedstock, contributing to a more sustainable practice that is able to reduce costs and increase quality in the feedstock.

Bioeconomy preaches about the advantage of using renewable biomass that can come in various ways, if used residues that come from food waste or from the production of end-use products, there are several benefits in taking this to create value. For example, when producing wine, there will be waste that comes from the skin and seeds of the grapes. But these can be seized for fertilizers which in turn, eliminate waste and generate value to the biomass (Lavelli, 2021). Other example reviewed was the waste created from slaughterhouses, which disposes multiple nutrient dense materials (Henchion & Shirsath, 2022).

Fiallos-Cárdenas et al. (2022) designed a banana supply chain, implementing circular bioeconomy, their suggestion was to take the residual biomass as a carbon source in a bio-based process along the use of fermentation. This would

create bioproducts or bioenergy due to the bio-based process, enabling to use everything from the banana (leaf, rachis, peels) without waste.

Table 8 shows potential implementations, in different sectors, that could be used from the waste and residues that come during the production or harvesting of the product, which can be used for other finalities.

Sector	**Bioeconomy Activities**
Agricultural	Use horticultural by-products as feedstock for biomaterials Use agricultural waste and by-products as a supplement for bioenergy production Food residues and waste for bioenergy production Use recovered vegetable oil as feedstock for biofuels Use seaweed or microalgae for food, pharmaceuticals, cosmetic and energy applications
Marine	Use of marine discard as feedstock for animal feed, biochemical production and for cosmetics.
Forestry	Use forestry resources as feedstock for decentralised heat generation, and for biochemicals and new biomaterials, besides timber and paper.

Table 8- Examples of potential opportunities of BE implementation in industries

If activities such as this, would be implemented in companies and firms during treatment process or extraction, it could lead to a less waste and residue planet field with new opportunities. If innovation and technology would be applied in these activities, they could benefit from these different paths towards more sustainability. It can increase more efficiency in production, economic profits and decrease fossil and GHG emissions, for instance by using a variety of different feedstocks for feed and agricultural proposes it can improve crops and varieties, higher yield and optimized quality, improving the use of water and nutrients,

higher yields of by-products, residues and animal breeds could have a higher feed use efficiency (Corell et al., 2014 ; Lewandowski, 2015).

To achieve sustainable exploitation of biological resources, is fundamental to introduce innovations at the multiple levels of supply-chains that affect the entire network of systems, so the framework of bioeconomy can grow into a sustainable economy.

There are a range of industries that could benefit from the use of residues or waste streams that come from the production or manufacture of an end-good of consumption and then transform it into a new bioproduct, bio material or bioenergy, generating more profits from the by-product and residue, in consequence, decreasing waste matter.

3.5 Interviews

The purpose of conducting the interviews was to gain insights into the perspectives of professionals concerning key issues underlined in the bioeconomy and also, benefits of implementing the economic activity. The opinions collected were able to identify significant strategies and policies that can lead to a more successful industry.

Table 9 shows the positions and the sector of activity of each of the interviewees. The total of the interviews caried was 9, this number demonstrates that there are significant levels of knowledge established.

ID	**Type of Organization**	**Position**	**Main Sector/activity**
1	Research Institute	Scientific coordinator	Management
2	Research Institute	Scientific coordinator	Food Engineering
3	Research Institute	Associate Professor	Biotechnology
4	Research Institute	Researcher	Biotechnology and Fine Chemistry
5	Company	Manager	Biochemical - Algae
6	Company	Director	Food and Feed
7	Company	Director	Research & Innovation

8	Company	CEO	Bioenergy
9	Company	Associate Partner	Environmental, Social and Corporate Governance

Table 9- Interviews Identification Data

To demonstrate the results of the interviews, it was constructed a table, summarizing the perspectives and opinions from the 9 interviews conducted.

