Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024

www.concienciadigital.org

Indicadores de rendimiento de la cadena de suministro 5.0 para la agroindustria: revisión de literatura

Supply chain 5.0 performance indicators for agroindustry: a review of the literature

[1] Nayeli Jhael Garcia Prado https://orcid.org/0000-0001-8667-3318
Technical University of Ambato, Faculty of Electronic and Industrial Systems Engineering, Industrial Engineering Degree, Ambato, Ecuador
ngarcia3499@uta.edu.ec

[2] Franklin Geovanny Tigre Ortega https://orcid.org/0000-0003-0254-029X
Technical University of Ambato, Faculty of Electronic and Industrial Systems Engineering, Industrial Engineering Degree, Ambato, Ecuador
fg.tigre@uta.edu.ec

[3] Freddy Roberto Lema Chicaiza https://orcid.org/0000-0001-5987-8975
Technical University of Ambato, Faculty of Electronic and Industrial Systems Engineering, Industrial Engineering Degree, Ambato, Ecuador
fr.lema@uta.edu.ec

[4] Cesar Hannibal Rosero Mantilla https://orcid.org/0000-0001-7806-2955
Technical University of Ambato, Faculty of Electronic and Industrial Systems Engineering, Industrial Engineering Degree, Ambato, Ecuador
cesararosero@uta.edu.ec

[5] Carlos Humberto Sánchez Rosero https://orcid.org/0000-0002-2253-8448
Technical University of Ambato, Faculty of Electronic and Industrial Systems Engineering, Industrial Engineering Degree, Ambato, Ecuador
carloshsanchez@uta.edu.ec

[6] Alejandro Sigcha Quezada https://orcid.org/0000-0003-3205-6271
University of Cuenca, Department of Computer Science, Faculty of Engineering, Cuenca, Ecuador
erick.sigchaq@ucuenca.edu.ec

Scientific and Technological Research Article
Sent: 04/16/2024
Revised: 05/14/2024
Accepted: 06/26/2024
Published:05/07/2024
DOI:**https://doi.org/10.33262/concienciadigital.v7i3.3089**

Please quote:

García Prado, NJ, Tigre Ortega, FG, Lema Chicaiza, FR, Rosero Mantilla, CA, Sánchez Rosero, CH, & Sigcha Quezada, A. (2024). Supply chain 5.0 performance indicators for the agribusiness: literature review. ConcienciaDigital, 7(3), 112-134.https://doi.org/10.33262/concienciadigital.v7i3.3089

DIGITAL CONSCIOUSNESS,andIt is a multidisciplinary, quarterly journal, which will be published electronically. Its mission is to contribute to the training of competent professionals with a humanistic and critical vision who are capable of presenting their research and scientific results to the same extent that their intervention promotes positive changes in society.https://concienciadigital.org
The journal is published by Editorial Ciencia Digital (a prestigious publisher registered with the Ecuadorian Book Chamber with membership number 663).www.celibro.org.ec

*This journal is licensed under a Creative Commons AttributionNonCommercialNoDerivatives 4.0 International License. Copy of the license:*http://creativecommons.org/licenses/by-nc-nd/4.0/

Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024

www.concienciadigital.org

Palabras claves:
resiliencia, sostenibilidad, enfoque en el ser humano, COVID-19.

Resumen

Introducción: los desafíos del sector agroalimentario han impulsado a las empresas a buscar diferentes formas de mejorar su competitividad, lo que ha llevado al surgimiento de la industria 5.0. Esta nueva era industrial no solo se enfoca en la implementación de tecnología avanzada en las cadenas de suministro, sino también en fomentar la resiliencia, incrementar la sostenibilidad y mantener un enfoque centrado en el ser humano en todas las etapas **Objetivos:** Proponer indicadores de evaluación de cadenas de suministro en la agroindustria, tomando en cuenta los tres pilares esenciales de la industria 5.0. **Metodología:** la selección de los indicadores se realizó a través de una revisión sistemática de literatura, utilizando la metodología de Fink. Se abarcó 97 artículos en inglés y portugués publicados entre los años 2020 y 2024. El análisis de estos documentos se llevó a cabo mediante el software Atlas.ti versión 2019, aplicando el modelo de las 4W (cuándo, quién, dónde y qué) y respondiendo a las tres preguntas de investigación planteadas mediante la estrategia PICO. **Resultados:** los resultados destacan un incremento en la publicación de artículos a partir de 2021, coincidiendo con el periodo posterior al pico más alto de contagios de COVID-19, cuando las empresas comenzaron a adaptarse a la nueva realidad. Durante este período, las empresas buscaron formas de mitigar el impacto de eventos disruptivos en sus actividades productivas y económicas, identificando factores clave de la Industria 5.0 para aplicar en las cadenas de suministro. **Conclusiones:** la implementación completa de la industria 5.0 aún enfrenta dificultades. Aunque en India se han realizado estudios significativos sobre el tema, su aplicación ha sido complicada. Finalmente, se proponen 21 posibles indicadores con sus variables para las cadenas agroalimentarias, basados en los tres elementos esenciales (sostenibilidad, resiliencia y enfoque en el ser humano) y ocho criterios clave derivados de estos elementos. **Área de estudio general:** Producción y Operaciones. **Área de estudio específica:** Diseño de materiales y producción. **Tipo de estudio:** revisión bibliográfica

Keywords:
resilience, sustainability,

Abstract

Introduction: the challenges of the agri-food sector have driven companies to look for different ways to improve their competitiveness, which has led to the emergence of industry 5.0.

human focus, COVID-19.

