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Responsible Production: A Systematic Review and Future Research Directions

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ABSTRACT

Responsible production (RP) aims to minimize negative consequences of active economic growth by producing and using resource-efficient and energy-efficient products and processes that have a minimal negative impact on the environment and are safe for employees, the community, and consumers. Despite the relevance of the RP concept, there are no systematic literature reviews containing thematic mapping and thematic evolution of research in this area. Therefore, this study aims to identify relevant research areas, research interests' current state and evolution, and potential future research directions on RP topics. A systematic review approach and content analysis were applied to achieve the study's aim. To conduct a systematic review, a search was carried out for keywords such as "responsible production" OR "sustainable production". Then, further filtering by such criteria as subject category, document type, and publication language took place. As a result, bibliographic data from 858 papers became a research basis for descriptive analysis. Data were derived from the Scopus database. The Biblioshiny tool was used for systematic review. Finally, the most relevant research areas were identified, including sustainable supply chains, consumer behavior in the context of RP, and the impact of Industry 4.0 on the realization of RP principles. According to the systematic review results, scientific activity in RP research has increased significantly. The role of supply chain management in achieving RP principles is notable. The environmental aspects of RP, environmental management, and environmental performance are particularly relevant.

KEYWORDS: Responsible Production, Sustainable Economic Growth, Sustainable Development, Thematic Mapping, Thematic Evolution

SCSTI: 06.52.13

JEL Code: Q20, Q32, Q50

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1. INTRODUCTION

Current production systems based on traditional practices and commercial technologies are generally unsustainable. The industrial sector, through its role in society, has contributed significantly to pollution and exploitation of the environment. The accelerated industrialization of most countries and the associated rapid environmental degradation have raised concerns about the unsustainability of current growth patterns (Tseng et al., 2013). The concept of responsible production is aimed at mitigating the harmful environmental and social consequences of economic activity through the manufacture of products and services, the use of processes and systems that generate a minimum of harmful emissions, save energy and natural resources, are economically feasible, safe for employees, the community and consumers and provide favorable social and creative conditions for the entire working population (The Lowell Center Framework for Sustainable Products, 2009).

Despite the undoubted relevance of the responsible production concept, there is a lack of systematic literature reviews containing descriptive analysis, thematic evolution, and mapping of the present state of research on this topic. The current review aims to fill these gaps by applying descriptive bibliographic analysis containing thematic mapping and thematic evolution. Additionally, the existing reviews along with the concept of responsible production deal with the concept of responsible consumption. The current review focuses only on the responsible production concept. Besides, the environmental aspects of responsible production are the primary research object in existing reviews. This review seeks to cover both the environmental and social aspects of responsible production.

Therefore, this study aims to undertake a systematic literature review that contains a descriptive part and content analysis. The R-package Bibliometrix, Biblioshiny tool (Aria & Cuccurullo, 2017; Biblioshiny) was applied for the descriptive part of the review. The aim of the current research is to identify relevant research areas, research interests' current state and evolution, and potential future research directions on responsible production topics. The research question identified was “What is the current focus of scientific interest in responsible production research?”

In order to provide an answer to this research question, the structure of the current paper is as follows: the data collection and sampling methodology is reflected in Section 2. The research results and discussion are presented in Section 3 by building thematic maps and networks, identifying thematic evolution, and content analysis of the most influential papers. Section 4 provides conclusions and future research directions.

2. LITERATURE REVIEW

A few papers have conducted literature reviews on the concept of responsible production. For instance, Roy and Singh (2017) conducted systematic literature review on sustainable production and consumption (SPaC). They revealed the business focus in SPaC literature revolving around five critical themes like the conceptualization of SPaC, the governing role of policy frameworks in the initiation and focus in SPaC literature, the guidance of SPaC transformation, strategic implementation issues, operational implementation issues and maintaining the progress of implementation. However, Roy and Singh (2017) did not include bibliographic analysis in the form of a co-occurrence network, thematic evolution, and thematic mapping in their review. Moreover, as part of the review, the authors consider sustainable production and sustainable consumption concepts together. The authors use “sustainable production” as a keyword for publication searches, thus focusing mainly on the environmental aspects of responsible production.

Bonvoisin et al. (2017) provided a structured overview of the research field in sustainable manufacturing with a particular focus on manufacturing technology and management. The authors highlighted

challenges in four research areas, mainly manufacturing technologies, product development, value creation networks, and global manufacturing impacts. In their study, the authors focus on the technological aspect of sustainable production. Moreover, the review does not contain a descriptive analysis in the form of thematic mapping and thematic evolution analysis.

Lukman et al. (2016) conducted a content analysis of 13 papers that focus on sustainable consumption and production (SCP), identified further challenges, and provided solutions related to resource efficiency (ReE), sustainable water systems, sustainable management, cleaner production (CP), and sustainable urban development. However, there is no bibliographic and descriptive analysis in their research. Also, within the framework of this review, the authors consider the concepts of sustainable production and consumption concurrently.

Thus, a few available reviews on sustainable production do not contain a descriptive bibliographic analysis, including thematic maps and thematic evolution. Moreover, the existing reviews consider the concepts of responsible production together with the concept of responsible consumption, and focus mainly on the environmental aspects of responsible production. The current review seeks to fill these gaps by applying descriptive bibliographic analysis containing thematic mapping and thematic evolution. In addition, this study considers both aspects of responsible production, namely environmental and social.

2. METHODOLOGY

The methodology of the systematic literature review is based on various established practices in the field of bibliometrics and systematic review.

1. Systematic Literature Review - is commonly used in various academic fields to synthesize the research on a given topic comprehensively. It involves a structured search and selection process to collect relevant literature and critically analyze its content. This approach is influenced by the general principles outlined in academic works on conducting systematic reviews.

2. Descriptive Bibliographic Analysis includes techniques such as thematic mapping, thematic evolution, and co-occurrence networks. These methods are rooted in bibliometrics and scientometrics, fields that study the quantitative aspects of academic literature. Thematic mapping and thematic evolution are methods used to visualize the development and relationships between themes in a body of literature over time. Co-occurrence networks visualize how key terms or concepts within a literature corpus relate to one another.

3. Content Analysis of Influential Papers is based on citation counts to analyze their content is a common method in bibliometric studies. It helps identify the most impactful studies within a field or topic and analyze trends and patterns in research themes.

4. Use of Biblioshiny for Descriptive Analysis is an application of the R-package 'Bibliometrix', which is specifically designed for comprehensive science mapping analysis. This tool supports the implementation of the bibliometric and scientometric methods mentioned above, providing capabilities for data visualization and analysis that are integral to systematic reviews in academic research.

The overall methodology is influenced by the need for a comprehensive and systematic approach to analyze literature on responsible and sustainable production. The combination of systematic literature review techniques with bibliometric analysis tools allows for a detailed exploration of both the environmental and social aspects of production, aiming to fill gaps identified in previous literature reviews. Such an approach is aimed at ensuring that the findings are robust, reproducible, and provide a clear picture of the current state of research in the field.

The initial search results, in the context of current study, included articles published up to and including February 2024. The basic search query applied keywords such as “responsible production" OR "sustainable production". As a result, 13,168 papers were generated.

Along with “responsible production", we used the keyword “sustainable production”, which is tightly linked to the responsible production concept and is commonly used in the scientific literature. The responsible production concept is aimed at studying both the environmental and social aspects of production, while the sustainable production concept focuses mainly on environmental issues (Alayón et al., 2017). Thus, the inclusion of the word “sustainable production” along with “responsible production” in the search query is explained by the intention to fully consider both the environmental and social aspects of responsible production and ensure the most comprehensive coverage of publications.

A brief reflection of key analysis stages is depicted in Figure 1. The search query in the Scopus database was conducted within the title of the article, the abstract, and keywords. Then, the obtained results were restricted to business, management, and accounting subject categories; this step generated 1,231 papers. Article or review document type selection was the next stage, which gave 913 outcomes. The last stage was publication language choice, for review papers in English were chosen. This step yielded 858 papers, and this final sample was the focus of a descriptive analysis. Biblioshiny software was used for descriptive analysis.

