Environmental Strategies, Differentiation and Competitive Advantage in Aquaculture: A Bibliometric Analysis

Alexander Gómez Ruz[1], Lissette Gabriela Maldonado Niño[2], Derly Caterine Rodríguez Munévar[3]

[1] Universidad Simón Bolívar, Barranquilla, Colombia Email: alexander.ruz@unisimon.edu.co

[2] Universidad Simón Bolívar, Barranquilla, Colombia Email: lissette.maldonad@unisimon.edu.co

[3] Docente Investigadora – Área Disciplinar Contable, Financiera y Gestión Programa de Contaduría Pública Universidad Pedagógica y Tecnológica de Colombia (UPTC), Facultad Seccional Sogamoso, Colombia Grupo de Investigación GEOS Email: derlycaterine.rodriguez@uptc.edu.co ORCID: https://orcid.org/0009-0007-6757-2969

Abstract

The relationship between environmental strategies, differentiation and competitive advantage in aquaculture has been addressed from lines of research on certification, traceability, standards, value chains, innovation, access to markets and environmental assessment. However, this knowledge is distributed among subfields that are not always read in an integrated way. This study analyzes the structure and evolution of scientific production on this intersection through a bibliometric analysis based on Scopus. The corpus was composed of 85 documents published between 2006 and 2026, selected using thematic, documentary and metadata inclusion criteria, with manual review of relevance. The descriptive analysis was performed with Bibliometrix/Biblioshiny, while VOSviewer was used to build networks of co-occurrence, co-authorship, cocitation and bibliographic coupling. The results show a gradual growth production, with greater accumulation in recent years and with 2026 as a partial period. Aquaculture was the source with the largest presence, followed by magazines associated with sustainability, marine policy and aquatic production systems. The co-occurrence network identified five thematic areas: governance, certification and trade; digital innovation and food chains; sustainability and value chains; market, traceability and aquaculture production; and environmental assessment. The intellectual structure showed shared referents and a segmented documentary organization, with 61 cited authors connected in seven clusters and 80 documents coupled in 13 clusters. The results indicate that environmental strategies can support differentiation and competitive positioning when articulated with governance, traceability, verifiable metrics, productive capacities and market recognition. The study provides an integrated bibliometric mapping of a dispersed field and identifies routes for future research on aquaculture chains, certification, technology adoption, price transmission and value capture.

Keywords: Aquaculture; environmental strategies; differentiation; competitive advantage; bibliometrics; value chains.

1. Introduction

Aquaculture has gained increasing weight in global food systems, and with that expansion has come sustained pressure for the sector to demonstrate its environmental performance. Certifications, sustainability standards, traceability, impact assessment and value chain management have gone from being niche requirements to conditions of access in higher-value markets. In this scenario, the relationship between environmental strategies, differentiation and competitive advantage becomes a problem of analysis in which adopting environmentally responsible practices does not in itself guarantee that this commitment becomes an attribute recognized by the chain or an advantageous position within the market.

Literature has not ignored this relationship, but has worked on it from relatively independent lines. There is production on certification and governance of standards, on value chains and access to markets, on traceability and digital innovation, on environmental assessment and on buyer behavior. Ababouch et al. (2023) place aquaculture chains in an unequal relationship between production concentrated in developing countries and value demands located in economies with stricter demands, which shows that environmental differentiation is a matter of articulation between production, market and institutional capacities.

From the perspective of value chains, Bush et al. (2019) present aquaculture research as a terrain of multiple actors, scales and configurations, which helps to understand why the link between sustainability, differentiation and competitiveness appears distributed among several lines of work. Nor et al. (2020) illustrate this tension from the seaweed industry in Malaysia, where certification coexists with difficulties in capturing value when intermediation and bargaining power mediate the effects of environmental strategies on commercial positioning. These contributions show that the relationship between sustainability, differentiation and competitiveness has been addressed from several lines of research, although with a still limited articulation between subfields.

The dispersion described makes it difficult to identify patterns, shared referents and areas of convergence between lines that approach the problem from different angles. Bibliometric analysis allows this distribution to be ordered by means of descriptive indicators and bibliometric networks on temporal evolution, editorial structure, scientific collaboration, thematic co-occurrence, cocitation and bibliographic coupling. Its scope focuses on showing how the knowledge produced on the subject is organized, without estimating economic effects or establishing causal relationships.

This article analyzes the structure and evolution of scientific production on environmental strategies, differentiation and competitive advantage in aquaculture through a bibliometric analysis based on Scopus, with the support of Bibliometrix/Biblioshiny and VOSviewer. The study contributes to organizing a literature distributed between sustainability, certification, traceability, value chains, innovation and environmental assessment, in order to identify its thematic cores, its intellectual connections and the areas where the integration of the field is still limited.

2. Materials and methods

2.1. Corpus search, export and selection strategy

This study was developed as a bibliometric analysis of the scientific production on environmental strategies, differentiation and competitive advantage in aquaculture. The scope of the analysis was limited to the corpus recovered using the search strategy defined in Scopus, so the results are interpreted as a bibliometric cartography of the analyzed documentary set.

The search was conducted on Scopus on April 15, 2026. The query was applied to the title, abstract, and keyword fields using TITLE-ABS-KEY. The strategy was structured around four axes of recovery: aquaculture, environmental strategies, differentiation and competitive advantage. The equation used was as follows:

(TITLE-ABS-KEY (aquacultur* AND ((environment* W/2 strateg*) OR (green W/2 strateg*) OR (environmental W/1 innovation) OR eco-innovation OR certification OR traceab* OR ecolabel* OR standard* OR sustainab*) AND (differentiat* OR premium OR value-added OR (product W/2 attribute*) OR brand* OR (market W/2 position*) OR value chain) AND (competitiv* OR (competitive W/1 advantage) OR (market W/2 access) OR export* OR supply chain))) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (LANGUAGE , "English"))

The search was limited to documents published in journals, with a documentary article or review, written in English and classified in the areas of Agricultural and Biological Sciences, Environmental Science, Social Sciences, Economics, Econometrics and Finance, and Business, Management and Accounting. These filters guided the recovery towards scientific literature located at the intersection between aquaculture discussion, sustainability, standards, market, value chains and competitiveness.

The inclusion criteria included documents indexed in Scopus, articles and reviews published in journals, texts in English, records located in the selected areas, works linking aquaculture with environmental strategies, sustainability, certification, traceability, standards, differentiation, product attributes, added value, positioning, value chains, competitiveness, market access, export or supply chains, and records with metadata sufficient for bibliometric processing. Documents other than article or review, records from sources other than journals, texts in languages other than English, works located outside the selected areas, documents without thematic correspondence with the objective of the study after the revision of title, abstract and keywords, and records with inconsistencies that prevented their processing were excluded.