This new industrial era not only focuses on the implementation of advanced technology in supply chains, but also on fostering resilience, increasing sustainability and maintaining a human-centric approach at all stages. Aim: supply chains in agribusiness, taking into account the three essential pillars of industry 5.0. Methodology: the selection of indicators was carried out through a systematic literature review, using Fink's methodology. It covered 97 articles in English and Portuguese published between 2020 and 2024. The analysis of these documents was carried out using the Atlas.ti software version 2019, applying the 4W model (when, who, where and what) and answering the three research questions posed through the PICO strategy. Results: The results highlight an increase in the publication of articles starting in 2021, coinciding with the period after the highest peak of COVID-19 infections, when companies began to adapt to the new reality. During this period, companies sought ways to mitigate the impact of disruptive events on their productive and economic activities, identifying key factors of Industry 5.0 to apply in supply chains. Conclusions: the complete implementation of Industry 5.0 still faces difficulties. Although significant studies have been carried out on the subject in India, its application has been complicated. Finally, 21 possible indicators are proposed with their variables for agri-food chains, based on the three essential elements (sustainability, resilience and human focus) and eight key criteria derived from these elements. General study area: Production and Operations. Specific study area: Materials design and production. Type of study: bibliographic review

Introduction

The agroindustry faces a challenging and complex scenario in the 21st century(Guo et al., 2023)Climate change, globalization, increasing demand for food and the need to ensure food security require a fundamental rethinking of food production and distribution practices and models.(Yun & Ülkü, 2023)In this context, Industry 5.0 is emerging as a new paradigm that provides a conceptual framework to transform the food supply chain into a more sustainable, flexible and human-focused model.(Leng et al., 2022).

Unlike Industry 4.0, which focuses on process automation and digitalization, Industry 5.0 focuses on human-machine interaction, ethics, environmental sustainability and social

responsibility.(Gamboa-Rosales & López-Robles, 2023)This new paradigm seeks to capture value from new technologies while respecting the planet's resources, providing prosperity beyond employment and placing the worker at the center of the production process.(Mishra & Paul, 2023)This implies a fundamental change in the way supply chains in the agri-food industry are planned, managed and evaluated.

This paper presents a conceptual framework for assessing agri-food supply chains in the context of Industry 5.0, proposing specific indicators that encompass its three key elements: sustainability, resilience and human-centredness.(Alves et al., 2023)Furthermore, it is argued that by applying these indicators, agri-food companies can improve their performance, contribute to a more sustainable future and better meet the challenges of the 21st century.

The structure of this article is divided into four essential sections. The first section presents a review of the literature on Industry 5.0, the agri-food supply chain and performance indicators. The second section describes the methodology used to support the literature analysis, applying the Fink methodology. The third section comprises the results and discussion, divided into two parts: the meta-analysis and the descriptive analysis, obtaining the trend of years of publication and the indicators of the agri-food supply chain 5.0. Finally, the conclusions of the study are presented and topics for future research are suggested.

This comprehensive approach will not only enable improved efficiency and sustainability of agri-food supply chains, but will also provide a robust framework for agri-food businesses to adapt to the changes and demands of the 21st century, ensuring long-term resilience and sustainability.

Methodology

A systematic literature review (SLR) was conducted by applying the Fink methodology, which uses seven fundamental steps for the identification and selection of relevant information, in addition to ensuring the quality and rigor of the results obtained.(Fink, 2019, pp. 3–5). Ensuring that research contains the three essential pillars of Industry 5.0 and that the indicators are applied in the agri-food supply chain.

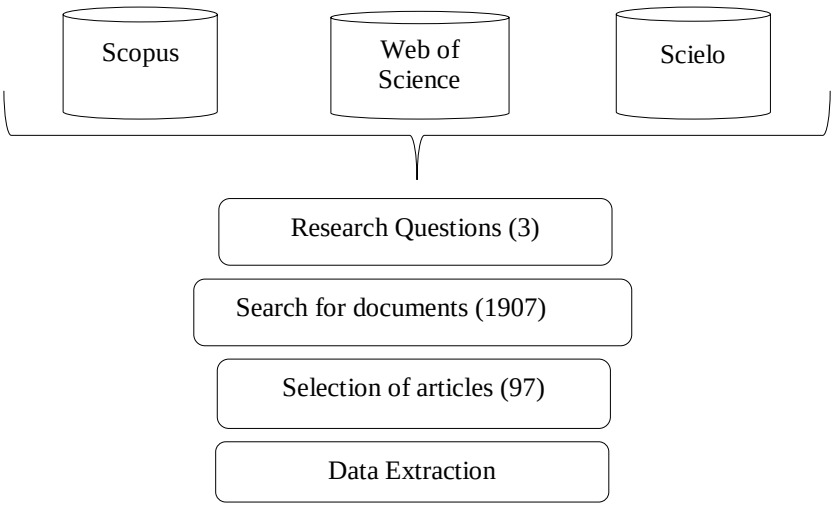
The initial step of the Fink methodology involves choosing the research questions, for which the PICO strategy was implemented. This strategy focuses on defining the population, the intervention, the comparison and the relevant results in relation to the topic under study. The four research questions obtained are RQ1: What is the conceptualization, elements or dimensions of Industry 5.0?, RQ2: How do resilience, sustainability and focus on the human being influence the supply chain?, RQ3: What key indicators of Industry 5.0 have been considered for the agri-food supply chain?

ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024
www.concienciadigital.org

In the second step, the database sources were specified, exposing Scopus, Web of Science and Scielo as the designated platforms for the collection of information. Figure 1 illustrates the systematic literature review, displaying the three databases used and the number of research questions. In addition, a population of 1907 articles was identified, of which 97 were selected using the exclusion criteria detailed in steps four and five of this methodology.

Figure 1

Database sources



Note: Based on systematic literature review

Consequently, in the third step, search strings were created with the key terms that respond to the previously established research questions. The strings used were: "Industry 5.0" & "(Element OR Elements)" OR "(Dimension OR Dimensions"); "Supply chain" & "Resilience" OR "Sustainability" OR "Human approach"; "Supply chain" & "(Indicator OR Indicators)" & "Industry 5.0" OR "Agro"; "Industry 5.0" & "Supply chain" & "(Indicator OR Indicators)" & "Feasibility" OR "Agro".

Steps four and five of this methodology were used to apply the practical and methodological criteria. In this process, the following inclusion and exclusion criteria were considered:

The inclusion criteria included: a) Articles from certified journals; b) Articles written in English and Portuguese; c) Articles related to the agri-food supply chain, Industry 5.0 elements and Industry 5.0 indicators for supply chains; d) Articles published between

2020 and 2024. Consequently, the exclusion criteria were: a) Duplicate articles; b) Articles unrelated to the topic; c) Articles older than 5 years.

In step six, aimed at reviewing the documentation, the computer tool Atlas.ti was used to facilitate the organization, analysis and interpretation of the results. The result of this process was the obtaining of 21 free codes, which were distributed into six groups of codes.

For the final phase of this methodology, the results obtained were synthesized. Figure 2 visually presents the process carried out where the previously mentioned exclusion criteria were applied, evaluating the eligibility of 97 articles.

Table 1

Application of practical and methodological selection criteria

Description	Articles			Total documents	Excluded documents
	Scopus	WOS	Scielo		
Articles obtained after applying inclusion criteria	893	983	31	1907	
Articles after the duplicate exclusion criteria	879	528	28	1435	472
Articles after reading the title	317	159	15	491	944
Articles after reading summary and conclusions	184	47	4	235	256
Articles after reading the full document	83	12	2	97	159

Note: Based on systematic literature review

Results and discussion

By examining 97 articles, the information is analysed in two main sections: a meta-analysis and a descriptive analysis. The meta-analysis allows to synthesize the information in a systematic way, in which a "4W" approach is used, answering the four fundamental questions: When?, Who?, What? and Where? This approach seeks to understand the influence of Industry 5.0 elements on agri-food supply chains. The synthesis of these questions provides a deeper and more structured understanding of the temporality, the actors involved, the specific elements and the geographical contexts where Industry 5.0 information is published in this sector. Meanwhile, the descriptive analysis focuses on relevant themes identified in the articles, such as Industry 5.0 definitions and agri-food supply chain 5.0 indicators. This analysis is essential to address the three main research questions (RQ1, RQ2 and RQ3).

Meta-analysis

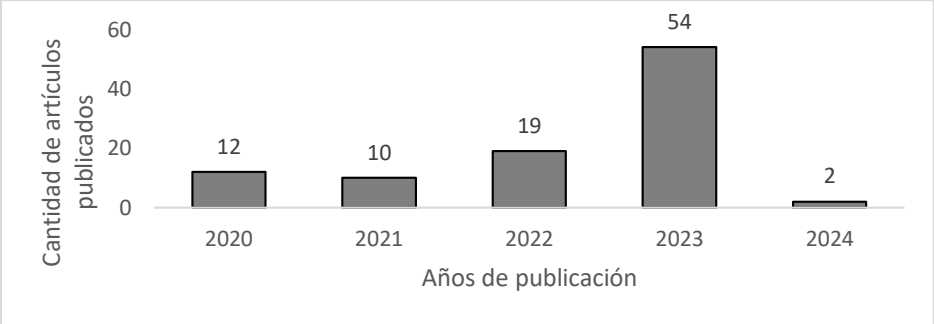
Data management was carried out using the computer tool Atlas.ti version 9, which allowed demographic coding and the identification of trends in years of publication, names of journals, countries of origin of the research and main topics covered.

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024
www.concienciadigital.org

At the beginning of the pandemic, the main concern was human health. However, as the pandemic lasted longer than expected, agro-industries began to face significant problems in supply and along the supply chain. This context led to an increase in attention and interest in Industry 5.0 studies. Consequently, 2023 sees a notable increase in the global trend, with 35 additional publications compared to 2022. Figure 2 presents the evolution of the publication years, spanning from 2020 to early 2024, with the aim of answering the question "when?" of the 4Ws.

Figure 2

Temporal distribution of the selected documents



Note: Based on systematic literature review

The analysis of Industry 5.0 studies reveals a significant increase in the last year of research, indicating the growing interest and relevance of this topic at a global level. To answer the question "Where?", a geographical distribution of the selected articles has been carried out, as shown in Figure 3. This world map uses different shades of grey to indicate the frequency of publications by country, providing a clear overview of the regional distribution.