For content analysis, 15 most influential papers (according to total citations) were selected (Annex 1).

The systematic literature review is comprised of two distinct sections. Initially, the review undertakes a descriptive analysis, which utilizes a substantial collection of 858 papers sourced from the Scopus database. This analysis encompasses several fundamental components, including the co-occurrence network, thematic mapping, and thematic evolution, among others.

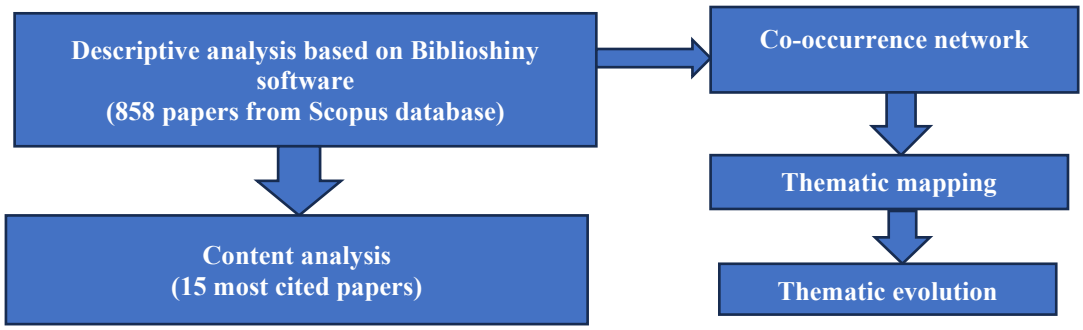

FIGURE 1. Stages of analysis

Note: compiled by authors

Subsequently, the second section of the review focuses on content analysis, which is conducted on the 15 most cited papers, as determined by their total citation count. This methodical approach ensures a comprehensive examination of the existing literature.

3. FINDINGS AND DISCUSSIONS

The current section of the review contains a descriptive analysis followed by a content analysis. The descriptive analysis is based on the selection of 858 articles derived from the Scopus database.

The descriptive analysis reveals the dynamics of scientific production in the studied field (Figure 2), the core journals involved in the study of responsible production (Figure 3, Figure 4), and the scientific influence of countries in the field of responsible production (Figure 5, Figure 6). Also, within the framework of the descriptive analysis, trend topics, the current state and evolution of scientific interests in the field of responsible

production in the form of thematic maps are identified. Figure 2 shows the dynamics of annual scientific production on responsible production.

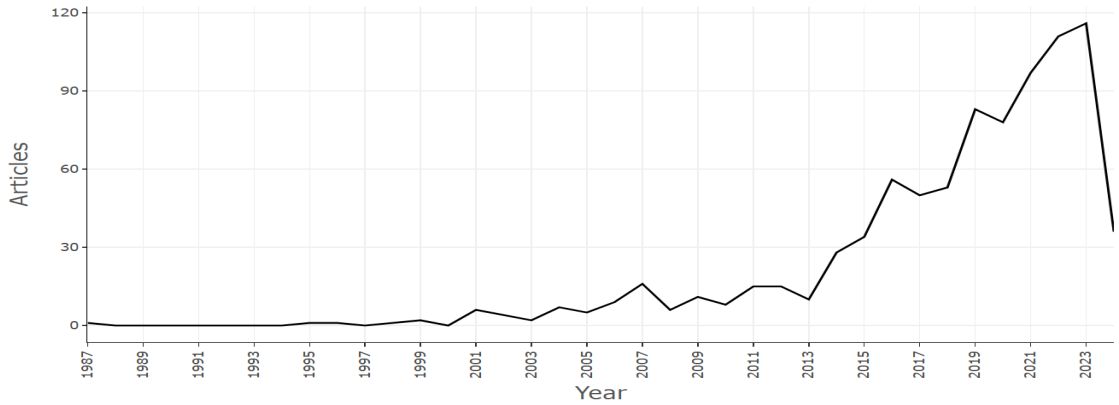

FIGURE 2. Annual scientific production

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Annual scientific production

The graph shows that from 1987 to 2000, there were almost no articles on this topic, except occasional articles appearing in some years. The next period on the graph from 2001 to 2013 is characterized by a smooth and stable increase in publication activity on responsible production, which indicates the gradually increasing scientific interest in this topic. During this period, the number of publications averaged about 10, with peak publication activity in 2007. After 2013, there has been an explosive increase in the number of publications on responsible production. In 2014, more studies were published than in the previous two years. This trend of steady and steep publication activity growth occurred until 2023. It will likely continue in 2024: 36 articles have already been published in the first quarter of 2024, as in 2015.

Core sources are shown in Figure 3 and Figure 4. Figure 3 shows most relevant sources.

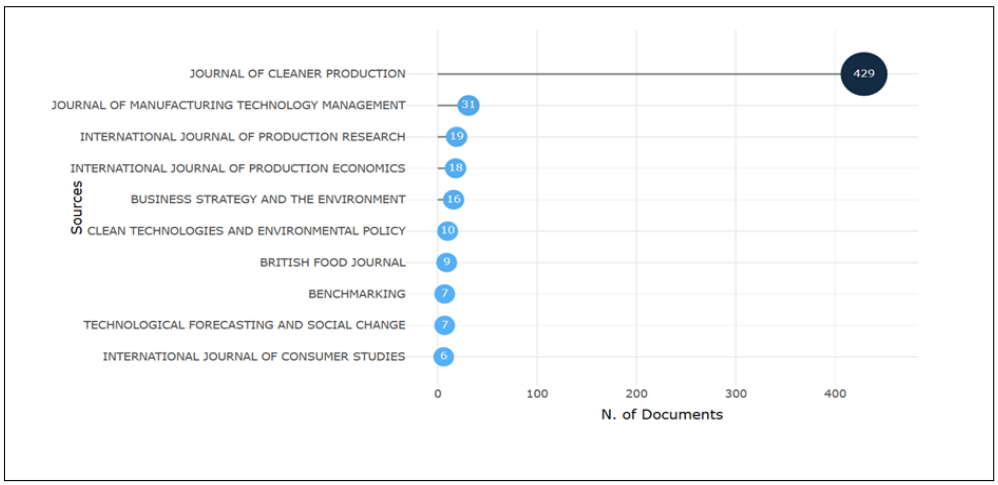

FIGURE 3. Most relevant sources

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Most relevant sources

The publication core of the topic is the Journal of Cleaner Production. It contains half of the entire analyzed collection. By a considerable margin, with 31 publications on the topic, the Journal of Manufacturing Technology

Figure 4 shows core sources by Bradford's Law.

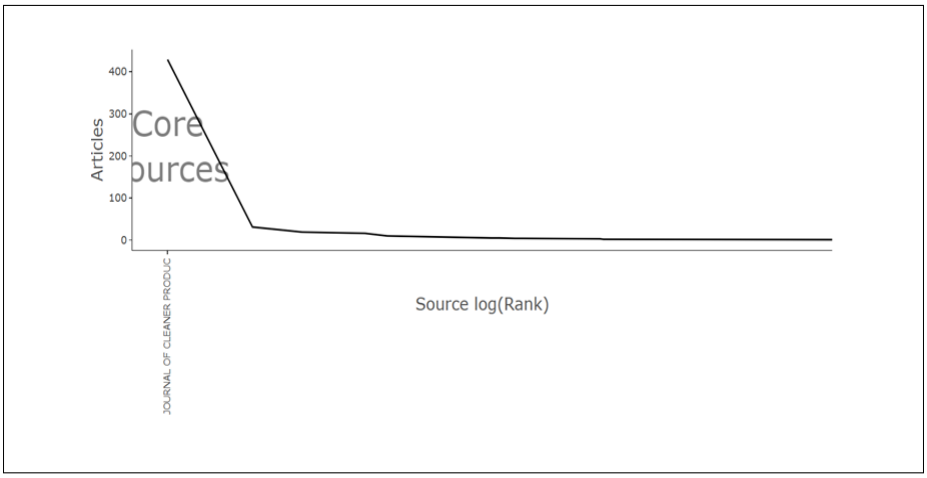

FIGURE 4. Core sources by Bradford's Law

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Management is in second place. The top five relevant sources included the International Journal of Production Research, the International Journal of Production Economics, Business Strategy, and the Environment.