The records retrieved by searching in Scopus were exported in CSV format, incorporating bibliographic information, abstracts, keywords, citations, and cited references. Subsequently, the records were manually reviewed using a control matrix, in which title, abstract, keywords, document type, source and thematic correspondence were contrasted with the objective of the study. This review made it possible to remove documents recovered by the equation that did not fit the thematic scope of the analysis. After this review and selection process, the final corpus was composed of 85 documents published between 2006 and 2026.

2.2. Preparation of data for bibliometric analysis

Once the final corpus of 85 documents was formed, the data were organized for reading in Bibliometrix, Biblioshiny and VOSviewer. This preparation included the review of bibliographic consistency and the verification of compatibility of the fields required by the analysis tools. During this stage, the bibliographic fields necessary for the analysis were reviewed, including DOI, titles, document type, authorship, keywords and cited references. This review sought to reduce duplication by DOI or title, harmonize minor variants in metadata, and favor a consistent reading of bibliometric results. In the authorship indicators, it was taken into account that Biblioshiny can present abbreviated names, while VOSviewer allows working with complete forms.

Terminological standardization was applied exclusively to author keywords using a thesaurus developed for this study, which allowed lexical variants to be grouped and reduced the dispersion of equivalent terms in the co-occurrence network, which depends directly on the way in which the authors name the research topics. On the other hand, the maps of cocitation, co-authorship and bibliographic coupling were constructed without thesaurus, since in these networks it was in the interest of preserving the original structure of bibliographic relationships.

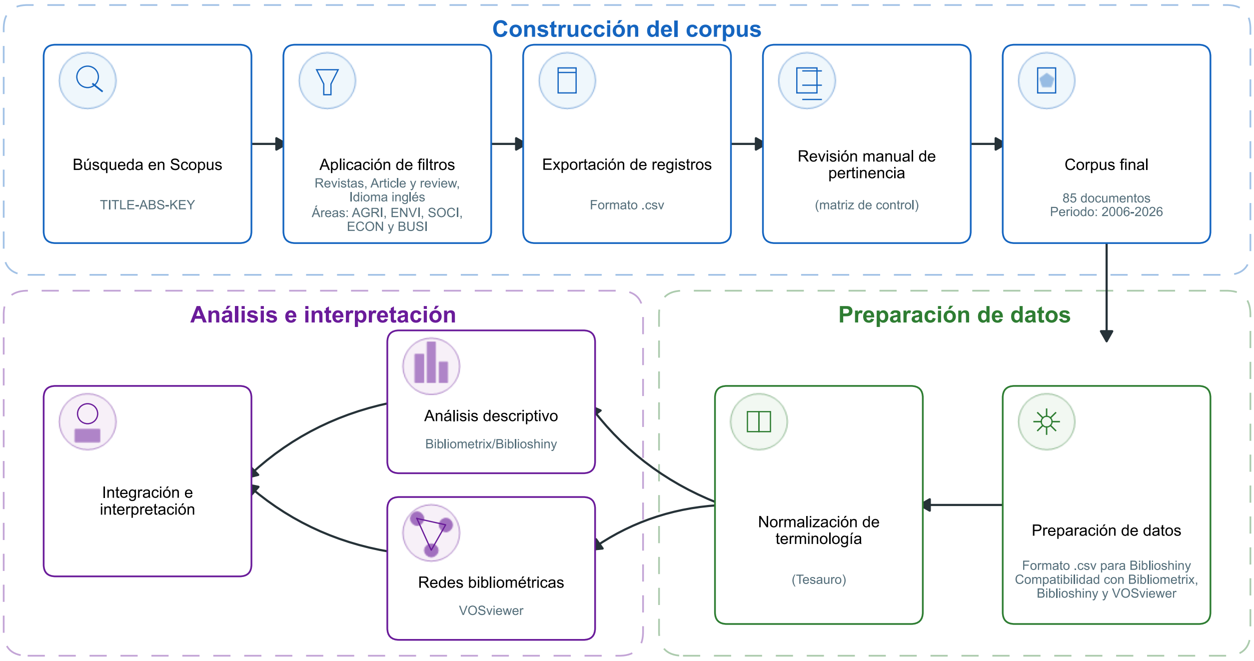
2.3. Bibliometric analysis and network visualization

The descriptive analysis was performed with Bibliometrix and its Biblioshiny interface in R to examine the general composition of the corpus using indicators of annual production, sources with greater presence, authors with greater production, documents with greater global citation, scientific production by country and frequency of author keywords. Before generating these indicators, the integrity of the metadata was reviewed to identify incomplete fields that could affect bibliometric reading.

The construction and visualization of bibliometric networks was performed in VOSviewer from the metadata prepared from the final corpus. The analysis included maps of co-occurrence, cocitation, co-authorship and bibliographic coupling between the units analyzed. In the differentiation between co-occurrence as thematic reading and cocitation as intellectual reading, Rejeb et al. (2025) was taken as a specific reference, for their application of both procedures in a bibliometric analysis on aquaculture. Mondal (2026) allows us to locate this distinction within a workflow in which Biblioshiny was used to organize the corpus and obtain descriptive indicators, while VOSviewer was oriented to the relational examination of the documentary set.

In Biblioshiny, the output corresponding to Author Keywords or DE was used for the frequency of words, in order to maintain correspondence with the thematic map built in VOSviewer. The scientific production by country obtained in Biblioshiny was interpreted as a descriptive indicator, while the co-authorship networks by countries and authors elaborated in VOSviewer were read as scientific collaboration relationships, since both outputs respond to different bibliometric logics. Figure 1 summarizes the methodological flow followed for the construction of the corpus, the preparation of the data and the bibliometric analysis.

Figure 1. Methodological flow of bibliometric analysis



Nota. CSV = comma-separated values; TITLE-ABS-KEY = title, abstract and keywords; AGRI = Agricultural and Biological Sciences; ENVI = Environmental Science; SOCI = Social Sciences; ECON = Economics, Econometrics and Finance; BUSI = Business, Management and Accounting.

VOSviewer maps were configured using full count. The thresholds of occurrence and citation were established according to the size of the corpus and the distribution of the units analyzed, in order to work on bibliographic relationships with sufficient recurrence within the documentary set. The bibliographic variants detected in the cited references were harmonized before constructing the corresponding map, in order to reduce the artificial fragmentation of nodes. Table 1 summarizes the parameters applied.

Table 1. Bibliometric network parameters used in VOSviewer

Network	**Unit of analysis**	**Counting method**	**Threshold**	**Thesaurus**	**Connected Component**
Co-occurrence	Author Keywords	Full counting	2 occurrences	Yes	Not applicable
Cocitation	Cited references	Full counting	3 quotes	No	Not applicable
Cocitation	Cited authors	Full counting	6 quotes	No	Yes
Co-authorship	Countries	Full counting	2 documents and 0 citations	No	Yes
Co-authorship	Authors	Full counting	2 documents and 0 citations	No	No
Bibliographic coupling	Documents	Full counting	0 quotes	No	Yes

Note. The descriptive analysis was executed in R 4.5.3 using Bibliometrix 5.3.0 and Biblioshiny, in RStudio Desktop 2026.4.0.526. Shiny 1.13.0 served as support for the Biblioshiny interface. Bibliometric networks were built in VOSviewer 1.6.20.