South and East Asia leads in article production, accounting for 38% of the total publications. In this region, India stands out with the highest number of publications, reaching a total of 14 articles, followed by China with 10 articles. In the Middle East, Iran contributes significantly with 6 publications.

In Europe, Spain stands out with 4 publications. Other European countries such as France, Italy, Germany and the United Kingdom have 2 publications each. Turkey, although geographically spread across both Europe and Asia, has 3 publications.

In North and South America, the United States has 2 publications, while Brazil and Mexico each have 3 publications, and Colombia and Ecuador each contribute 1 publication. In Oceania, Australia contributes 3 publications. Finally, in Africa, Algeria is represented with 1 publication.

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024
www.concienciadigital.org

Figure 3

Global distribution of selected documents

Note: Based on systematic literature review

To address the questions “Who?” and “What?”, 47 articles were selected from a sample that included 9 journals. Those with a frequency of more than one publication were considered, representing 48% of the total documents. The journal “Sustainability” leads with 15 articles, focusing on research that contributes to sustainability through technology and innovation. “Annals of Operations Research” follows with 6 publications, covering diverse areas such as logistics, manufacturing and services. “Business Strategy and the Environment”, also with 6 publications, specializes in the intersection between environmental issues and business management.

With a frequency of less than 5 articles, the journals "Operations Management Research" and "Environmental Science and Pollution Research" stand out. The first one publishes works on innovative management practices and operational efficiencies, while the second one focuses on research on environmental pollution and its impact on ecosystems.

Among the journals with less frequency, "Supply Chain Management: An International Journal", with 3 publications, addresses aspects of supply chain management and sustainability. The journal "Journal of Cleaner Production", also with 3 publications, is dedicated to research on clean production and sustainable development. Journals with only 2 publications include "Cleaner Logistics and Supply Chain", which focuses on logistics and supply chain management from a sustainable perspective, and "Environment, Development and Sustainability", which publishes studies on environmental policies and the impacts of climate change on sustainable development.

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024
www.concienciadigital.org

Figure 4

Frequency of articles per journal

Note: Based on systematic literature review

Each of these journals provides relevant information on the topic to be addressed in order to advance sustainable practices and research in their respective areas, contributing to the selection of supply chain 5.0 indicators.

Descriptive analysis

In this section, we seek to answer the three research questions posed by the PICO strategy. To answer RQ1, we turn our attention to Industry 5.0 in order to explore its definitions, components and elements. From the total sample selected, 12 articles provide relevant information for this research question. For example,(Ivanov, 2023)defines Industry 5.0 as the integration of advanced technologies and human-centered management principles to create more efficient and sustainable value systems. Table 2 presents the most common definitions of Industry 5.0 from different authors.

Table 2

Industry 5.0 Definitions

Definitions	References
Industry 5.0 sees the industrial future as a human-oriented, sustainable system capable of recovering from challenges.	Ivanov (2023), Mishra & Paul (2023), Villar et al. (2023)
The European Commission has defined the term Industry 5.0 as an industrial prototype that emerges as a response to European social and environmental priorities, promoting the integration of sustainable practices, resilience and a people-centred approach in business activities.	Alves et al. (2023), Borchardt et al. (2022), Madsen & Berg (2021)
Industry 5.0 is defined as an approach that leverages human creativity and expertise in collaboration with intelligent and precise machines to improve the efficiency of industrial processes.	Gamboa-Rosales & López-Robles (2023), Pizoń & Gola (2023)

Note: Based on systematic literature review

Considering the authors' definitions, it is observed that in the documents reviewed there is an agreement on the key components, which may vary depending on the type of organization, thus determining sustainability, resilience and the human approach.(Ivanov, 2023; Modgil et al., 2023)This approach combines human skills with the capabilities of machines, driving innovation in the industrial process.(Mishra & Paul, 2023)The topic has a different approach to Industry 4.0 as it does not only focus on technology, but has significant implications in the transformation of operations and supply chain management, promoting productivity, efficiency and viability of supply chain networks in a changing environment.(Atif, 2023).

In order to address the second research question RQ2, definitions of supply chain 5.0 and each of its main elements are presented, determining their influence within the supply chain.

In recent years, the evolution of traditional supply chains has led to the development of the concept of Supply Chain 5.0. This new stage is characterized by the integration of smart technologies that allow a rapid reaction to changes in demand and supply, through the efficient reallocation and reorganization of its components.(Ghufran et al., 2022; Hajar & Saida, 2022). In addition, it focuses on meeting essential human needs and creating sustainable value.(Tarigan et al., 2021; Villar et al., 2023).

In this context, logistics 5.0 is closely related to the principles of industry 5.0, which seeks to integrate concepts such as sustainable transport, green warehouses, ecological packaging and trained human resources, with the aim of promoting the sustainability and efficiency of logistics operations.(Trstenjak et al., 2022). Based on this definition, Supply Chain 5.0 is based on the integration of logistics 5.0 and Industry 5.0 to optimize the comprehensive management of the supply chain.(Jefroyet al., 2022).

In the field of agri-food supply chains, one of the most debated topics is their impact on climate change.(Yun & Ülkü, 2023). Therefore, environmental resilience is addressed as a crucial strategy to absorb and recover from climate disturbances.(Hägele et al., 2023)This resilience must be intrinsically linked to sustainability, presenting key aspects of the elements of Supply Chain 5.0, which seek to strengthen the response capacity to these variations.