The geographical influence of research on responsible production is reflected in Figure 5 and Figure 6. Next in Figure 5 there is data on citations by country.

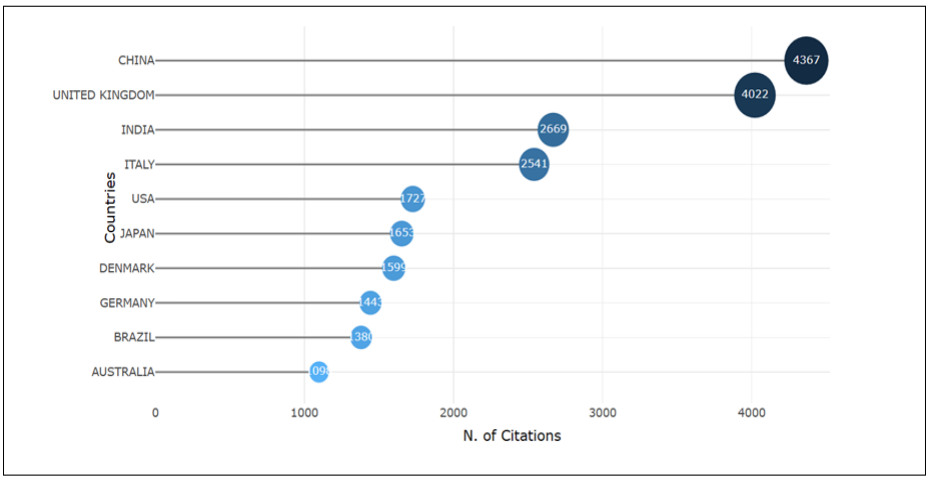

FIGURE 5. Total number of citations per country

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Geographical influence of research

These figures reflect the countries with the most citations by two indicators: the total number of citations and the average number of citations per publication. Regarding total citations, China and the UK are the leading countries. Each of these countries individually accounts for about 4 thousand citations. India and Italy are next in terms of the total number of citations: the studies of these countries have been cited about 2,500 times in total. This may indicate that research on responsible production is actively being conducted in the countries mentioned above, and these studies contribute to the analyzed area. However, total citations may not adequately reflect the impact of published research.

Next in Figure 6 there is data on average citations by country.

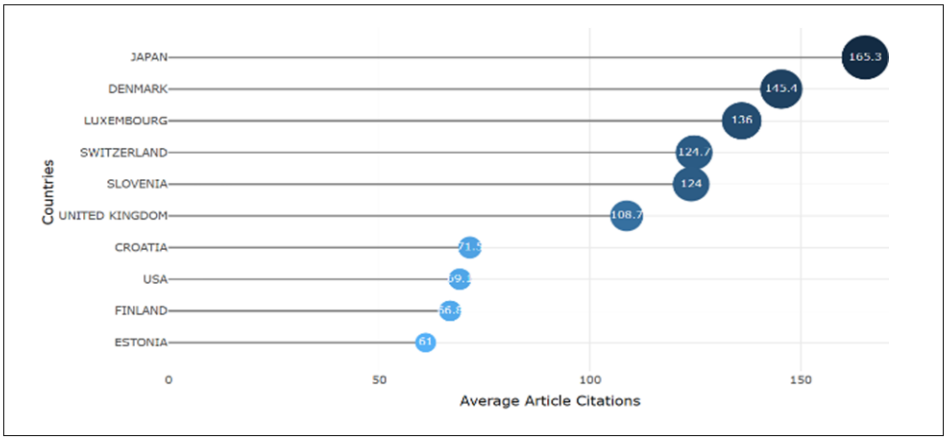

FIGURE 6. Average article citations per country

Note: compiled by authors based on Bibliometrix Biblioshiny tool

The indicator of the average number of citations per publication considers the number of publications and, therefore, can reflect the impact of published research more adequately. In terms of the average number of citations per publication, other countries are already leading, particularly Japan, Denmark, Luxembourg, Switzerland, Slovenia, and the UK. In these countries, on average, one publication was cited more than 100 times, indicating a relatively high impact of research on responsible production in these countries.

Next in Figure 7 there is data on Most relevant affiliations.

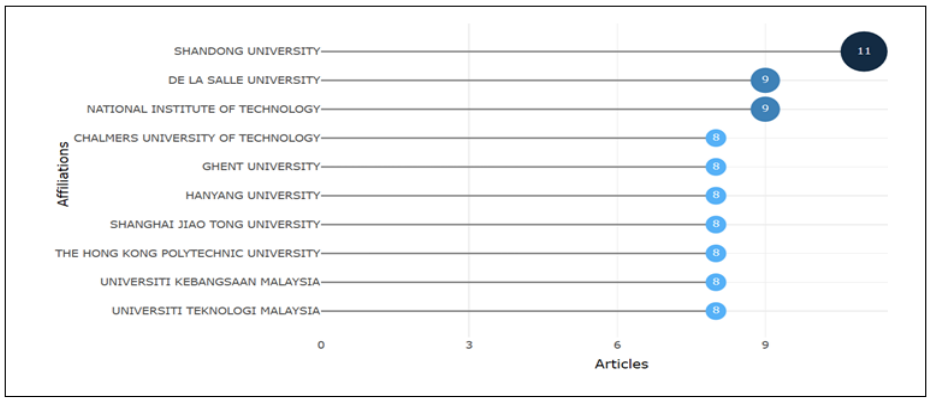

FIGURE 7. Most relevant affiliations

Note: compiled by authors based on Bibliometrix Biblioshiny tool

As for the most relevant affiliations, Shandong University has the most significant number of publications on responsible production; the second and third places are occupied by De La Salle University and the National Institute of Technology (Figure 7).

The intensity of the international collaboration is reflected in Figure 8. The most intensive collaboration takes place in Australia. There, out of 40 publications, 25 studies were conducted jointly with scientists from other countries. In Belgium, 11 out of 15 studies cooperated with foreign scientists. China and Canada performed half of their research jointly with foreign scientists.

The least intensive international collaboration is observed in the United Kingdom: out of 37 publications, only three were conducted jointly with foreign scientists. Out of 25 studies on responsible production in the USA, only two were conducted jointly with foreign scientists. The situation is similar in Spain, Sweden, Malaysia, the Netherlands, and Turkey.

Figure 8 presents the number of documents by country and type of collaboration.