The interpretation articulated the descriptive indicators, the bibliometric networks and the reading of the included documents. This strategy made it possible to relate the temporal evolution of the corpus, its distribution by sources, authors and countries, and the thematic and intellectual groupings observed in the maps. The clusters were read as groupings constructed from the bibliometric relationships of the corpus analyzed. Therefore, its interpretation was carried out together with the reading of the documents and descriptive indicators, and not as a complete representation of the field.

3. Results

The results are presented in six blocks: First, the general composition and temporal evolution of the corpus are described; then the sources, authors and documents with greater visibility are reported. Geographical distribution, scientific collaboration, thematic structure through author keywords and intellectual structure through bibliographic coupling and coupling are then examined. The section ends with a synthesis of the bibliometric patterns observed.

3.1. General composition and temporal evolution of the corpus

The corpus analyzed comprises 85 documents published between 2006 and 2026, retrieved in Scopus. The time window allows us to observe a scientific production of gradual development, with low initial accumulation and a greater presence of publications in recent years.

Table 2 summarizes the general information of the corpus. Research articles predominate, with 65 papers, compared to 20 reviews. The 46 sources recorded show a wide editorial distribution, without exclusive concentration in a single journal or publication channel.

Table 2. Corpus Overview

Indicator	Result
Period analyzed	2006-2026
Documents included	85
Articles	65
Reviews	20
Sources	46
Authors	397
References	5999
Annual growth	8.38 %
Average citations per document	22.28
International co-authorship	45.88 %
Co-authors per paper	4.95

Note. The table summarizes the general descriptive indicators of the bibliometric corpus. The year 2026 corresponds to a partial period.

The corpus brings together 397 authors, with an average of 4.95 co-authors per document, reflecting a predominantly collaborative production. International co-authorship reaches 45.88%, an indicator of a visible presence of collaboration between countries within the documentary collection.

The documents included accumulate 5999 references and register an average of 22.28 citations per document. This value should be interpreted as an aggregate indicator, since it may be influenced by older documents or by works with greater relative visibility within the corpus. Figure 2 presents the annual evolution of scientific production:

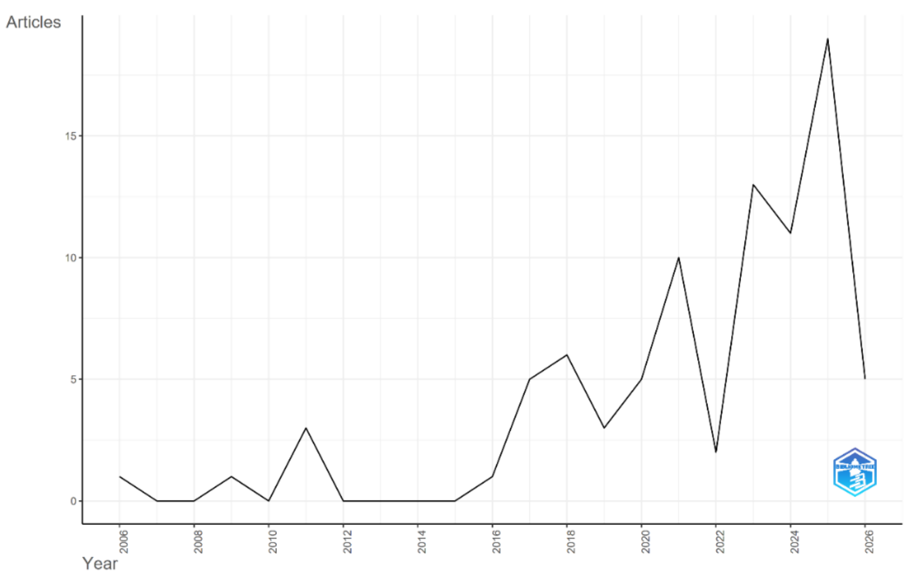


Figure 2. Annual evolution of the scientific production of the corpus

Note. The figure presents the number of documents published per year within the corpus analyzed. The year 2026 corresponds to a partial period and should be interpreted with caution.

The time trajectory shows limited initial production and subsequent expansion, with greater accumulation in the recent stage. The annual growth of 8.38% summarizes this general trend, although the distribution by year shows that the increase was not uniform throughout the period.

3.2. Sources, authors and documents with greater visibility

The source with the greatest presence in the corpus is Aquaculture, with 16 documents, followed by Sustainability (Switzerland), with 8, and Journal of the World Aquaculture Society, with 6. Aquaculture and Fisheries and Marine Policy register 4 documents each. Table 3 presents the sources with the largest number of documents and the works with the highest overall citation within the corpus.

Table 3. Main sources and documents with the highest global citation

Result Type	Item	Indicator
Source	Aquaculture	16 documents
Source	Sustainability (Switzerland)	8 documents
Source	Journal of the World Aquaculture Society	6 documents
Source	Aquaculture and Fisheries	4 documents
Source	Marine Policy	4 documents
Document	Rowan et al. (2023), Aquaculture and Fisheries	144 citations
Document	Little et al. (2018), Aquaculture	119 citations
Document	Bush et al. (2019), Aquaculture	108 citations
Document	Kumaran et al. (2021), Aquaculture	92 quotes
Document	Wei et al. (2011), Journal of Applied Ichthyology	91 citations

Note. The table presents the sources with the highest number of documents and the documents with the highest overall citation within the corpus analyzed.

The editorial distribution combines production-oriented journals with sources associated with sustainability, marine policy and sectoral governance. Aquaculture concentrates the largest number of documents and brings together several of the works with the greatest bibliographic circulation, while the other sources listed maintain a presence within the main group.

The five documents with the highest global citation register between 91 and 144 citations. This indicator expresses cumulative visibility within the consulted database and is not equivalent, by itself, to a conceptual hierarchy. The most cited documents cover different lines within the corpus. Rowan et al. (2023) is linked to digital transformation and supply chain; Little et al. (2018) and Bush et al. (2019), with aquaculture value chains; Kumaran et al. (2021), with disruptions in the shrimp chain during the pandemic; and Wei et al. (2011), with production, strategies, labeling, added value and industrial chain in sturgeon. This diversity confirms that the accumulated citation is distributed among productive, organizational, commercial and technological problems.

As for the authors with the highest production, the bibliometric processing identifies Little, Nielsen, Young and Zhang with three documents. Two documents include, among others, Ahmed, Alam, Bush, Han, Haque, Hossain, Hou, Hudson, Islam, Jia, Liu, Ma, Newton, Rust and Stead. Since Biblioshiny can present abbreviated names, these records are reported as a descriptive indicator of authorial presence within the corpus, without attributing to them a hierarchy of influence.