Questions	**Results**
Q1.	All participants agreed that bioeconomy contributes for a sustainable development. Not only environmentally but also societally and economically.
Q2.	For companies it can maximize the value of the product by using the residues and waste to generate other products for animal feed and others. The environment benefits from that use by reducing the amount of waste that is polluting for the environment and reduces the amount of CO2 that is released to the atmosphere and the consumers have more available products in the market that have the same quality.
Q3.	To implement a CBE in the supply chains is required to produce an effective mapping of the processes which needs to conform depending on each value chain. It's important to incorporate a manufacturing symbiosis that enables the proximity of the raw materials to support variability, standardization of quality and control. The value chain of perishable products is extremely more complex, requiring a greater reflection, and is also necessary to adopt tailored economic models.

Q4.	The participants agreed that to increase the adoption of this transaction, not only needs the support of technological innovations but also there needs to be investment and support from society to increase the economic activity.
Q5.	The creation of consortiums and multidisciplinary groups could help to create solutions for the gap in technology to assure efficient systems that would reduce costs. More government incentives for innovation and creation of more companies in the industry and EU funding. Also, what will create a turnover is legal modifications which will promote companies to include bioeconomy in their economic activity, increasing the demand of the raw materials (residues or waste), the political intervention is a furcal point for the implementation.
Q6.	Is important to evaluate the type of raw material due to the cost of transport and the ingredients produced to find the best method of feasibility. The goal should be to reduce the supply chain and to be closer to the source. Production and transformation need to be nearby the raw material. But if is a scarce good and is scattered, then is necessary to invest in transport costs, implementing concentration systems and gathering to forward for transformation units. The goods can come from division units of pre-treatment, minimizing costs. During the supply chain, other alternative fuels should be included, such as gas and hydrogen vehicles and renewable energies as a source of energy to replace fossil fuels inside the manufacturing unit or reuse resources.

Table 10- Interview's Results

It is important to apply a model of scale economy, of valorisation to be able to provide the consumer with a price equivalent to the market with equal quality and with more sustainability. Because if it is more expensive, the consumer may

not join. This is the effort that industries working in the bioeconomy have to focus on generating, otherwise it is difficult to compete with fossil raw materials.

Examples during interviews showed that there is a range of possibilities that companies have, to support the transaction and shift to bioeconomy. For example, residues and by-products contain important molecules for food or pharmaceuticals that would otherwise be collected from endangered animals to obtain a specific resource. Sugar cane, generates a yeast from which is extracted replacing natural molecules from other organisms that are scarce or that can bring impact in its extraction, such as the molecule extracted from shark liver, that is used for cosmetics, causing the death of many sharks, which puts in question the survival of the species.

Also, the extraction of bioactive compounds is an issue that is being valued more to replace organically synthesised products such as preservatives, dyes etc, with products of natural origin, from natural sources (residues) that may also have similar properties to these synthetic compounds.

Other example provided was blood, from slaughterhouses when slaughtering animals there is a set of by-products generated from the same slaughter, from the cutting of the animal until it is transformed into parts for human consumption. Blood is a biological liquid with a nutritious source, but on the other hand it is a huge water pollutant if seen as waste. So is collected, stored locally in the febrile unit to transform the liquid into flour that is reintroduced into the animal chain or used for fertiliser.

Avoids an environmental burden, takes the by-product from the producer and transforms it into an animal feed product or fertiliser.

Chapter 4- Discussion and Conclusions

The emerging interest in a more sustainable and circular economy brough bioeconomy as a solution, influencing breakthroughs in research and technology to allow implementation, but there are still many issues pending and several gaps (Xei et al., 2022).

As discussed previously, for the bioeconomy to become more incorporated in companies and for the consumer to adopt, there needs to be more predominant research in innovation, technology, mapping and regulatory support as is consistently mentioned by the articles reviewed and supported between interviewees, but the incorporation to do so is still very unexplored among researchers.

As Santagata et al. (2021) pointed out, for the CBE to be applied in the supply chains, in order to overcome challenges and to be sustainable it needs; (1) technical-operational, economic and regulatory activities have to be addressed by decision-makers, researchers and end users. Available resources, financial affairs and governmental competences need to invest for long-term feasibility; (2) cooperation between different scientific industries, in order to, implement bioeconomy at an industrial level; (3) More technological applications for the creation of by-products and bioenergy; (4) Further research needed to assess economic and industrial scale of biomass and waste residues activities, specially cost and transportation operations.