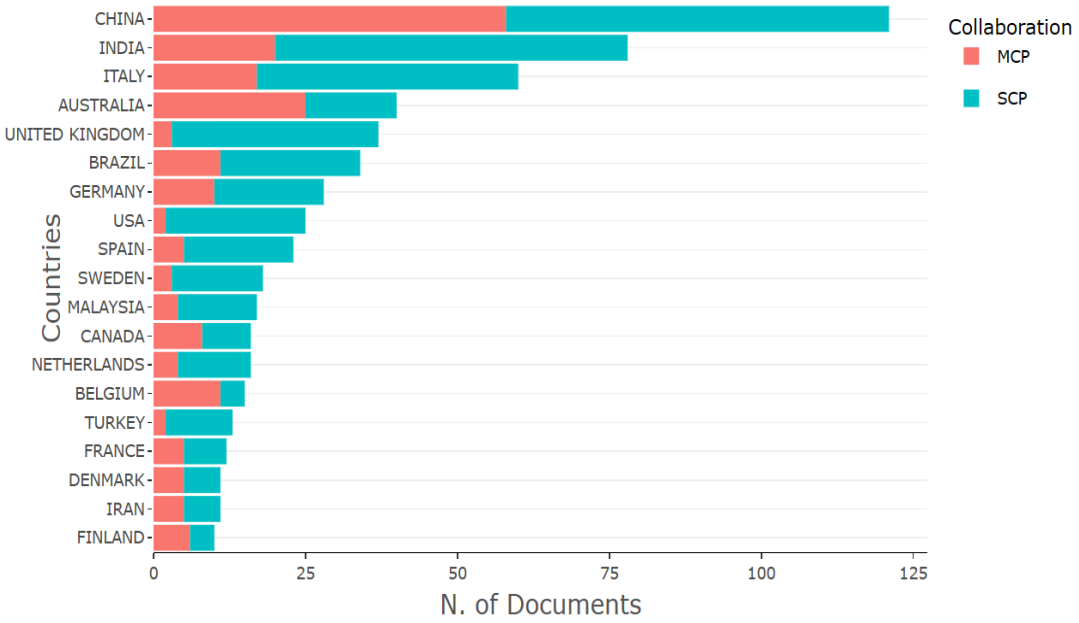

FIGURE 8. Corresponding author's country

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Figure 9 reflects trend topics in the field of responsible production for the period from 2008 to 2024. Topics such as agriculture, production, and environment remain relevant throughout the analyzed period, indicating these topics' fundamental nature. The key ones were the terms sustainable production and sustainability, occurring 171 and 111 times, respectively, in the analyzed collection. The circular economy, as a concept closely related to responsible production, has also become one of the trend topics. Life cycle assessment, sustainable consumption, supply chain management are the topics that were relevant up to 2021. Certification as an integral mechanism for ensuring responsible production was widespread between 2011 and 2018. Industry 4.0, renewable energy, additive manufacturing – all these topics are gaining relevance since 2022.

Figure 9 describes trend of research terms over time (2008-2024).

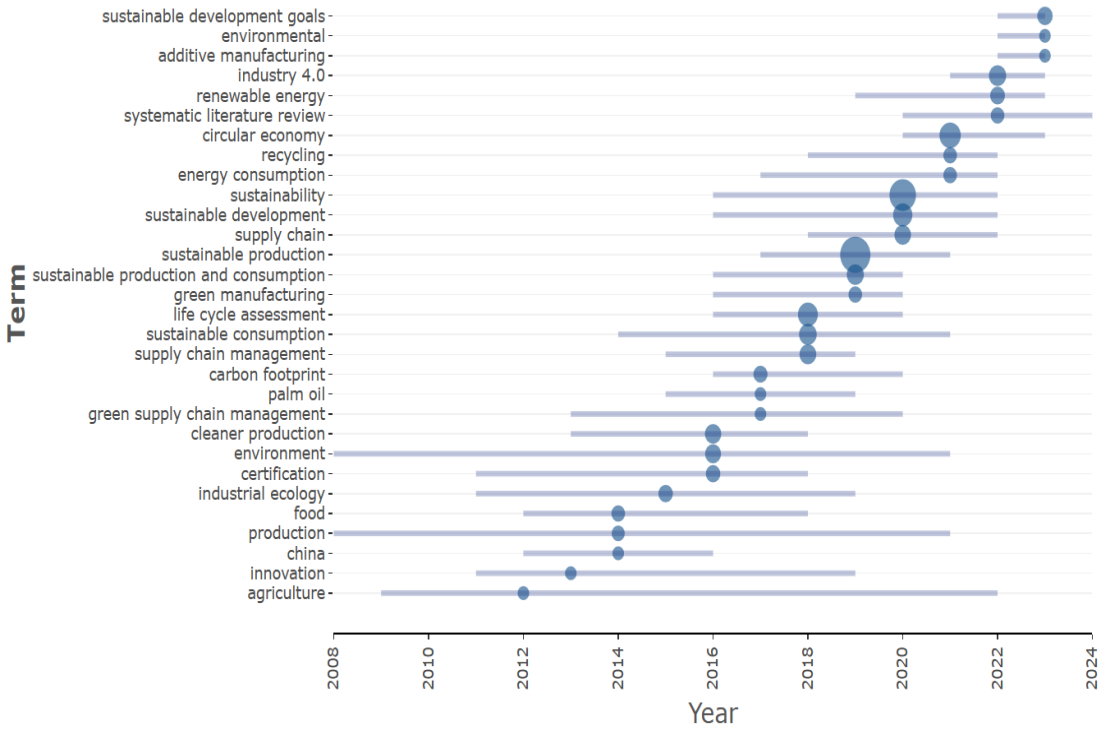

FIGURE 9. Trend topics

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Three fields plot

A three-field plot reflects the interrelation of paper elements (Zhidebekkyzy et al., 2022). For example, figure 10 displays the specialization of countries and journals in exploring a definite area of responsible production.

The bulk of research outputs identified in the study originates from countries such as China, Italy, India, and the United Kingdom, highlighting their active participation in this domain. Brazil and Malaysia also emerge as significant contributors, especially among the developing nations, showcasing their growing involvement in sustainability research.

Delving deeper into the attribute interconnections, China exhibits a remarkably broad and integrated approach to the study of responsible production. This nation engages comprehensively in the field, from exploring the foundational principles of sustainable production to investigating its practical implications and technologies, including life cycle assessment, Industry 4.0 applications, and supply chain management intricacies.

In contrast, Germany appears more selective, focusing predominantly on advanced technological aspects rather than the broader scope of sustainable production. The country shows a particular interest in Industry 4.0, reflecting its advanced industrial base and technological prowess.

Italy, meanwhile, has carved a niche in exploring the life cycle assessment aspect of responsible production, reflecting its commitment to detailed environmental impact studies. India, similar to Germany, shows a strong inclination towards integrating Industry 4.0 technologies within the framework of responsible production, indicating a strategic focus on modernizing its manufacturing sectors.

Furthermore, supply chain management within the context of responsible production

attracts substantial scholarly attention, particularly from researchers in Australia, the UK, the USA, and Italy. This focus underscores the global importance of optimizing supply chain operations to enhance sustainability across industries.

The Journal of Cleaner Production stands out as a premier publication venue, leading in disseminating diverse research encompassing all dimensions of responsible production. This journal's prominence underscores its pivotal role in shaping discourse and advancing research in the field of sustainability and responsible production practices.

Figure 10 describes the mapping of research contributions by country, topic, and journal.

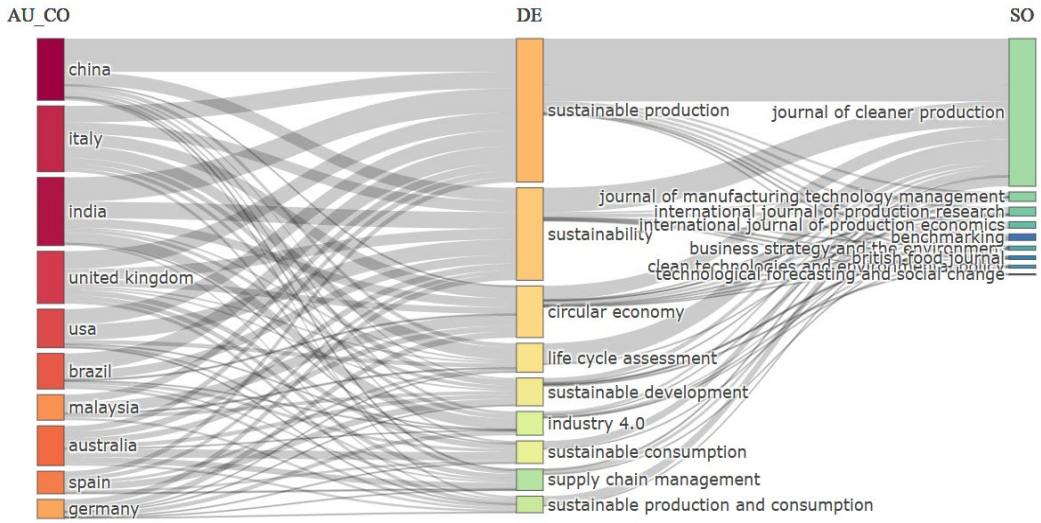

FIGURE 10. Three-fields plot

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Co-occurrence Network

R-package Bibliometrix with the Biblioshiny tool was applied to build a co-occurrence network. The author's keywords with Walktrap clustering algorithm were used.