Resilience is considered one of the main pillars in this approach, as it guarantees adaptability and stability in highly changing and dynamic environments.(Sharma et al., 2023). In recent years, studies on resilience have grown significantly. Table 3 summarizes various definitions and approaches provided by researchers, providing a comprehensive overview of how resilience can be implemented in the agri-food supply chain within the framework of Supply Chain 5.0.

Table 3

Definitions of resilience

Definitions	References
Resilience is the ability of companies and their partners to anticipate, prevent and recover from disruptions. It involves proactive preparation, such as formulating emergency plans, and collaboration among partners to optimize value creation, even after risk events.	Das & Mcclung (2020), Sajjad (2021)
Resilience is evident when manufacturing systems can withstand harsh conditions and adapt to disruptions without incurring significant additional costs.	The Korchi (2022)
Supply chain resilience involves the ability to return to its original state or adapt to a new one after being disrupted.	Pu et al. (2023)

Note: Based on systematic literature review

This approach is essential to effectively deal with adversities and crises. One of the essential aspects to achieve this is risk management, which involves having plans in place for any changes or disruptions that may occur.(Zavala-Alcívar et al., 2020). Lack of flexibility can significantly limit resilience, underlining the importance of having a flexible and adaptable supply chain.(Hägele et al., 2023)The integration of advanced technologies, such as automation and artificial intelligence, facilitates this adaptability, allowing us to respond quickly and efficiently to fluctuations in demand and supply.

Another essential pillar is sustainability, which aims to meet current demands without compromising the availability of resources for future generations, promoting an environmentally friendly and sustainable environment.(Mwangi et al., 2022). Authors who emphasize this topic provide different perspectives as shown in Table 4.

Table 4

Definitions of sustainability

Definitions	References
It is defined as the strategic and transparent management of supply chain activities with a sustainable approach, considering the entire life cycle of the product or service to ensure that environmental impacts are taken into account.	Lopez-Castro & Solano-Charris (2021)
Sustainability refers to using your products at the end of their life cycle, having an important economic value and a reduction in environmental impacts.	Sarkis (2021)

Note: Based on systematic literature review

This element is based on three fundamental pillars: social, environmental and economic. When integrated, these pillars facilitate conscious environmental management at each stage of the supply chain.(Doyle-Kent & Kopacek, 2023)In recent years, in response to global warming, companies have intensified their efforts to mitigate the environmental impact in all its phases, without compromising the performance of any of them.(Ababou et al., 2023).

By considering the dimensions of sustainability, the social aspect in the agri-food industry can be assessed by creating new business models that integrate social and sustainable benefits.(Patidar et al., 2023). In terms of the environmental aspect, the technologies used in Industry 5.0 will be essential to reduce carbon dioxide emissions and the consumption of natural resources at all stages of the supply chain, thus promoting an ecological balance by minimizing the environmental impact.(Ghufran et al., 2022)From an economic perspective, the aim is to increase profitability by reducing production costs and improving operational efficiency.

When talking about sustainable supply chain, it is crucial to address Green Supply Chain Management(Trstenjak et al., 2023). Furthermore, the integration of sustainability and resilience can be achieved by adopting the LARG (Lean, Agile, Resilient, Green) approach, which improves the competitiveness and sustainability of the supply chain, ensuring its adaptability to challenges or crises, as evidenced during the COVID-19 pandemic.(Sarkis, 2021).

The human-centered approach to the supply chain involves prioritizing human needs and interests at every stage of the supply chain. This approach highlights several key aspects, such as prioritizing human well-being and making technology available to serve people.(Alves et al., 2023)It is essential that technologies are adapted to human needs rather than humans adapting to them, placing people at the centre of the process and prioritising social responsibility.(Villar et al., 2023). This ensures that decisions taken are geared towards human well-being ((Ivanov, 2023)). Implementing this approach in the agri-food supply chain not only improves the quality of life of workers, but can also increase the productivity, sustainability and resilience of the system. Table 5 presents various definitions of the human-centred approach from different perspectives and contexts.

Table 5

Definitions of human focus

Definitions	References
The human-centered approach in supply chains is aligned with sustainability practices in the dimensions of resilience, human and labor rights.	Alves et al. (2023)
Emphasize human needs over operations, that is, focus on enhancing the skills, competencies and well-being of their staff as a key element for the success and continuous improvement of the organization.	Ivanov (2023)
Human-centricity fuses digital technologies with the collaboration of highly trained workers, resulting in personalized, innovative and high-quality products.	Villar et al. (2023)

Note: Based on systematic literature review

Following the COVID-19 pandemic, a redesign of agri-food supply chains has been promoted. This adaptation responds to the critical need to guarantee food security, given that any interruption in these chains directly impacts the availability of food for the population.(Kumar et al., 2023)In this context, increasing resilience in supply chains is crucial to mitigate vulnerability to various natural hazards, such as hurricanes, floods and droughts.(Yun & Ülkü, 2023).

One of the most pressing challenges currently facing the agri-food industry is climate change. Increases in temperature, variations in rainfall and the frequency of extreme weather events are factors that can lead to significant losses and increase operating costs.(Yun & Ülkü, 2023)To address these issues, Table 6 presents key aspects based on the essential pillars of Supply Chain 5.0, highlighting strategies to improve the adaptability and efficiency of the agri-food system in the face of these threats.