This can be difficult to apply when there are many barriers to overcome for the economic activity to flourish. The first steps would be to create higher valorisation systems for residues and waste with the support of legislations that

allow a more effective plan to transform residues and waste into other products. Along the regulation there are still many steps owners and producers have to proceed in order to transform waste into a feasible alternative.

Nevertheless, Brandão et al. (2021) indicates, that bioeconomy has societal, economic and environmental benefits that meet the expectations of sustainable development such as ensures management of natural resources sustainably, decreasing the chemicals in the agricultural products and helps meet demand of food in the growing population, it can ensure quality of life and health benefits from environmental changes and can overcome social attitudes for the support of residue treatment. The economic benefits focus on economic growth from bio-based industries and new markets, which in consequence creates more jobs in the bioeconomy field, concluding with the environmental benefits the bioeconomy allows the independence of fossil fuels, sustainable management of natural resources and ecosystems.

But throughout the articles examined the main considerations are that bioeconomy to be implemented in supply chains or activities of production it needs to overcome the barriers of infrastructures, stakeholders and policy making (Egea et al., 2021 ; Lewandowski, 2015 ; Marcone et al., 2022 ; Mertens et al., 2019 ; Moktadir et al., 2022).

Along that though was the same suggestions by the experts interviewed that also point out, the main constraints as shortage of government and consumer support resulting in problems in legislation and operations.

Earlier in the results section it was showed a strong correlation between bioeconomy and SDGs due to the colliding objectives of both, the aim is to promote economic growth that is sustainable in the medium-long term. This growth should also take into account social concerns and be sustainable from a territorial perspective. To achieve this, it's important to have effective institutions,

governments and stakeholders that prioritize growth on social, ecological and economic inclusion.

The findings of this study can be understood as an answer to the gap in knowledge on how bioeconomy in the supply chains promotes a sustainable development with the application of a systematic review of the literature. To this aim, it discussed the necessary logistics to implement bioeconomy that enable sustainable development.

In summary, the integration of bioeconomy in supply chains, would benefit sustainable development in several ways by (1) closing resource loops using by-products and waste from one process as inputs for another process which reduces waste and increases resource efficiency; (2) reduces dependence on finite resources using renewable resources such as plant-based materials which reduces greenhouse gas emissions; (3) enhances rural development creating new business opportunities and jobs in rural areas, in particular, in regions with abundance on biological resources, improving the livelihoods of communities.

Bioeconomy provides alternative uses for agricultural products and reduces the pressure on land for food and feed production, helping to reduce soil degradation and promoting land use. Also, it will drive innovation by promoting the development of new technologies and products based on biological resources leading to the creation of new business and industries which will generate economic growth and job creation. But to create coherent circular supply chains for bioeconomy is still a challenge companies face, as the regulations are still not adjusted for a shift in circularity, most rules and laws support the linear economy models, and there needs to be a construction of higher valorisation (cascading) processes of residues and waste. On one hand, residues contain higher added value for other purposes, opposite from waste which has lower value, but the focus should be on the value chain of the biomass and how can the residue

contribute for human/ animal consumption or energy/ material production, creating more essential goods.

The focus is in creating superior technology and higher accessibility for companies to outline systems of operations to effectively collect residue and waste that can generate value to compete in the market with other non-sustainable options that have lower costs. To do so the economic activity has to growth and develop into industrial symbiosis that are capable of storing and operate locally or by using centralised systems gathering the scarce goods which are relocated to a global unit for treatment which will result in higher costs of transportation. Therefore, is essential to invest in the structure of the operations that lead to an efficient and organized strategy. The final good should compensate the investment, adding value to the company and undisputedly to the environment. Bioeconomy can be viewed as an economic activity that can achieve greening, corporate responsibility and change customer demands.

Chapter 5- Limitations and Future Research

The thesis contains the inherent limitations of a systematic literature review. As the literature search is limited to academic journals, only including reviewed and research articles, as grey literature was not included for analysis.