The basic, central, and largest cluster is "Sustainable production". There are four critical clusters on the co-occurrence network (see Figure 11).

FIGURE 11. Co-occurrence Network

Note: Compiled by authors based on Bibliometrix Biblioshiny tool

The second largest cluster, closely related to the "Sustainable production" node, is the circular economy cluster. The concept of CE is essential for achieving responsible production. There is a close relationship between CE cluster and Industry 4.0 which lets assume the critical role of Industry 4.0 tools in applying CE principles. Barriers, waste management, food waste are located within a cluster of CE, which indicates an active study of barriers to CE and special scientific attention to food waste management.

The next cluster is the life cycle assessment. Keywords such as sustainable production and consumption, climate change, environmental impact, and environmental sustainability are inside the cluster. This cluster is most likely studying how to achieve sustainable production and consumption, environmental sustainability, and prevent climate change with the help of the life cycle assessment concept.

Sustainable development has been allocated to a separate cluster. This cluster focuses on corporate social responsibility, social responsibility, and responsible consumption. Whereas previous clusters focused on the environmental aspects of responsible production, the sustainable development cluster focused on the aspects of social responsibility.

Thematic map

Figure 12 shows the current state-of-the-art of responsible production research.

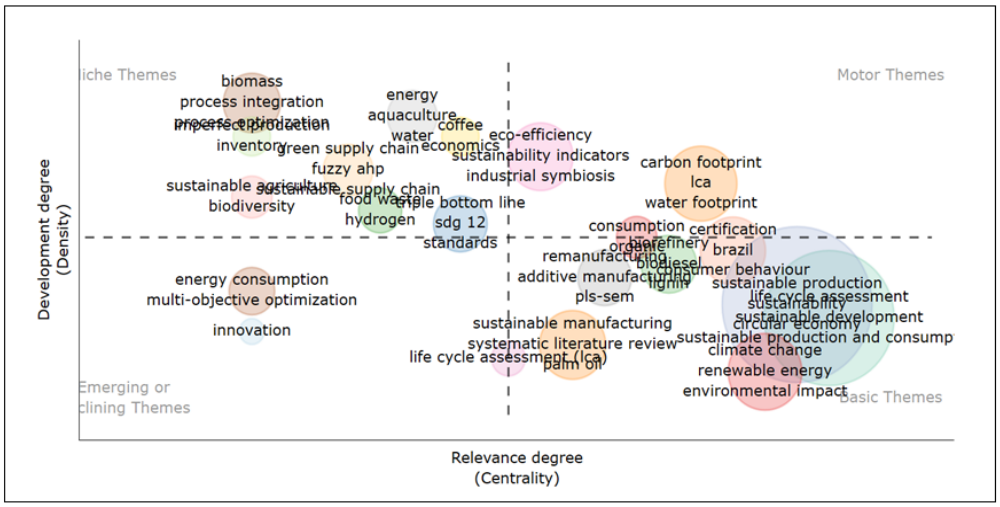

FIGURE 12. Thematic map

Note: compiled by authors based on Bibliometrix Biblioshiny tool

The author's keywords were applied to reflect the thematic map, and a minimum cluster frequency of 5 points was set. Besides, a total data sample of 858 papers was taken for the thematic mapping.

The map has two dimensions: centrality (x-axis) and density (y-axis). Centrality refers to how important a particular theme is, while density refers to the development of the theme. The 2×2 matrix in the thematic map yields four quadrants, where the size of the bubble refers to the occurrence of the keywords (Madsen et al., 2023).

In the upper right quadrant, we find the motor themes that are the most discussed topics in the field. About responsible production research field, motor themes are carbon footprint, life cycle analysis and water footprint. Inside the "carbon footprint" cluster are two other keywords: crop production and wine. At the stage of transition to the category of motor themes are eco-efficiency, sustainability indicators, and industrial symbiosis, as well as product design and

sustainable consumption and production.

In the lower right quadrant, we find the themes considered basic and transversal, with low levels of development but high levels of centrality and relevancy to the responsible production literature. According to the map, the largest primary cluster is "sustainable production". It consists of such keywords as sustainability, circular economy, sustainable consumption, industry 4.0, supply chain management, cleaner production, energy efficiency, optimization, and environmental performance. The second largest basic cluster is the "life cycle assessment" cluster, which, among other things, contains keywords such as "waste management" and "industrial ecology". Among other basic themes are climate change, renewable energy, sustainable manufacturing, remanufacturing, and biorefinery. Keywords such as certification, Brazil, consumer behaviour, consumption are likely to become motor themes. Life cycle assessment is going to turn into a central topic.

In the lower left quadrant, the emerging or declining themes are situated. These are energy consumption, multi-objective optimization, and innovation.

The upper left quadrant consists of niche themes, which are well-developed but isolated (niche) or highly specialized themes. Niche clusters include biomass, process integration, process optimization, and process simulation. Among niche themes are energy, green supply chain, sustainable agriculture, food waste, coffee, triple bottom line, and standards.

Thematic evolution

Thematic evolution reveals changes in theme temporal development (see Figure 13).

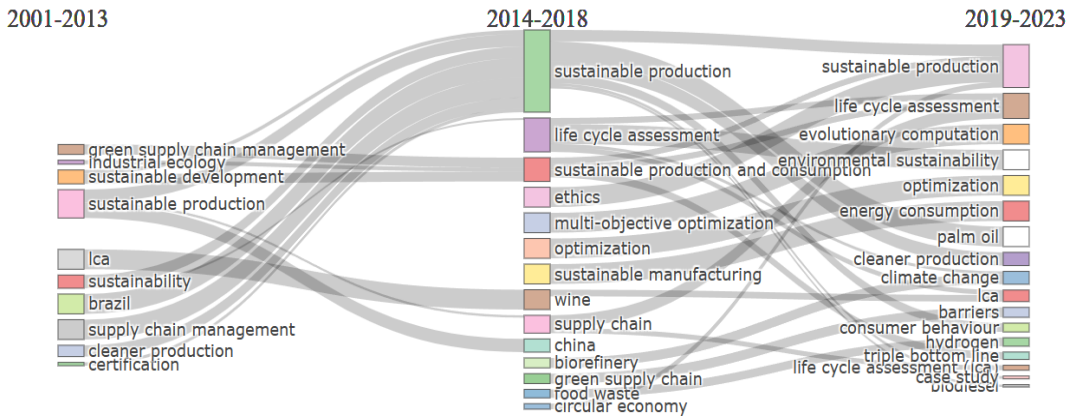

FIGURE 13. Thematic evolution

Note: compiled by authors based on Bibliometrix Biblioshiny tool

The period from 2001 to 2023 was taken to form the thematic evolution. The period from 1987 to 2000 was removed because, during this period, the number of publications was insignificant. The year 2024 was deleted because this year began recently, and the picture of publication activity is incomplete.

The dataset was divided into three time periods. The degree of publication activity was chosen as a key criterion for defining time slices. The first time slice (2001-2013) is characterized by a smooth and barely noticeable increase in publication activity. The period from 2014 to 2023 is characterized by explosive growth in publication activity (Figure 1), and it was decided that this period should be divided into two equal time intervals.

The author's keywords that appeared at a minimum seven times (min Freq.) per subperiod were reflected in the formed three thematic maps (Figures 13-15). In each thematic map, the y-axis evaluates the density, and the x-axis evaluates the centrality of the defined themes. The spheres' size corresponds

to the keywords' cumulative frequency (Schöggl et al., 2020).

From 2001 to 2013, the most relevant keywords were sustainable production, supply chain management, life cycle assessment, and Brazil. In the period 2014 to 2018, the topic of sustainable production was split into three topics: sustainable production, China, and supply chain. During this period, particular attention was given to supply chain management, and China's role in the issue of responsible production was highlighted separately. LCA has moved to wine, reflecting the importance of production management at every stage of the product lifecycle using the example of winemaking.

Brazil and supply chain management were united in a theme of "sustainable production," which suggests that in 2014-2018, supply chain management issues began to be considered within the framework of the responsible production concept, and Brazil became more active in studying responsible production issues.