3.3. Geographical distribution and scientific collaboration

In scientific production by country, the United States registers the highest frequency, with 38 appearances, followed by China, with 28; Bangladesh, with 22; Indonesia, with 21; and the United Kingdom, with 19. Australia, Italy, France, Norway, Canada, Germany, Ireland and the Netherlands, among other countries are also listed less frequently. The distribution by country describes documentary presence in the corpus, while the co-authorship network examines jointly signed documents; For that reason, a country's position in the descriptive count does not necessarily coincide with its location in the collaboration structure. Figure 3 shows the co-authorship network by country constructed from the corpus analyzed.

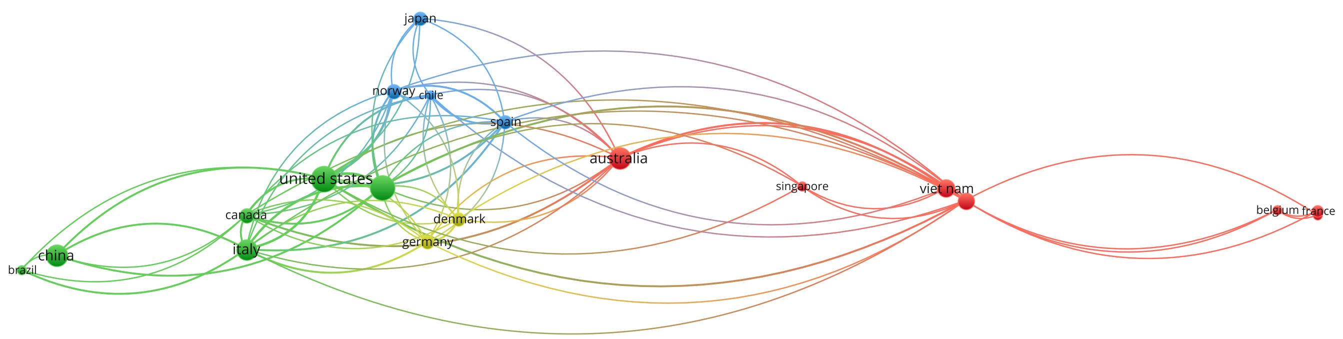


Figure 3. Network of co-authorship by country in the corpus analyzed

Note. The figure shows the co-authorship relationships between countries within the corpus. The network was built with a country analysis unit, complete count, minimum threshold of two documents and zero citations. The map presents 19 countries in the largest connected component, organized into four clusters.

The co-authoring network by country includes 19 countries in the largest connected component, grouped into four clusters. Collaboration is concentrated in a few nodes and presents an unequal distribution of links between the countries represented. The four clusters indicate differentiated collaborative groupings within the corpus, whose reading is limited to the bibliometric associations derived from the observed co-authorship. Co-authorship by authors registers 18 authors in six clusters, with a greater component of five authors. These results show small groupings within the authorial network and limit collaboration to specific groups of the corpus.

3.4. Thematic structure using author keywords

Table 4 presents the author keywords with four or more occurrences in the corpus. The most frequent terms are aquaculture (27) and sustainability (19), followed by supply chain and value chain, with 10 occurrences each. At a second level appear food security, Bangladesh, blockchain, governance and seafood, between 5 and 6 occurrences, along with environmental impact, fisheries, life cycle assessment and value chain analysis, with 4 occurrences. With three occurrences, certification, traceability and trade, terms linked to the axes of the study, are registered.

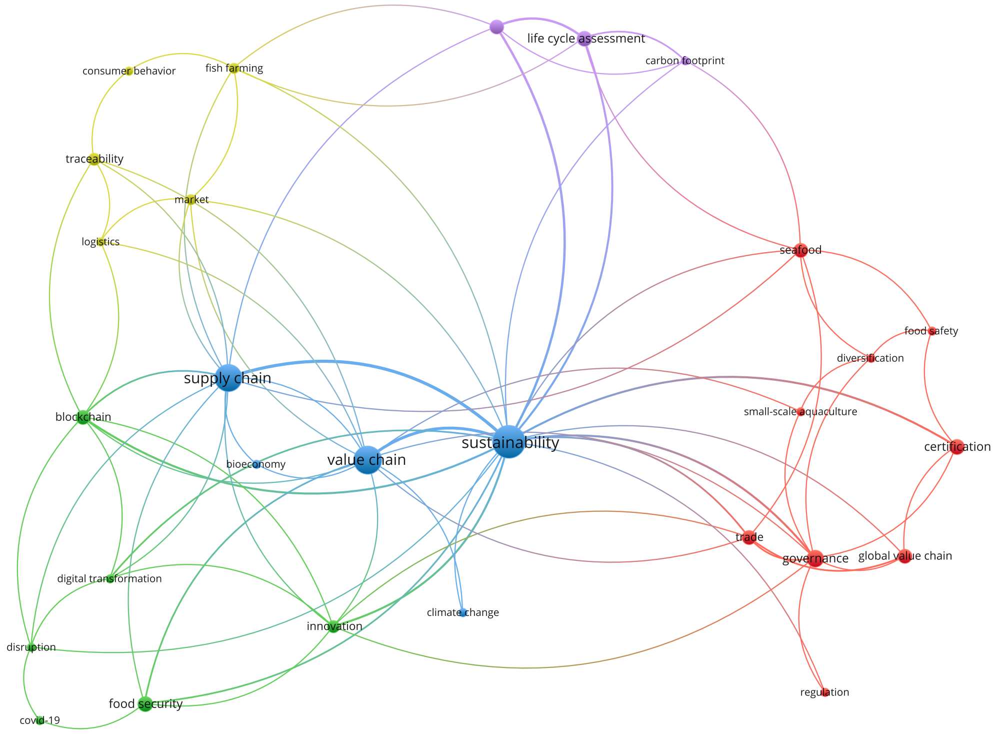
Table 4. Author keywords with four or more occurrences

Author keyword	Occurrences
aquaculture	27
sustainability	19
supply chain	10
value chain	10
food security	6
bangladesh	5
blockchain	5
governance	5
Seafood	5
environmental impact	4
fisheries	4
life cycle assessment	4
value chain analysis	4

***Note*.** The table presents the author keywords with four or more occurrences in the analyzed corpus.

The frequency distribution combines vocabulary from the aquaculture sector with terms associated with productive organization, value chains and environmental management. To observe the relationship between these terms, Figure 4 presents the co-occurrence network constructed from the author keywords.

Figure 4. Co-occurrence of author keywords in the analyzed corpus



Note. The figure presents the co-occurrence network built with Author Keywords. The analysis corresponds to co-occurrence, complete count, minimum threshold of two occurrences and thesaurus applied. The network contains 28 nodes distributed in five clusters.