The results section is based on academic viewpoints, and concepts discussed are limited by the number of papers published that frame interconnections between themes addressed. The study also includes the risk of bias due to the inclusion of suggested papers from the database during the analysis of each article for the sample. However, heterogeneity and quality of papers was always a concern during the examination of papers for eligibility to include in the data sample.

The main suggestion for further research is to focus on consumers behaviours and opinions, if they would be willing to consume products that come from bio sources of waste and residues. The further step would be to create a survey for regular consumers, obtaining answers that could provide necessary information for practitioners and policy-makers according to the industry of the bioeconomy.

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Appendix A:

Author	Year	Title	Journal
Angouria et al	2021	Limits to circular bioeconomy in the transition towards Decentralized Biowaste Management Systems	Resources, Conservation and Recycling
Ayrapetyan et al	2022	The role of sustainability in the emergence and evolution of bioeconomy clusters: An application of a multiscalar framework	Journal of Cleaner Production
Barcelos et al	2021	Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons	Journal of Environmental Management
Befort	2020	Going beyond definitions to understand tensions within the bioeconomy: The contribution of sociotechnical regimes to contested fields	Technological Forecasting and Social Change
Blair et al	2021	Contribution of biomass supply chains for bioenergy to Sustainable Development Goals	Land
Blomsma & Brennan	2017	The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity	Journal of Industrial Ecology
Böckel et al	2021	Blockchain for the Circular Economy: Analysis of the Research-Practice Gap	Sustainable Production and Consumption
Brandão et al	2021	Circular Bioeconomy Strategies: From scientific research to commercially viable products	Journal of Cleaner Production

Bressanelli et al	2018	Challenges in supply chain redesign for the Circular Economy: A Literature Review and a multiple case study	International Journal of Production Research
Bressanelli et al	2022	Circular economy and the evolution of Industrial Districts: A supply chain perspective	International Journal of Production Economics
Bröring et al	2020	Innovation types in the Bioeconomy	Journal of Cleaner Production
Burke et al	2021	Integrating product design and supply chain management for a circular economy	Production Planning & Control
Carraresi et al	2018	Emerging value chains within the Bioeconomy: Structural changes in the case of phosphate recovery	Journal of Cleaner Production
Cerca et al	2022	Strategic planning of bio-based supply chains: Unlocking bottlenecks and incorporating social sustainability into Biorefinery Systems	Sustainable Production and Consumption
Christensen et al	2022	Bridging modelling and policymaking efforts to realize the European bioeconomy.	GCB Bioenergy
Colasante & D'Adamo	2021	The circular economy and bioeconomy in the fashion sector: Emergence of a "sustainability bias"	Journal of Cleaner Production
Correll et al	2014	Logistical supply chain design for bioeconomy applications	Biomass and Bioenergy
Cristóbal et al	2018	Techno-economic and profitability analysis of food waste biorefineries at European level.	Bioresource Technology

Cristóbal et al	2016	Environmental sustainability assessment of bioeconomy value chains	Biomass and Bioenergy
D'Amato et al	2020	Reviewing the interface of Bioeconomy and Ecosystem Service Research	Ambio
D'Amato & Korhonen	2021	Integrating the green economy, circular economy and bioeconomy in a strategic sustainability framework	Ecological Economics
D'Amato et al	2017	Green, circular, Bio Economy: A Comparative Analysis of Sustainability Avenues	Journal of Cleaner Production
De Angelis et al	2018	Supply Chain Management and the circular economy: Towards the circular supply chain	Production Planning & Control
De Lima	2022	#circular economy – a Twitter analytics framework analyzing Twitter data, drivers, practices, and sustainability outcomes	Journal of Cleaner Production
De Lima et al	2021	A systematic literature review exploring uncertainty management and sustainability outcomes in circular supply chains	International Journal of Production Research
Devanery	2018	Consensus, caveats and conditions: International learnings for Bioeconomy Development	Journal of Cleaner Production
Di Foggia & Beccarello	2021	Designing waste management systems to meet circular economy goals: The Italian case	Sustainable Production and Consumption
Egea et al	2021	Bioeconomy as a transforming driver of intensive greenhouse horticulture in SE Spain	New Biotechnology