Besides cleaner production, certification were also incorporated in sustainable production.

From 2014 to 2018, the key topics continued to be sustainable production, life cycle assessment.

The topic "sustainable production and consumption" has appeared among the key topics during this period. This fact may indicate an awareness during this period of the close relationship between responsible production and responsible consumption and the importance of the consumer's role in achieving responsible production principles.

Other essential topics from 2014 to 2018 were ethics, multi-objective optimization, sustainable manufacturing, and wine.

From 2019 to 2023, key research areas remain sustainable production, life cycle assessment. New areas such as evolutionary computation, environmental sustainability, optimization, energy consumption, and palm oil are added. Besides, life cycle assessment was included in environmental sustainability, which indicates the increasing role of the life cycle assessment concept in achieving environmental sustainability. Sustainable manufacturing strengthened its connection with energy consumption, which is reflected in the transition of sustainable manufacturing to the field of energy consumption. The cleaner production concept has again detached itself into an independent field of research after merging with the sustainable production concept in 2014-2018. LCA and biorefinery were incorporated into climate change, and the green supply chain moved into barriers. Such a thematic evolution suggests an increase in scientific interest in studying the impact of LCA and biorefinery on climate change, as well as an increase in the relevance of studying barriers to achieving a green supply chain. Consumer behavior has emerged from sustainable production into a separate area, indicating the formation of a self-standing scientific direction studying consumer behavior in the context of responsible production. In addition, food waste has been transformed into hydrogen, indicating the relevance of studying hydrogen production from food waste.

Responsible production research between 2001 and 2013

Next, in Figure 14 there is provided data on responsible production between 2001 and 2013.

Sustainable development and waste management are this period's basic and fundamental topics. The two most significant motor clusters, characterized by both high relevance and high development, are sustainable production, which includes sustainable consumption and food, and sustainability, which includes environment, agriculture, and life cycle assessment.

From this, it can be concluded that in the period 2001-2013, the scientific community was intensively involved in problems of responsible production and consumption with an emphasis on the food industry and agriculture, as well as mainly considering environmental concerns. Other reasonably large clusters in this period are certification and industrial ecology.

They are both closely related to the sustainable production and sustainability clusters. Another small-sized motor cluster is green supply chain management. The eco-efficiency cluster is characterized by low relevance but high development, which made it possible to classify it as a niche topic. This suggests that the issues of eco-efficiency indicators and their assessment have already been studied by scientists during this period but were not so relevant. The clusters' cleaner production, innovation, and LCA belong to emerging themes (Figure 14).

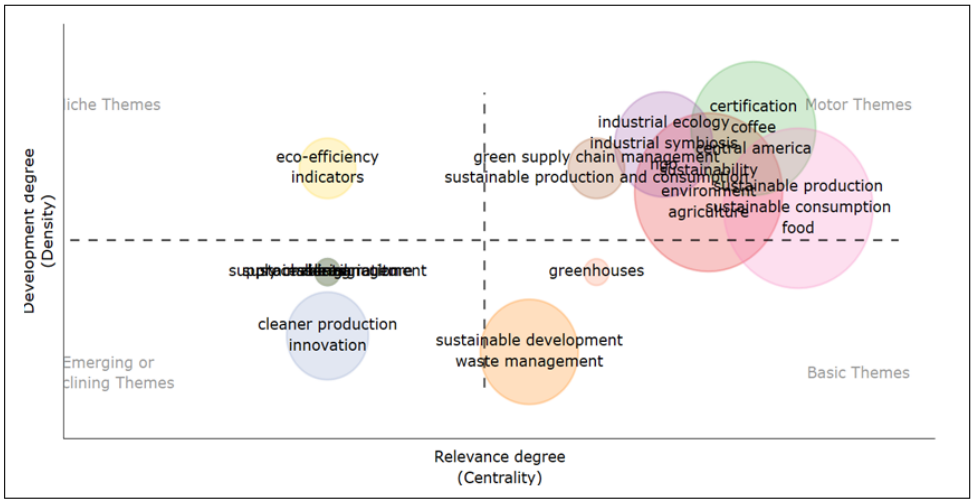

FIGURE 14. Thematic map of responsible production research between 2001 and 2013

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Responsible production research between 2014 and 2018

During this period, the keywords sustainable production and sustainable consumption merged and formed a single cluster of sustainable production and consumption. Such a merger indicates that these two concepts began to be studied in an inextricable connection. However, this combined cluster has moved from the category of motor topics to the category of basic ones, maintaining high relevance but losing its sophistication. This may be due to the emergence of new topics and concepts within the vast field of responsible production. Within the cluster of sustainable production and consumption, the keyword corporate social responsibility appeared, indicating that corporate social responsibility issues began to be considered within the framework of the responsible production concept. In addition, energy efficiency is also located inside the sustainable production and consumption cluster. That is, during this period, special attention was paid to energy efficiency issues as a tool for achieving the principles of responsible production.

The next largest primary cluster from 2014 to 2018 is the life cycle assessment cluster, which includes keywords such as carbon footprint, climate change, environmental sustainability, and environmental impact. The remaining basic clusters are biorefinery, collaborative consumption, and optimization.

As for motor topics, the largest motor cluster is the cluster of sustainable production, where sustainability and supply chain management were included. Compared to the previous period, supply chain management topic has become more relevant, by increasing the number of occurrences from 2 to 11 and becoming part of the sustainable production cluster. The other three motor clusters are supply chain, circular economy, and wine. The

wine cluster contains keywords such as ecological footprint, land use, water footprint, and willingness to pay. The combination of such keywords in the same cluster indicates increased scientific interest in studying ecological and water footprint in the production processes. In addition, land use, as well as the willingness to pay a premium when buying products manufactured according to responsible production principles, are also gaining relevance. The food waste management cluster belongs to niche topics that are not yet very relevant but are actively being studied by scientists. This cluster contains keywords such as food waste, food surplus, waste prevention. Another niche topic is the green supply chain. Emerging or declining topics include sustainability indicators, stability, and China (Figure 15).

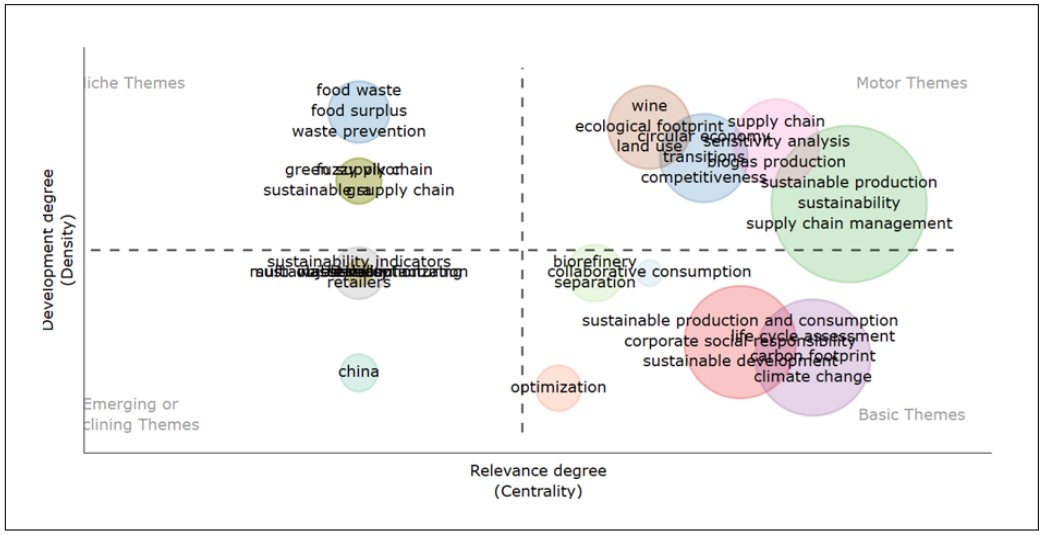

FIGURE 15. Thematic map of responsible production research between 2014 and 2018

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Responsible production research between 2019 and 2023

Next in Figure 16 there is provided data on responsible production between 2019 and 2023. The largest basic cluster of this period is the sustainable production cluster. From 2019 to 2023, the concepts of responsible consumption and corporate social responsibility continue to be considered within the framework of the responsible production concept. This fact indicates that the significant role of consumers in achieving responsible production continues to be recognized, and corporate social responsibility has been firmly integrated into the concept of responsible production.