Table 6

Key aspects of the agri-food supply chain 5.0

Items	Criterion	Description
Sustainability	Environmental perspective	By reducing travel in the supply chain and using environmentally friendly transport vehicles, they contribute to reducing the carbon footprint.(Trstenjak et al., 2023).
	Development of sustainable business models	By creating sustainable businesses, the transformation of agricultural raw materials into food is guaranteed in a profitable way, generating benefits for society without

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024
www.concienciadigital.org

		permanently depleting natural resources.(Kumar et al., 2023).
	Balancing quality and profitability	The economy in the supply chain is important, so the right quantity is sought, in the agreed time frames, the expected quality and at the optimal cost.(Leng et al., 2022).
Resilience	Resilience assessment	It is sought to implement in risk management planning(Mohammed, 2020).
	Flexibility	Quickly adapt to environmental disruptions and changes(Villar et al., 2023).
	Using IoT	In order to react quickly to disruptions through AI, IoT and programming interfaces, collecting, storing and processing data(Metwally et al., 2020).

Table 6

Key aspects of the agri-food supply chain 5.0 (continued)

Items	Criterion	Description
Focus on the human being	Human rights and workers' welfare	Guarantee fair and respectful working conditions for workers to increase productivity(Borchardt et al., 2022).
	Human-Centered Technology	It involves the integration of devices and collaboration between humans and robots to improve worker productivity and ergonomics.(Villar et al., 2023)

Note: Based on systematic literature review

To address the last research question (RQ3), possible indicators are proposed that can be applied both in Industry 5.0 and in other industrial sectors, according to their specific needs. From the selected documents, indicators and variables have been identified that are presented as essential tools to facilitate monitoring, understanding of critical parameters and decision-making in the process of adaptation towards an Industry 5.0.

Table 7

Definitions of human focus

Indicators of the agri-food supply chain 5.0			
Items	Criterion	Indicator	Possible Variables
Sustainability	Environmental perspective	Fuel consumption	- Amount of fuel consumed - Replenishment frequency - Kilometers traveled - Fuel cost

		Number of eco-friendly vehicles	- Number of eco-friendly vehicles - Shelf life - Acquisition and maintenance cost
		Environmental certification	- Number of certifications obtained - Frequency of audits - Compliance with environmental standards and regulations
		Carbon footprint	- Amount of CO2 emissions released from vehicles - Emissions measurement and reporting - Carbon offset cost

Table 7

Human-centered definitions (continued)

Indicators of the agri-food supply chain 5.0			
Items	Criterion	Indicator	Possible Variables
	Development of sustainable business models	Innovation and sustainable technology	- Adoption of green technologies - Collaboration on sustainable projects - Sustainability training
		Efficiency of raw material use	- Consumption of raw materials per unit of production - Rate of use of recycled raw materials
		Waste reduction	- Waste recycling rate - Implementation of circular economy practices
	Balancing quality and profitability	Profit margin	- Sustainable production cost - Investment in green technology - Revenue from sustainable products
		Quality index	- Customer satisfaction - Durability and product life cycle - Compliance with sustainable standards
Resilience	Flexibility	Flexibility in logistics and transportation	- Alternative routes - Temporary storage capacity
		Response time to disruptions	- Detection time - Recovery time - Contingency plans
	IoT	Amount of data retrieved and stored	- Storage capacity - Real-time data availability

ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024

		- Data security
	Using artificial intelligence for data analysis	- Number of AI algorithms deployed - Data processing time
Risk management	Recovery time from disturbances	- Downtime - Response time - Recovery cost
	Ability to adapt to climate change	- Climate contingency plans - Training and education

Table 7

Human-centered definitions (continued)

Indicators of the agri-food supply chain 5.0			
Items	Criterion	Indicator	Possible Variables
Focus on the human being	Human rights and well-being	Occupational safety	- Number of employees trained in occupational safety - Security Measures Implementation Index
		Workplace accident rate	- Number of work accidents - Classification of accidents according to their severity
		Fair working conditions	- Pay equity index - Access to employment benefits
		Employee satisfaction surveys	- Satisfaction index - Identification of areas for improvement
	Human-Centered Technology	New technology training	- Participation in training programs - Knowledge retention
		Ergonomics	- Investments in ergonomic improvements - Training in ergonomic practices

Note: Based on systematic literature review

These indicators and their variables focus on the fundamental pillars of the 5.0 supply chain: sustainability, resilience and a human-centered approach. Companies that adopt these indicators position themselves to face 21st century challenges, promoting sustainability, labor justice and contributing to a prosperous future in the global market. This allows the agribusiness to be more robust and adaptable to disruptions.