Elia et al	2017	Measuring Circular Economy Strategies Through Index Methods: A Critical Analysis	Journal of Cleaner Production
Falcone et al	2020	Towards a sustainable forest-based bioeconomy in Italy: Findings from a SWOT analysis	Forest Policy and Economics
Fernández et al	2021	Bi-objective optimization of multiple agro-industrial wastes supply to a cogeneration system promoting local circular bioeconomy	Applied Energy
Fiallos-Cárdenas et al	2022	Prospectives for the development of a circular bioeconomy around the banana value chain	Sustainable Production and Consumption
Geissdoerfer et al	2018	Business models and supply chains for the circular economy	Journal of Cleaner Production
Geissdoerfer et al	2020	Circular business models: A Review	Journal of Cleaner Production
Geissdoerfer et al	2017	The Circular Economy – A new sustainability paradigm?	Journal of Cleaner Production
Geissdoerfer et al	2018	Sustainable business model innovation: A review	Journal of Cleaner Production
Ghisellini et al	2016	A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	Journal of Cleaner Production
Giampietro	2019	On the Circular Bioeconomy and Decoupling: Implications for Sustainable Growth	Ecological Economics

Govindan & Hasanagic	2018	A systematic review on drivers, barriers, and practices towards Circular Economy: A Supply Chain Perspective	International Journal of Production Research
Hailemariam & Erdiaw-Kwasie	2022	Towards a circular economy: Implications for emission reduction and environmental sustainability	Business Strategy and the Environment
Heimann	2019	Bioeconomy and SDGs: Does the Bioeconomy Support the Achievement of the SDGs?	Earth's Future
Henchion & Shirsath	2022	Developing and implementing a transdisciplinary framework for future pathways in the circular bioeconomy: The case of the Red Meat Industry	Journal of Cleaner Production
Hobson	2015	Closing the loop or squaring the circle? locating generative spaces for the circular economy	Progress in Human Geography
Homrich et al	2018	The Circular Economy Umbrella: Trends and gaps on integrating pathways	Journal of Cleaner Production
Ilić & Nikolić	2016	Drivers for development of circular economy – a case study of Serbia	Habitat International
Jander & Grundmann	2019	Monitoring the transition towards a bioeconomy: A general framework and a specific indicator.	Journal of Cleaner Production
Kalmykova et al	2018	Circular economy – from review of theories and practices to development of Implementation Tools	Resources, Conservation and Recycling
Kennedy & Linnenluecke	2022	Circular economy and Resilience: A Research Agenda	Business Strategy and the Environment

Kirchherr & Hekkert	2017	Conceptualizing the circular economy: An analysis of 114 definitions	Conservation and Recycling
Lahane et al	2020	Circular Supply Chain Management: A state-of-art review and future opportunities	Journal of Cleaner Production
Lavelli	2021	Circular food supply chains – Impact on value addition and safety	Trends in Food Science & Technology
Lewandowski	2015	Securing a sustainable biomass supply in a growing bioeconomy	Global Food Security
Lieder & Rashid	2016	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	Journal of Cleaner Production
Liu et al	2021	Sustainable blueberry waste recycling towards Biorefinery Strategy and Circular Bioeconomy: A Review	Bioresource Technology
Loiseau et al	2016	Green economy and related concepts: An overview	Journal of Cleaner Production
Lüdeke-Freund et al	2018	A review and typology of circular economy business model patterns	Journal of Industrial Ecology
MahmoumGonbadi et al	2021	Closed-loop supply chain design for the transition towards a circular economy: A systematic literature review of methods, applications and current gaps	Journal of Cleaner Production
Mak et al	2019	Sustainable food waste management towards circular bioeconomy: Policy review, limitations and opportunities	Bioresource Technology