The second largest primary cluster is the additive manufacturing cluster, which includes such keywords as environmental performance and remanufacturing. Other primary clusters were optimization, life cycle assessment, and biodiesel.

Life cycle assessment has become more actively studied, as evidenced by the transition of the corresponding cluster from the basic category to the motor one. The life cycle assessment cluster contains keywords such as supply chain, energy efficiency, manufacturing, and blockchain. It can be assumed that the relationship between the life cycle and the supply chain is becoming increasingly relevant, as well as energy efficiency at each stage of the life cycle, the use of blockchain technologies in evaluating and analyzing the product life cycle.

The second largest motor cluster is the climate change cluster. The content of this cluster indicates the significant role of renewable energy, biomass, biorefinery in climate change issues. The third largest motor cluster is barriers, including India's green supply chain. The remaining motor clusters are hydrogen, which is an imperfect production. The hydrogen cluster is moving from niche topics to motor ones, reflecting the growing importance of studying the issues of obtaining hydrogen and biogas from food waste.

The life cycle assessment cluster, which includes keywords such as carbon footprint and water footprint, is at the stage of transition from niche topics to motor ones. Thus, there is an increase in the relevance of carbon footprint and water footprint research within the product lifecycle. Another niche topic is efficiency. Emerging themes include triple bottom line, case study, and cleaner production (Figure 16).

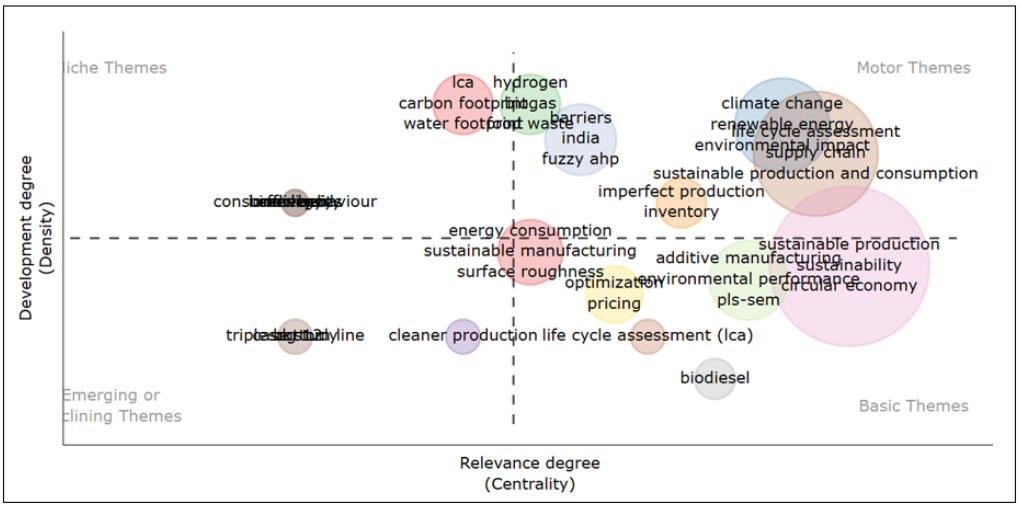

FIGURE 16. Thematic map of responsible production research between 2019 and 2023

Note: compiled by authors based on Bibliometrix Biblioshiny tool

Content analysis results

A qualitative content analysis was additionally conducted to complement RP research's previous quantitative bibliographic analysis. The period from 2014 to 2024 was taken for content analysis. This implied defining the 15 most influential papers from the RP literature, i.e., those with the highest total citation score. The list of these 15 papers is represented in Annex 1.

The most discussed topic, according to the content analysis results, was the area of sustainable supply chains. Yildiz and Sezen (2019) evaluated the effects of green supply chain management practices on sustainability performance in Turkish manufacturing firms. The authors concluded that all GSCM dimensions are related to at least one of the performance dimensions except for green purchasing. Awasthi et al. (2018) presented an integrated framework for sustainable global supplier selection that considers sustainability risks from sub-suppliers.

Consumer behaviour in the context of responsible production is the second most discussed research area. Gullstrandedbring et al. (2016) examined consumer attitudes, motivations, and barriers relating to the three alternative consumption models, with particular emphasis on furnishing products. The main motivation for the consumption of second-hand products is economic. The biggest obstacle for people buying second-hand products for use in the home is that they are seen as unsanitary. Materialism and the desire

to own are severe barriers to the access-based consumption model.

The third most relevant topic is the impact of Industry 4.0 on implementing responsible production principles. Bag et al. (2021) identified thirty-five resources that are essential for the adoption of Industry 4.0. Also, the authors concluded that I4.0 adoption has a positive relationship with sustainable production. Nascimento et al. (2019) proposed a circular business model for recycling waste and delivering new products, significantly reducing resource consumption and optimizing natural resources by integrating web technologies, reverse logistics, and AM.

Other important topics were the sustainable management of food surplus and food waste and the role of life cycle assessment in supporting sustainable food systems. Papargyropoulou et al. (2014) propose the food waste hierarchy as a framework to identify and prioritize the options for minimizing and managing food surplus and waste throughout the food supply chain. Bocken et al. (2014) identified a wide range of examples of mechanisms and solutions that can contribute to business model innovation for sustainability. Annex 2 reflects main information on top 15 works on responsible production research.

5. CONCLUSIONS

This study sought to identify the current focus of scientific interest in responsible production research as well as possible future research questions on this topic. A mixed-methods approach was applied to achieve the research aim, combining systematic bibliographic analysis and content analysis. According to the review results, scientific activity on RP research has increased sharply since 2013. The core publication of responsible production is the Journal of Cleaner Production.

According to the results of the co-occurrence network analysis and thematic mapping, the role of supply chain management in achieving responsible production principles is significant. Also, at the moment, the environmental aspect of RP, in particular environmental management and environmental performance, is of the greatest scientific interest. The role of consumers in achieving the goals of the responsible production concept is also important. Among all types of resources, the issues of efficient use of energy resources are at the forefront. The issues of responsible production in the food industries, in particular, the issues of food waste management, are of particular relevance. The study of the impact of industry 4.0 tools on achieving responsible production principles is also the focus of scholars' attention.

Reducing the negative effects of production processes, waste management at each stage of the product life cycle, as well as achieving environmental sustainability within the framework of the life cycle assessment concept are also relevant areas of research. The issues of water footprint and carbon footprint throughout the product life cycle, in particular, carbon footprint in crop and wine production, are characterized by special relevance and arouse active scientific interest. Although small in size, the concepts of corporate social responsibility and social responsibility formed an independent cluster. Social responsibility issues are also an object of current scientific interest, although not yet as active as environmental responsibility issues.

Thematic mapping has shown that interest in topics such as sustainability indicators and industrial symbiosis, as well as product design, is steadily growing. There is an increase in the relevance of obtaining hydrogen and biogas from food waste.

Content analysis of the most influential papers in the field of RP generated results that align with descriptive analysis. In particular, according to the content analysis results, sustainable supply chains were the topic discussed the most. The impact of green supply chain management practices on sustainability performance and sustainable global supplier selection is among the most relevant topics.

According to the content analysis results, consumer behaviour in the context of responsible production is the second most

discussed research area. Consumer attitudes, motivations, and barriers relating to responsible consumption models are being actively studied. The impact of Industry 4.0 on the implementation of responsible production principles is another area of research that has been actively studied, according to the results of content analysis, which is consistent with the results of descriptive analysis. Responsible business models and sustainable management of food surplus and food waste are also the focus of scientific interest. Future research directions derived from content analysis are reflected in Annex 3.