The first grouping can be understood as a governance, certification and trade area, made up of certification, food safety, global value chain, governance, regulation, seafood, small-scale aquaculture and trade. In this block, relationships are organized around global chains, regulation and commercial circulation of aquaculture products. Governance records high binding strength within the cluster.

The second zone brings together blockchain, covid-19, digital transformation, disruption, food security and innovation. Due to its composition, the cluster is associated with digital innovation and food chains, especially due to the joint presence of digital transformation, disruption, food safety and innovation.

In the third cluster, bioeconomy, climate change, supply chain, sustainability and value chain articulate a sustainability and value chain zone. Sustainability appears as the largest node with the greatest link strength, while value chain and supply chain occupy visible positions within the same grouping. The fourth grouping connects consumer behavior, fish farming, logistics, market and traceability. The designation market, traceability and aquaculture production allows the link between circulation, product tracking, consumer behaviour and production to be collected. Traceability appears both in the descriptive frequency and in the co-occurrence network.

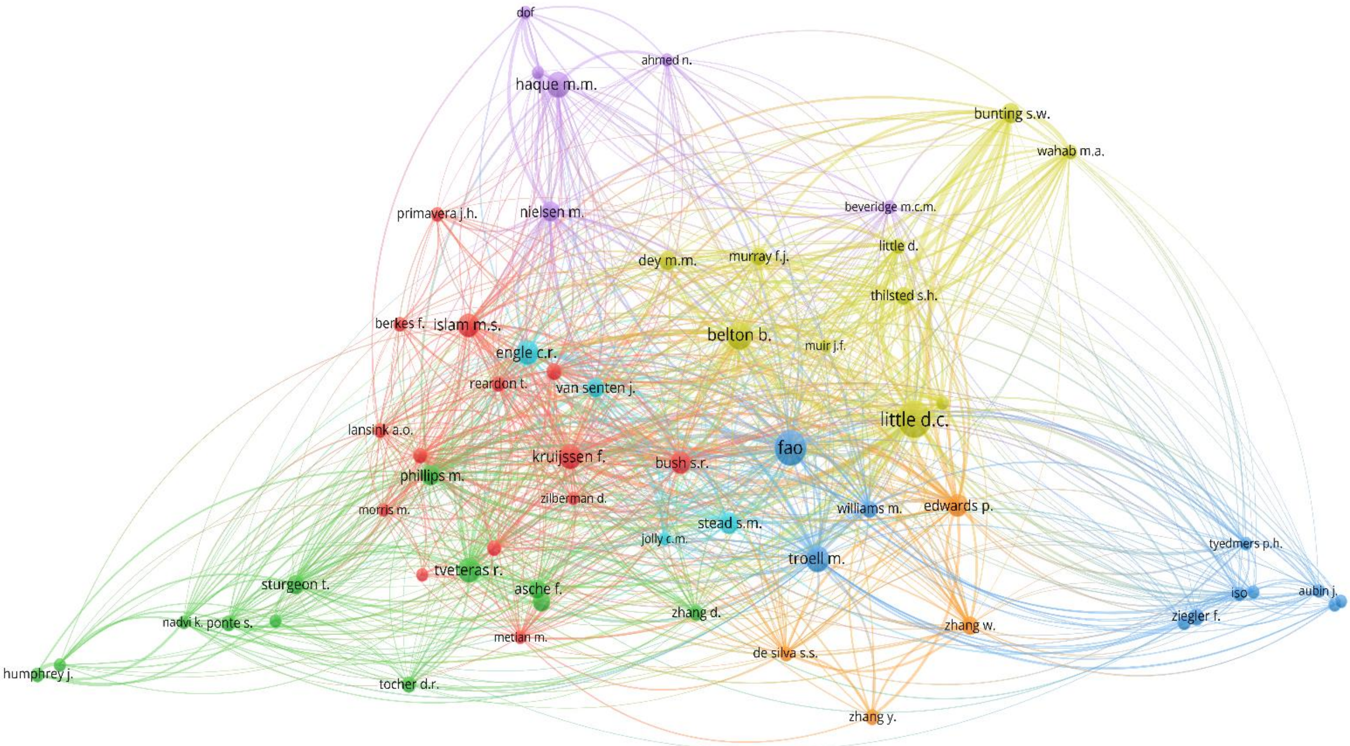
The last cluster, made up of carbon footprint, environmental impact and life cycle assessment, concentrates the vocabulary of environmental assessment. Although it has fewer nodes than the other clusters, it brings together terms directly associated with impact measurement and life cycle analysis. The network organizes the thematic structure of the corpus into five zones: governance, certification and trade; digital innovation and food chains; sustainability and value chains; market, traceability and aquaculture production; and environmental assessment. This reading is limited to the patterns of co-occurrence observed in the author keywords of the corpus.

3.5. Intellectual structure and bibliographic proximity

The intellectual structure of the corpus was examined by cocitation by cited authors, cocitation of cited references, and bibliographic coupling by documents. Each network operates at a different relational level and allows bibliographic connections to be observed within the corpus.

The list of authors identifies researchers and organizations cited jointly in the documents analyzed. The indicator describes proximity between bibliographic references and is distinguished from authorial production, associated with the authorship of the works included in the corpus. Figure 5 presents the cocitation network by the authors cited.

Figure 5. Cocitation by authors cited in the corpus analyzed



Note. The figure presents a cocitation network constructed with authors cited as the unit of analysis, complete count, minimum threshold of six citations and a larger connected component. The network includes 61 connected cited authors and seven clusters.