Marcone et al	2022	Closing the gap between EU-wide national bioeconomy monitoring frameworks and Urban Circular Bioeconomy Development	Journal of Cleaner Production
Masi et al	2018	Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective	Production Planning & Control
Merli et al	2018	How do scholars approach the circular economy? A systematic literature review	Journal of Cleaner Production
Mertens et al	2019	Overcoming non-technical challenges in Bioeconomy Value-chain development: Learning from practice	Journal of Cleaner Production
Mobtaker et al	2021	A review on decision support systems for Tactical Logistics Planning in the context of forest bioeconomy	Renewable and Sustainable Energy Reviews
Moktadir et al	2022	Antecedents for circular bioeconomy practices towards sustainability of Supply Chain	Journal of Cleaner Production
Moraga et al	2019	Circular economy indicators: What do they measure?	Resources, Conservation and Recycling
Mustalahti	2018	The responsive bioeconomy: The need for inclusion of citizens and environmental capability in the forest based bioeconomy	Journal of Cleaner Production
Negri et al	2021	Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda	Business Strategy and the Environment
Nematollahi & Tajbakhsh	2020	Past, present, and prospective themes of sustainable agricultural supply chains: A content analysis	Journal of Cleaner Production

Okorie et al	2021	Circular business models in high value manufacturing: Five industry cases to bridge theory and Practice.	Business Strategy and the Environment
Parobek et al	2019	Changes in carbon balance of harvested wood products resulting from different wood utilization scenarios	Forests
Pelli et al	2017	Services in the forest-based bioeconomy – analysis of european strategies	Scandinavian Journal of Forest Research
Pomponi & Moncaster	2017	Circular economy for the built environment: A research framework	Journal of Cleaner Production
Popp et al	2021	Bioeconomy: Biomass and biomass-based energy supply and demand	New Biotechnology
Raimondo et al	2021	Moving towards circular bioeconomy: Managing olive cake supply chain through contracts	Sustainable Production and Consumption
Roy & Tu	2022	A review of system dynamics modeling for the Sustainability Assessment of Biorefineries.	Journal of Industrial Ecology
Sacchelli et al	2022	A geography-based decision support tool to quantify the circular bioeconomy and financial performance in the forest-based sector (r.forcircular)	European Journal of Forest Research
Saidani et al	2019	A taxonomy of circular economy indicators	Journal of Cleaner Production
Salvador et al	2022	How to advance regional circular bioeconomy systems? identifying barriers, challenges, drivers, and opportunities	Sustainable Production and Consumption

Santagata et al	2021	Food Waste Recovery Pathways: Challenges and opportunities for an emerging bio-based circular economy. A systematic review and an assessment	Journal of Cleaner Production
Sarkar et al	2022	Circular economy-driven two-stage supply chain management for nullifying waste	Journal of Cleaner Production
Scheiterle et al	2022	From commodity-based value chains to biomass-based value webs: The case of sugarcane in Brazil's Bioeconomy	Journal of Cleaner Production
Schipfer & Kranzl	2019	Techno-economic evaluation of biomass-to-end-use chains based on densified bioenergy carriers (dbecs)	Applied Energy
Sherwood	2020	The significance of biomass in a circular economy	Bioresource Technology
Starke et al	2022	Conceptualizing controversies in the EU Circular Bioeconomy Transition	Ambio
Sudusinghe & Seuring	2022	Supply Chain collaboration and sustainability performance in Circular Economy: A Systematic Literature Review	International Journal of Production Economics
Takala et al	2019	Shaping the concept of bioeconomy in participatory projects – an example from the post-graduate education in Finland	Journal of Cleaner Production
Talwar & Holden	2022	The limitations of bioeconomy LCA studies for understanding the transition to sustainable bioeconomy	The International Journal of Life Cycle Assessment
Ubando et al	2020	Biorefineries in circular bioeconomy: A comprehensive review	Bioresource Technology