As for practical implications, the conclusions of this study may be useful for academic community representatives involved in the study of responsible production issues, as well as for government bodies and the business environment involved in the development and implementation of responsible production practices.

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Data collection, analysis and interpretation: Dinara T.Kalmakova
Visualization: Dinara T.Kalmakova.
Writing review and editing research: Aknur Zhidebekkyzy, Dinara T.Kalmakova, Anna Kotaskova

ANNEX 1

Papers selected for content analysis

No.	Paper	Total Citations
1	Bocken N, 2014	2144
2	Papargyropoulou E, 2014	961
3	Govindan K, 2018	738
4	Nascimento D, 2019	499
5	Rajeev A, 2017	438
6	Awasthi A, 2018	402
7	Notarnicola B, 2017	401
8	Glover JL, 2014	313
9	Yildiz Çankaya S, 2019	310
10	Esfahbodi A, 2016	273
11	Schäufele I, 2017	271
12	Franco MA, 2017	260

13	Gullstrand Edbring E, 2016	245
14	Akenji L, 2014	232
15	Bag S, 2021	205

ANNEX 2

Top 15 works on responsible production research selected for content analysis

No.	Article (author and reference)	Article type	Research Topic/ question	Main findings	Dep. Var.	Indep. Var.	Methods adopted
1	Bocken N, 2014	review	How can we encourage corporate innovation that significantly changes the way companies operate to ensure greater sustainability?	The paper introduces sustainable business model archetypes to categorize mechanisms and solutions for sustainability in business models	N/A	N/A	a systematic review approach
2	Papargyropoulou E, 2014	empirical	How to manage food surplus and food waste more sustainably?	The main findings include the proposal of a food waste hierarchy to challenge current waste management approaches	N/A	N/A	Qualitative data analysis through interviews with specialists
3	Gullstrand Edbring E, 2016	empirical	What are the attitudes of young consumers to the three models of consumption? What are the underlying motivations and obstacles relating to changing young consumers' consumption behaviour towards alternative consumption models?	Attitudes towards buying second-hand products are primarily driven by practical and economic reasons, with a lesser emphasis on environmental concerns.	N/A	N/A	interviews with experts and an online survey of consumers
4	Govindan K, 2018	review	What are the drivers, practices, and barriers towards the circular economy in a supply chain?	The key conclusions of the paper include the significance of government engagement in implementing the circular economy in supply chains, the challenges organizations face in addressing technological issues, and the need for awareness and education in society and among consumers.	N/A	N/A	a systematic review approach
5	Akenji L, 2014	Theoretical paper	What is the effectiveness of green consumerism	- Green consumerism is not an effective driver of sustainable	N/A	N/A	The methodology involves

			in driving society towards sustainable consumption patterns?	consumption and may distract from urgent structural changes needed for sustainable development.			clarifying differences between green consumerism and sustainable consumption
6	Bag S, 2021	empirical	What are the required resources for I4.0 implementation in the context of sustainable production and Circular Economy? Can we establish a relationship between I4.0 adoption, sustainable manufacturing and CE capabilities?	I4.0 adoption have a positive relationship with sustainable production	Sustainable production, Circular economy capabilities	production systems, human resources, project management, management leadership, green logistics, green design	exploratory factor analysis (EFA), testing using PLS-SEM
7	Franco MA, 2017	empirical	What factors hinder firms' ability to go fully circular and how do these factors interact to move firms and industries towards a circular production system?	the speed and quantity of Cradle to Cradle (C2C) products manufactured and available to customers and take-back partners depend on the availability of basic materials and component parts	N/A	N/A	qualitative research through multiple case studies
8	Glover JL, 2014	empirical	What are the factors affecting the acceptance of sustainable practices and energy reduction strategies in the dairy supply chain?	The major findings of the study include the emphasis on cost reduction and profit maximization as dominant logics in the dairy supply chain, the significant power of supermarkets in exerting pressure on sustainable practices	Sustainable practices implemented, level of energy efficiency	Stakeholders across the dairy supply chain, Sustainable practices in the dairy supply chain	conducting 70 semi-structured telephone interviews with stakeholders across the dairy supply chain
9	Yildiz Çankaya S, 2019	empirical	What is the effect of different dimensions of green supply chain management on economic, environmental, and social performance in the context of corporate sustainability?	The main findings emphasize the significance of GSCM in enhancing sustainability performance	Environmental performance Economic	Green purchasing, green manufacturing, green distribution, green packaging, green marketing	a plant-level survey, using cross-sectional face-to-face and e-mail surveys

					performance Social performance		
10	Schäufele I, 2017	review	How do consumers' values, beliefs, and attitudes influence their purchase behavior towards wine with sustainability characteristics	The paper emphasizes the complexity of consumers' wine choices, the importance of sustainability cues as credence attributes	N/A	N/A	an online literature search
11	Nascimento D, 2019	Review and empirical	How can Industry 4.0 technologies be integrated into circular economy practices to reuse electronic waste and scrap materials?	- The recommendation of a circular model to reuse scrap electronic devices - Positive influence on business sustainability by reinserting waste into the supply chain	Impact of reusing materials on resource spending and environmental effects	- Industry 4.0 technologies -Additive manufacturing (AM) -Smart production systems	a qualitative research method literature review, interviews and focus groups
12	Rajeev A, 2017	Review	Analyze the progress of sustainability research within supply chain management literature	The study emphasizes a lack of research focusing on all three dimensions of sustainability in supply chain management	N/A	N/A	Systematic literature review
13	Awasthi A, 2018	empirical	RQ1: What is the best approach to evaluate supplier sustainability? RQ2: Which sustainability criteria need to be considered for evaluating sustainable suppliers?	- Economic criteria had the highest weight, while global risk had the least weight among the sustainability criteria considered.	Sustainability performance and risks of suppliers and sub-suppliers in the	- Time - Space - Density - Mass - Fluid flow rate	fuzzy AHP and VIKOR, case study, and fuzzy AHP.

					global supply chain		
14	Notarnicola B, 2017	empirical	What are the issues and research preferences for life cycle assessment in supporting sustainable food supply chains?	- Life cycle thinking is crucial for sustainable food supply chains. - Improving food production and consumption systems is essential for sustainable development.	N/A	N/A	discussing challenges and research priorities including dedicated modeling approaches
15	Esfahbodi A, 2016	empirical	Does the adoption of SSCM practices result in a higher level of environmental performance and improved cost performance in emerging economies?	- Implementation of SSCM activities leads to higher environmental performance but not improved cost performance in emerging economies	Environmental Performance, Cost Performance	- Sustainable procurement - Sustainable distribution - Sustainable design - Investment recovery	linear regression analysis, a one-way ANOVA

ANNEX 3

Selected opportunities for future research on responsible production

Research areas	Suggestions and questions for future research
Case studies in responsible production research area	What are the cases of best practices, business models for the introduction of responsible production on the example of companies in various industries?
	What are the features of the introduction of responsible production on the example of companies from countries with different levels of per capita income?
Supply chain management in the context of responsible production	How do organizational resources, organizational structure, and corporate culture affect the performance of implementing responsible production?
	What are sustainable supply chain management practices, issues, and models on the most polluting industries across the world?
	There is a necessity to include more industry specific studies, as the responsible production needs and performance of all the industries are not equivalent.
	There is a need for more studies to develop better scales for measuring the social impact of various supply chains
	What are the effects of green supply chain management practices on sustainability performance in non-manufacturing organizations like wholesalers or retailers?
	Does the application of SSCM activities lead to a higher level of environmental performance and eventually result in enhanced cost performance in emerging economies, in SMEs, in service sectors?

Consumer behaviour in the context of responsible production	Compare attitudes, motives and barriers to responsible consumption patterns in developed and developing countries, countries with different income levels, in different regions of the same country, among representatives of generations X,Y, Z
Industry 4.0 and responsible production	To evaluate and compare the impact of industry 4.0 on the implementation success of responsible production principles in various industries
Responsible business models	What is the role of social business model innovations in sustainability? What is the impact of social business model innovations on corporate economic and financial performance?

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