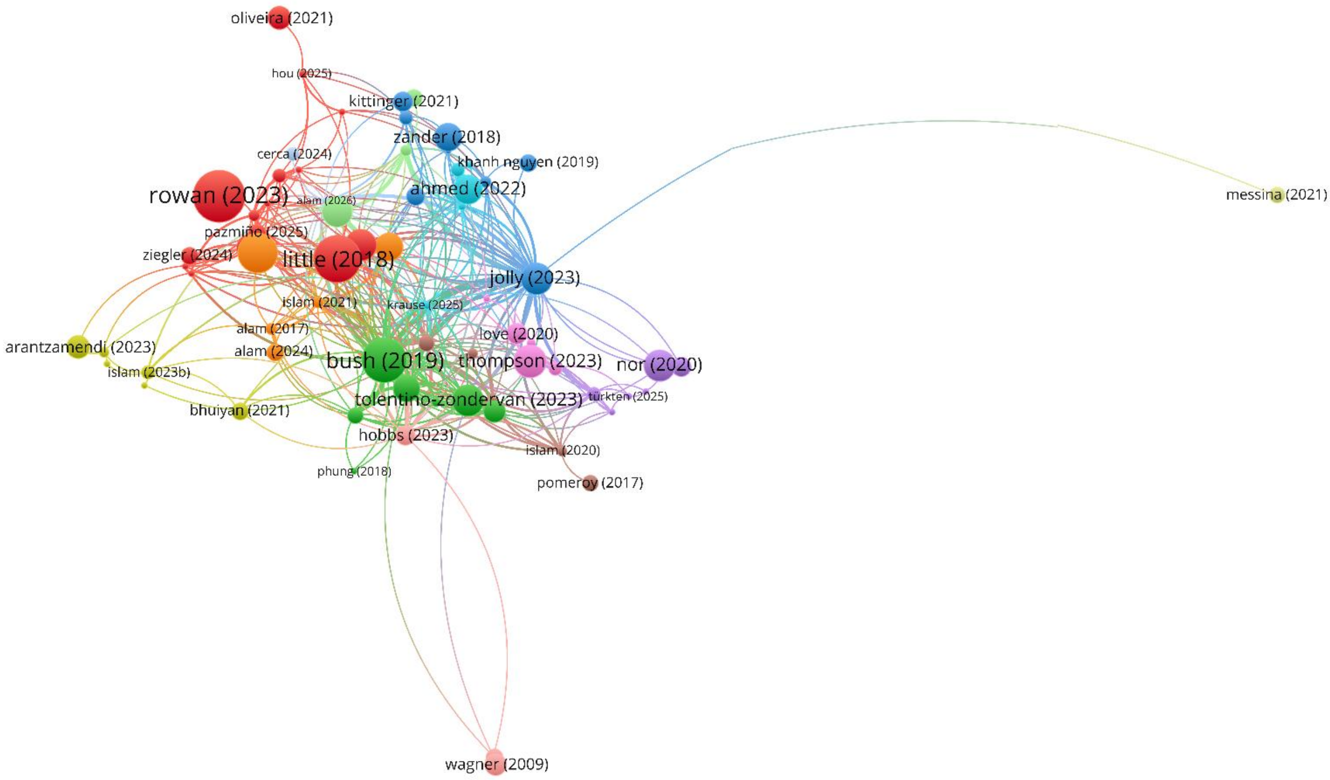
The map shows 61 connected cited authors, distributed in seven clusters. Among the nodes present are Little, Belton, Kruijssen, FAO, Edwards, Bunting, Troell, Bush, Engle and Tveteras, located in different clusters. Some nodes concentrate greater connectivity within the network, while others occupy more peripheral positions. The clusters reflect patterns of joint occurrence in the reference lists and are reported as bibliographic groupings.

The co-citation of cited references operates on a more specific level: it groups together specific documents cited together.

With references cited as a unit of analysis, complete count and minimum threshold of three citations, the network was composed of 27 references after bibliographic harmonization. The result allowed us to identify shared documentary nuclei within the corpus, although it maintained an organization close to that observed in the cocitation by the authors cited.

Bibliographic coupling groups the documents in the corpus according to the similarity of their reference lists. The proximity on the map expresses bibliographic bases shared between included works, without representing direct citation relationships between them. Figure 6 shows the bibliographic coupling network by corpus documents.

Figure 6. Bibliographic coupling by corpus documents



Note. The figure presents a bibliographic coupling network with documents as a unit of analysis, complete count, minimum threshold of zero citations and a larger connected component. The network includes 80 connected documents and 13 clusters.

The 80 documents of the largest connected component are distributed in 13 clusters. This output presents a more segmented organization than the cocitation by cited authors, with documentary groupings of variable size. The distribution into 13 groups indicates that the bibliographic databases shared within the corpus are ordered in several areas of documentary proximity, with some documents located in less connected positions on the map.

3.6. Synthesis of bibliometric patterns

The results show a recent growth corpus, distributed among sources specialized in aquaculture, sustainability, marine policy and aquatic production systems. The temporal evolution indicates a greater accumulation of documents in recent years, while editorial distribution and production by country show that the theme has been developed in a wide network of journals, authors and national contexts.

The thematic structure allows us to connect this evolution with the dominant contents of the corpus. The author's keywords organize the field into five zones: governance, certification, and trade; digital innovation and food chains; sustainability and value chains; market, traceability and aquaculture production; and environmental assessment. These zones show that the relationship between environmental strategies, differentiation and competitive advantage is not concentrated in a single vocabulary, but distributed among certification, traceability, chains, market, innovation and environmental measurement mechanisms.

The intellectual structure allows us to observe shared references and common bibliographic bases. The citation by cited authors identifies authors cited in a close manner by the included documents, while the bibliographic coupling shows groupings constructed from common references between documents in the corpus. These results indicate that the documents have points of convergence, although it maintains a segmented organization between thematic and documentary lines.

4. Discussion

Scientific production on environmental strategies, differentiation and competitive advantage in aquaculture does not configure a field of clear borders, although neither can it be read as a disjointed accumulation of publications. The corpus analyzed, composed of 85 documents published between 2006 and 2026, shows an area of progressive configuration whose activity has been concentrated in recent years. The annual growth of 8.38% reflects this trend, although the distribution by year was not uniform throughout the period. The 2026 figure corresponds to a partial year and should be maintained as an open value within that trajectory.

The editorial distribution indicates that the corpus is located in a crossroads between productive management, chain organization, environmental regulation and access to markets. Aquaculture concentrates the largest documentary presence, which places the technical and productive discussion as the visible basis of the whole. The participation of Sustainability (Switzerland), Marine Policy and Aquaculture and Fisheries extends this register to sectoral governance, environmental policy and management of production systems. The documents are located in a space where environmental strategies, differentiation and competitive positioning cannot be addressed from a single discipline or from a single research tradition.

The works with the highest global citation within the corpus, including Little et al. (2018), Bush et al. (2019) and Kumaran et al. (2021), concentrate accumulated visibility within the analyzed database. This visibility guides the reading of the corpus as bibliometric data, but it does not in itself equate to a conceptual hierarchy nor does it directly express the contents that each work develops.

The gap that this study addresses is located in the dispersion of this knowledge. Certification, traceability, environmental assessment, market access, value chains and buyer behaviour have been addressed by specific lines within the aquaculture literature, but their articulation is not always visible when each line moves independently. A work on standards can follow a different route than one on prices in export chains; An environmental impact assessment can be removed from the discussion of product attributes and commercial differentiation. The keyword co-occurrence network, organized into five zones: governance, certification and trade; digital innovation and food chains; sustainability and value chains; market, traceability and aquaculture production; and environmental assessment, makes this distribution visible. The zones have internal density, but their articulation with each other varies according to the grouping.

Bibliometric mapping allows these areas to be read as parts of the same analytical intersection. By bringing together temporal evolution, editorial distribution, scientific collaboration, co-occurrence, cocitation and bibliographic coupling, the study organizes a field that shows recognizable connections, although still segmented between several lines of work. From this base, the discussion advances towards how environmental strategies are articulated through certification, governance and trust mechanisms that condition, without automatically determining, the possibilities of differentiation and competitive positioning in aquaculture.