Urbaniec et al	2021	Fostering Sustainable Entrepreneurship by Business Strategies: An explorative approach in the Bioeconomy	Business Strategy and the Environment
Urbinati et al	2017	Towards a new taxonomy of circular economy business models	Journal of Cleaner Production
Urmetzer et al	2020	Learning to change: Transformative knowledge for building a sustainable bioeconomy	Ecological Economics
Venkata et al	2016	Waste Biorefinery models towards Sustainable Circular Bioeconomy: Critical review and future perspectives	Bioresource Technology
Vinante et al	2021	Circular economy metrics: Literature review and company-level classification framework	Journal of Cleaner Production
Wei et al	2022	Knowledge mapping of Bioeconomy: A Bibliometric analysis	Journal of Cleaner Production
Wesseler & von Braun	2017	Measuring the bioeconomy: Economics and policies	Annual Review of Resource Economics
Wohlfahrt et al	2019	Characteristics of bioeconomy systems and sustainability issues at the territorial scale	Journal of Cleaner Production
Yadav et al	2020	Bioconversion of waste (water)/residues to bioplastics- a circular bioeconomy approach	Bioresource Technology
Zilberman et al	2018	Economics of Sustainable Development and the Bioeconomy	Applied Economic Perspectives and Policy

Zilberman et al	2019	Innovation-induced food supply chain design	Food Policy

Table 11- Data sample of the systematic literature review

Appendix B :

Journals	**Number of publications**
Journal of Cleaner Production	37
Bioresource Technology	7
Sustainable Production and Consumption	6
Business Strategy and the Environment	5
International Journal of Production Research	3
Resources, Conservation and Recycling	3
Journal of Industrial Ecology	3
Ecological Economics	3
Production Planning & Control	3
International Journal of Production Economics	2
Applied Energy	2

Ambio	2
New Biotechnology	2
Biomass and Bioenergy	2
Conservation and Recycling	1
Annual Review of Resource Economics	1
Applied Economic Perspectives and Policy	1
Land	1
Journal of Environmental Management	1
Global Food Security	1
Progress in Human Geography	1
Earth's Future	1
The International Journal of Life Cycle Assessment	1
European Journal of Forest Research	1
Renewable and Sustainable Energy Reviews	1
Food Policy	1
Scandinavian Journal of Forest Research	1
Forest Policy and Economics	1

Technological Forecasting and Social Change	1
Forests	1
Trends in Food Science & Technology	1
GCB Bioenergy	1
Habitat International	1
Total	**99**

Table 12- Complete Table of Journals per publication

Authors	**Number of articles**
Geissdoerfer	4
D'Amato	2
De Lima	2
Bressanelli	2
Cristóbal	2
Zilberman	2
Saidani	1

Merli	1
Vinante	1
Brandão	1
Okorie	1
Ayrapetyan	1
Sudusinghe	1
Bröring	1
MahmoumGonbadi	1
Burke	1
Moraga	1
Carraresi	1
Popp	1
Cerca	1
Scheiterle	1
Christensen	1
Urbaniec	1
Colasante	1

Böckel	1
Correll	1
Marcone	1
Barcelos	1
Mobtaker	1
D'Amato	1
Negri	1
Befort	1
Pelli	1
De Angelis	1
Roy	1
Blair	1
Santagata	1
Devanery	1
Sherwood	1
Di Foggia	1
Talwar	1

Egea	1
Urmetzer	1
Elia	1
Wesseler	1
Falcone	1
Lüdeke-Freund	1
Fernández	1
Mak	1
Fiallos-Cárdenas	1
Masi	1
Blomsma	1
Mertens	1
Ghisellini	1
Moktadir	1
Giampietro	1
Mustalahti	1
Govindan	1

Nematollahi	1
Hailemariam	1
Parobek	1
Heimann	1
Pomponi	1
Henchion	1
Raimondo	1
Hobson	1
Sacchelli	1
Homrich	1
Salvador	1
Ilić	1
Sarkar	1
Jander	1
Schipfer	1
Kalmykova	1
Starke	1

Kennedy	1
Takala	1
Kirchherr	1
Ubando	1
Lahane	1
Urbinati	1
Lavelli	1
Venkata	1
Yadav	1
Wei	1
Angouria	1
Wohlfahrt	1
Liu	1
Loiseau	1
Lewandowski	1
Lieder	1
Total	**99**

Table 13- Complete Table of authors per publication