Conclusions

- The significant escalation in the number of publications since 2022 highlights the urgency of integrating Industry 5.0 principles into agri-food supply chains. The COVID-19 pandemic has revealed the vulnerability and need for resilience in global supply chains, underlining the relevance and applicability of this new paradigm. This study contributes to science by providing an empirical basis that validates the need for a shift towards more resilient and sustainable models in agribusiness.
- The research has identified and validated 21 specific indicators based on sustainability, resilience and a human-centred approach. These indicators not only provide a robust framework for assessing and improving agri-food supply chains, but also represent a significant contribution to the field by setting a standard for monitoring and adapting agro-industrial practices to Industry 5.0 principles. Validation by professionals in the field ensures the relevance and applicability of these indicators in real-world contexts, increasing the reliability and usefulness of the results.
- This study has not only generated a set of applicable indicators, but has also proposed a methodological framework for the assessment of agri-food supply chains in the context of Industry 5.0. This methodological contribution is crucial for future research and practical applications, facilitating a deeper and more structured analysis of supply chains in various agri-food industries.
- The results of this study have important practical implications for the agri-food industry. By embracing the proposed indicators, companies can improve their performance and contribute to a more sustainable future. In addition, this topic opens up a range of topics for future research, such as: studies of the application of Industry 5.0 in different types of agri-food products, evaluating sustainability and resilience or even studying the long-term effects of the implementation of Industry 5.0 in agri-food supply chains by analysing economic factors.

Acknowledgements

The authors would like to thank the research project “Enhancing the Agrifood Supply chain towards Industry 5.0 (AGRO5) in the Ecuadorian Andes” for the support provided, which has been fundamental for the development of this literature review. In addition, we acknowledge the unconditional support and collaboration of the Technical University of Ambato and the University of Cuenca, whose academic contributions have significantly enriched this work.

Conflict of interest

The authors of the article indicate that there is no conflict of interest.

Bibliographic References

Ababou, M., Chelh, S., & Elhiri, M. (2023). A bibliometric analysis of the literature on food industry supply chain resilience: Investigating Key Contributors and Global Trends. Sustainability, 15(11), 8812.https://doi.org/10.3390/su15118812

Alves, J., Lima, TM, & Gaspar, PD (2023). Is Industry 5.0 a Human-Centred Approach? A systematic review. Processes, 11(1), 193.https://doi.org/10.3390/pr11010193

Atif, S. (2023). Analyzing the alignment between circular economy and industry 4.0 nexus with industry 5.0 era: an integrative systematic literature review. Sustainable Development, 31(4), 2155–2175. https://doi.org/10.1002/sd.2542

Borchardt, M., Pereira, GM, Milan, GS, Scavarda, AR, Nogueira, EO, & Poltosi, LC (2022). Industry 5.0 Beyond Technology: An Analysis Through the Lens of Business and Operations Management Literature. Organizacija, 55(4), 305–321.https://doi.org/10.2478/orga-2022-0020

Das, K., & Mcclung, W. (2020). Green and resilient supply chain design model. International Journal of Precision Technology, 9(2-3), 235-269.https://doi.org/10.1504/IJPTECH.2020.112059

Doyle-Kent, M., & Kopacek, P. (2023). Optimizing human potential through diversity and inclusion for industry/production 4.0, 5.0 and 6.0 [The International Symposium for Production Research, Towards Industry 5.0]. DOI:10.1007/978-3-031-24457-5_22

El Korchi, A. (2022). Survivability, resilience and sustainability of supply chains: The COVID-19 pandemic. Journal of Cleaner Production, 377.https://doi.org/10.1016/j.jclepro.2022.134363

Fink, A. (2019). Conducting research literature reviews: from the internet to paper (Fifth Edit). Thousand Oaks, CA: Sage Publications. https://www.scirp.org/reference/referencespapers?referenceid=2636360

Gamboa-Rosales, NK, & López-Robles, JR (2023). Evolving from Industry 4.0 to Industry 5.0: evaluating the conceptual structure and prospects of an emerging field. Transinformação, 35. https://doi.org/10.1590/2318-0889202335e237319

Ghufran, M., Khan, KIA, Ullah, F., Alaloul, W.S., & Musarat, M.A. (2022). Key enablers of resilient and sustainable construction supply chains: a systems thinking approach. Sustainability, 14(19), 11815.https://doi.org/10.3390/su141911815

Guo, L., Sun, D., Warraich, M.A., & Waheed, A. (2023). Does industry 5.0 model optimize sustainable performance of Agri-enterprises? Real-time investigation from the realm of stakeholder theory and domain. Sustainable Development, 31(4), 2507–2516. https://doi.org/10.1002/sd.2527

Hägele, S., Grosse, EH, & Ivanov, D. (2023). Supply chain resilience: a tertiary study. International Journal of Integrated Supply Management, 16(1), 52–81. https://doi.org/10.1504/IJISM.2023.10050753

Hajar, R., & Saida, N. (2022). Supply chain management, between resilience and sustainability: a literature review [2022 IEEE 14th International Conference of Logistics and Supply Chain Management, LOGISTIQUA 2022]. https://doi.org/10.1109/LOGISTIQUA55056.2022.9938028

Ivanov, D. (2023). The industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives. International Journal of Production Research, 61(5), 1683–1695. https://doi.org/10.1080/00207543.2022.2118892

Jefroy, N., Azarian, M., & Yu, H. (2022). Moving from Industry 4.0 to Industry 5.0: What are the implications for smart logistics? Logistics, 6(2), 26.https://doi.org/10.3390/logistics6020026

Kumar, V., Yetkin Ekren, B., Wang, J., Shah, B., & Frederico, G.F. (2023). Investigating the impact of COVID-19 on sustainable food supply chains. Journal of Modeling in Management, 18(4), 1250–1273.https://doi.org/10.1108/JM2-03-2022-0072