Within the corpus, certification appears as one of the most visible mechanisms to convert environmental attributes into signals recognizable by buyers, chains and regulators. Its function goes beyond the internal ordering of production practices: it operates as a translation device between environmental commitments and markets that demand sustainability, quality or compliance with standards. This mediation explains why the terms certification, governance, regulation, seafood and trade appear connected in the network of co-occurrence; The documents in the corpus do not treat certification as an isolated seal, but as part of a governance and market architecture.

Certification, however, does not in itself guarantee competitive differentiation. Bush (2018) examines the potential of eco-certification in salmon and shrimp chains and shows that chain coordination, producer capacity, and production risks determine whether certification is adoptable and credible. In chains with more integrated forms of coordination, certification is more likely to be adopted; in chains with looser coordination, their signal is less consistent. Azizah et al. (2020) illustrate this point from shrimp aquaculture in Indonesia, where the adoption of the national eco-certification scheme has been slow despite government push: actors in the chain show divergent perceptions about obstacles, incentives, and expected benefits, indicating that certification operates in a terrain where social negotiation interacts. incentives, productive capacities and technical compliance. Haque et al. (2021) report, when evaluating the compliance of pangasius producers in Bangladesh with the requirements of the Aquaculture Stewardship Council (ASC), an international certification system for responsible aquaculture, that only 35% of the indicators were met at the appropriate level, with the social and environmental dimensions as the most deficient. Environmental differentiation, in this context, depends on structural conditions that many producers do not yet meet.

Governance acts as the ground where those signals are validated or worn down. Jolly et al. (2023) present aquaculture governance as a dynamic field in which institutional frameworks, accountability mechanisms, and stakeholder participation shape the conditions for sustainable growth of the sector. Galappaththi et al. (2016) show, from shrimp cooperatives in Sri Lanka, that the exchange of information between actors can integrate environmental management within supply chain management, provided that functional cooperative structures exist. Governance plays a structuring role, as it delimits the margins within which environmental strategies are viable and the signs of differentiation can be sustained over time.

Traceability extends that argument by connecting verification, trust, and chain coordination. Oliveira et al. (2021) present traceability systems aimed at quality monitoring as coordination tools between links in the fisheries and aquaculture chain, not as isolated administrative records. Senthilkumar et al. (2025) show that technologies such as IoT, artificial intelligence, blockchain, and RFID have potential to improve efficiency, transparency, and food safety in the shellfish chain. Its effective implementation depends, however, on adoption conditions, costs and institutional capacities that are not guaranteed. The fact that these systems appear in the corpus both from the perspective of their possibilities, in Tolentino-Zondervan et al. (2023), and from that of the factors that block their adoption, in Thompson and Rust (2023) indicate that traceability depends on institutional and organizational conditions to be effective, in particular the governance environment and the willingness of the actors to sustain these systems.

The environmental assessment introduces a necessary counterweight in this reading. The grouping of terms such as carbon footprint, environmental impact and life cycle assessment in the co-occurrence network indicates that part of the literature deals with measuring impacts and is not limited to communicating sustainability. Ziegler et al. (2024) show, when analysing emission reduction opportunities in Norwegian salmon farming, that the projected growth of the sector can neutralise the environmental gains achieved. Pazmiño et al. (2025) identify, from a review of life cycle assessments in shrimp and shrimp, methodological variability between studies in functional units, system limits and impact categories, which limits the comparability of the results. These works move the discussion towards a specific methodological requirement, by showing that a differentiation strategy based on sustainability requires verifiable metrics, effective traceability and governance capable of making the attribute to be communicated credible. Without these elements, competitive advantage can be reduced to a commercial statement without technical support.

The adoption of environmental practices, certifications or traceability systems does not guarantee, by itself, access to more demanding markets or positions of greater value within the chain. Environmental differentiation depends on the attribute produced being recognized, transmitted, and valued by buyers, processors, intermediaries, and target markets. This recognition is conditioned by the structure of the chain, the bargaining power of the actors and the ability to convert environmental information into commercial trust.

The corpus literature shows this tension in several productive contexts. Nor et al. (2020) analyse the seaweed value chain in Malaysia and show that producers, despite operating under the MyGAP certification scheme, face difficulties in capturing the value generated: part of the margin remains in the hands of intermediaries, on-farm prices remain low and quality does not always mean better commercial positioning. Saguin (2018), from urban aquaculture chains in the Philippines, reinforces this reading by showing that access to the chain is mediated by social relations and institutions that distribute benefits unequally. Differentiation, therefore, depends on the position occupied by the producer and its links with buyers, processors and regulators.

The transmission of price signals also conditions value capture. Pham et al. (2018) show, for the pangasius export chain in Vietnam, that international prices are transmitted backwards to the producer, although this transmission is not symmetrical nor does it ensure that the incentives associated with environmental standards reach the production link in a stable way. Islam et al. (2023) add that seed quality, training, credit, and supply conditions influence the ability to meet standards and sustain access to more demanding markets. The distance between producing an environmental attribute and capturing value through it usually passes through links that the producer controls in a limited way.

Ababouch et al. (2023) expand on this discussion by placing aquaculture chains in an unequal relationship between production and destination market. Much of the production is concentrated in developing countries, with the presence of small producers, while the demand for higher value is often located in economies with stricter commercial and environmental requirements. In this relationship, environmental attributes can be demanded by external buyers without producers always receiving sufficient incentives to sustain them. Bush et al. (2019) also situate research on aquaculture chains in a field of multiple actors, scales and configurations, which helps to understand why the results of differentiation vary according to the production context.

Digital innovation appears as a possible support for traceability, transparency and coordination, but its effect depends on the conditions of adoption. Rowan (2023) locates the digital transformation in fisheries and aquaculture through technologies such as IoT, artificial intelligence, machine learning, blockchain, cloud-edge computing, and immersive technologies, aimed at improving efficiency, productivity, waste control, and security in the supply chain. Tolentino-Zondervan et al. (2023) show that blockchain in fisheries and aquaculture chains responds mainly to vertical market demands and competitiveness, with still limited uses for horizontal coordination between producers. Thompson and Rust (2025) analyze the adoption of blockchain in seafood chains and point out that its results depend on the ability to integrate the technology into business models and organizational practices. Competitiveness is shaped by the articulation of technology with buyer confidence, compliance with standards, and sustained access to higher-value markets.

Nguyen et al. (2025) examine the competitiveness of the Vietnamese aquaculture chain after the pandemic and show that its determinants include chain, market, regulation, and adaptive capacity factors. This reading coincides with the bibliometric organization of terms such as value chain, supply chain, market, trade and competitiveness. Competitive advantage appears, then, as a possibility conditioned by the convergence between verifiable environmental attributes, chain coordination, productive capacities, market signals and institutional support.