Leng, J., Sha, W., Wang, B., Zheng, P., Zhuang, C., Liu, Q., Wuest, T., Mourtzis, D., & Wang, L. (2022). Industry 5.0: perspective and retrospect. Journal of Manufacturing Systems, 65, 279–295.https://doi.org/10.1016/j.jmsy.2022.09.017

López-Castro, LF, & Solano-Charris, EL (2021). Integrating resilience and sustainability criteria in the supply chain network design. A systematic literature review. Sustainability, 13(19). https://doi.org/10.3390/su131910925

Madsen, D. Ø., & Berg, T. (2021). An exploratory bibliometric analysis of the birth and emergence of industry 5.0. Applied System Innovation, 4(4), 87.https://doi.org/10.3390/asi4040087

Metwally, ABM, Ali, SAM, & Mohamed, ATI (2020, October 26). Resilience and agility as indispensable conditions for sustaining viable supply chain during pandemics: the case of Bahrain [2020 International Conference on Data Analytics

for Business and Industry: Way Towards a Sustainable Economy, ICDABI 2020]. https://doi.org/10.1109/ICDABI51230.2020.9325609

Mishra, D.K., & Paul, D. (2023). Industry 5.0: human touch and the future [2022 OPJU International Technology Conference on Emerging Technologies for Sustainable Development, OTCON 2022]. https://doi.org/10.1109/OTCON56053.2023.10113946

Modgil, S., Singh, R.K., & Agrawal, S. (2023). Developing human capabilities for supply chains: an industry 5.0 perspective. Annals of Operations Research, 1-31https://doi.org/10.1007/s10479-023-05245-1

Mohammed, A. (2020). Towards 'gresilient' supply chain management: a quantitative study. Resources, Conservation and Recycling, 155, 104641.https://doi.org/10.1016/j.resconrec.2019.104641

Mwangi, GM, Despoudi, S., Espindola, OR, Spanaki, K., & Papadopoulos, T. (2022). A planetary boundaries perspective on the sustainability: resilience relationship in the Kenyan tea supply chain. Annals of Operations Research, 319, 661–695. https://doi.org/10.1007/s10479-021-04096-y

Patidar, A., Sharma, M., Agrawal, R., & Sangwan, K.S. (2023). Background of a resilient sustainable supply chain. Procedia CIRP, 116, 558–563.https://doi.org/10.1016/j.procir.2023.02.094

Pizoń, J., & Gola, A. (2023). Human–Machine Relationship—Perspective and Future Roadmap for Industry 5.0 Solutions. Machines, 11(2), 203.https://doi.org/10.3390/machines11020203

Pu, G., Qiao, W., & Feng, Z. (2023). Antecedents and outcomes of supply chain resilience: integrating dynamic capabilities and relational perspective. Journal of Contingencies and Crisis Management, 31(4), 706–726. https://doi.org/10.1111/1468-5973.12473

Sajjad, A. (2021). The COVID-19 pandemic, social sustainability and global supply chain resilience: a review. Corporate Governance, 21(6), 1142–1154. https://doi.org/10.1108/CG-12-2020-0554

Sarkis, J. (2021). Supply chain sustainability: learning from the COVID-19 pandemic. International Journal of Operations and Production Management, 41(1), 63–73. https://doi.org/10.1108/IJOPM-08-2020-0568

Sharma, M., Antony, R., & Tsagarakis, K. (2023). Green, resilient, agile, and sustainable fresh food supply chain enablers: evidence from India. Annals of Operations Research. https://doi.org/10.1007/s10479-023-05176-x

Tarigan, Z.J.H., Siagian, H., & Jie, F. (2021). Impact of internal integration, supply chain partnership, supply chain agility, and supply chain resilience on sustainable advantage. Sustainability, 13(10), 5460. https://doi.org/10.3390/su13105460

Trstenjak, M., Mustapić, M., Gregurić, P., & Opetuk, T. (2023). Use of green industry 5.0 technologies in logistics activities. Tehnicki Glasnik, 17(3), 471–477. https://doi.org/10.31803/tg-20230518185836

Trstenjak, M., Opetuk, T., Đukić, G., & Cajner, H. (2022). Logistics 5.0 implementation model based on decision support systems. Sustainability, 14(11). https://doi.org/10.3390/su14116514

Villar, A., Paladini, S., & Buckley, O. (2023). Towards supply chain 5.0: redesigning supply chains as resilient, sustainable, and human-centric systems in a post-pandemic world. Operations Research Forum, 4(3). https://doi.org/10.1007/s43069-023-00234-3

Yun, NY, & Ülkü, MA (2023). Sustainable supply chain risk management in a climate-changed world: review of extant literature, trend analysis, and guiding framework for future research. Sustainability, 15(17). https://doi.org/10.3390/su151713199

Zavala-Alcívar, A., Verdecho, M.-J., & Alfaro-Saiz, J.-J. (2020). Resilient strategies and sustainability in agri-food supply chains in the face of high-risk events. Proceedings, 21, 23–25. https://doi.org/10.1007/978-3

Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 3, pp. 112 – 134, July – September 2024

www.concienciadigital.org

The article published is the sole responsibility of the authors and does not necessarily reflect the thinking of the Revista Conciencia Digital.

Ciencia Digital Editorial

The article remains the property of the journal and, therefore, its partial and/or total publication in another medium must be authorized by the director of the Conciencia Digital Journal.

latindex catálogo

Conciencia Digital

Indexaciones