The intellectual structure of the corpus, examined by cocitation by cited authors, cocitation of references and bibliographic coupling, allows the thematic vocabulary to be contrasted with the shared bibliographic bases. While co-occurrence describes how the documents of the corpus organize their thematic vocabulary, the networks of cocitation and coupling show which referents they share proximity to and what bibliographic bases they have in common. These two perspectives point in the same direction, as the field shows recognizable connections, although it does not yet configure a fully integrated conversation.

The network of cocitation by cited authors brings together 61 connected authors distributed in seven clusters. Among the nodes present are references from different aquaculture research traditions, associated with value chains, governance, nutrition and production. The fact that these referents appear grouped together on the network does not mean that their positions are equivalent or that the corpus has worked on them in a homogeneous way; it means that the documents included cite them in a close manner, which indicates areas of intellectual convergence within the whole. The more specific cocitation of cited references groups together 27 documents cited together and allows us to observe shared documentary nuclei. Due to its smaller size, it offers a more limited reading compared to the network of cited authors.

Bibliographic coupling allows us to observe another dimension of intellectual structure, by grouping the included documents according to the similarity of their reference lists. The 80 documents of the largest connected component are distributed in 13 clusters, which indicates a more segmented organization than that observed in the author collection. This segmentation does not contradict the existence of the field; shows that the documents that compose it have built their arguments from partially different bibliographic bases. This pattern is consistent with an area developed through relatively autonomous lines on certification, value chains, traceability, market, innovation and environmental assessment.

This structure confirms the gap that motivated the study. The literature on environmental strategies, differentiation and competitive advantage in aquaculture was not absent, but it was distributed among subfields that share references without having yet built an integrated conversation. Bibliometric mapping makes this distribution visible and shows where the areas of greatest density are located and where less articulated spaces persist.

The analysis has limits that must be kept in mind. The corpus was constructed from a search equation applied in Scopus, which circumscribes the results to the coverage and indexing criteria of that database. The thresholds defined for bibliometric networks determined which nodes and connections were visible and which were left out. The author keywords, on which the co-occurrence network was built, depend on the terminological decisions of the authors themselves and do not always capture all the topics addressed. The year 2026 provides partial records that do not allow a closed reading of the trend for that period. These limits limit the interpretative scope of the results.

The analysis offers an integrated bibliometric cartography of a dispersed field, identifying its thematic nuclei, its shared referents and its areas of less articulation. On this basis, the conclusions section can specify the contribution of the study, its operational limits and the routes that future research could follow to advance towards a greater integration of the lines that appear here connected, although still distributed.

5. Conclusions

This bibliometric analysis mapped the structure and evolution of scientific production on environmental strategies, differentiation and competitive advantage in aquaculture. The corpus of 85 documents published between 2006 and 2026 shows a gradual trajectory, with greater accumulation in recent years and with 2026 treated as a partial period. The results indicate that this area of research is not organized around a single disciplinary line, but at the intersection between aquaculture production, sustainability, governance, value chains, access to markets, traceability, innovation and environmental assessment.

The study addresses a dispersed body of knowledge, not an absent literature. The co-occurrence network shows that certification, trade, governance, food safety, blockchain, supply chains, value chains, traceability, market, carbon footprint and life cycle assessment form differentiated but connected thematic zones. This configuration supports the contribution of the article, by ordering the bibliometric relationships between topics that have been examined through separate lines of inquiry, despite their common link with environmental differentiation and competitive positioning in aquaculture.

The findings also indicate that environmental strategies do not automatically translate into competitive advantage. Certification, traceability, environmental metrics, and digital tools can support differentiation when connected to governance arrangements, productive capacities, credible verification mechanisms, coordination between actors in the chain, and recognition by buyers or markets. From this perspective, competitive advantage appears in the literature as a conditioned possibility, not as a direct effect demonstrated by bibliometric design.

This study presents methodological limits of bibliometric design. The corpus was constructed from a search equation applied in Scopus, so the findings correspond to the coverage, indexing criteria and metadata available in that database. The selected document types and the language filter influenced the composition of the corpus. The co-occurrence network was elaborated from author keywords, and the thresholds defined in VOSviewer determined the nodes and links represented in the maps. The year 2026 was included as available production until the date of search, so it is interpreted as a partial period and not as a closed year. Future research could complement this bibliometric mapping with empirical analyses on aquaculture value chains, certification adoption, producer capacities, digital traceability, price transmission and value capture. This expansion would make it possible to study, with field data or economic information, under what conditions environmental attributes are recognized by actors in the chain and can be associated with differentiation or competitive positioning.

References

1. Ababouch, L., Nguyen, K. A. T., Castro de Souza, M., & Fernandez-Polanco, J. (2023). Value chains and market access for aquaculture products. *Journal of the World Aquaculture Society, 54*(2), 527-553. https://doi.org/10.1111/jwas.12964
2. Aria, M., & Cuccurullo, C. (2026). *bibliometrix: Comprehensive science mapping analysis* (Version 5.3.0) [R package]. CRAN. https://cran.r-project.org/package=bibliometrix
3. Azizah, F. F. N., Ishihara, H., Zabala, A., Sakai, Y., Suantika, G., & Yagi, N. (2020). Diverse perceptions on eco-certification for shrimp aquaculture in Indonesia. *Sustainability, 12*(22), 9387. https://doi.org/10.3390/su12229387
4. Bush, S. R. (2018). Understanding the potential of eco-certification in salmon and shrimp aquaculture value chains. *Aquaculture, 493*, 376-383. https://doi.org/10.1016/j.aquaculture.2017.07.027
5. Bush, S. R., Belton, B., Little, D. C., & Islam, M. S. (2019). Emerging trends in aquaculture value chain research. *Aquaculture, 498*, 428-434. https://doi.org/10.1016/j.aquaculture.2018.08.077

6. Chang, W., Cheng, J., Allaire, J. J., Sievert, C., Schloerke, B., Aden-Buie, G., Xie, Y., Allen, J., McPherson, J., Dipert, A., & Borges, B. (2026). *shiny: Web application framework for R* (Version 1.13.0) [R package]. CRAN. https://cran.r-project.org/package=shiny
7. Galappaththi, E. K., Kodithuwakku, S. S., & Galappaththi, I. M. (2016). Can environment management integrate into supply chain management? Information sharing via shrimp aquaculture cooperatives in northwestern Sri Lanka. *Marine Policy, 68*, 187-194. https://doi.org/10.1016/j.marpol.2016.03.013
8. Haque, M. M., Alam, M. M., Hoque, M. S., Hasan, N. A., Nielsen, M., Hossain, M. I., & Frederiksen, M. (2021). Can Bangladeshi pangasius farmers comply with the requirements of aquaculture certification? *Aquaculture Reports, 21*, 100811. https://doi.org/10.1016/j.aqrep.2021.100811
9. Islam, M. R., Olowe, O. S., Mely, S. S., Hossain, M. A., Das, M., & Zaman, M. F. U. (2023). Review of the current situation, problems, and challenges in fish seed production and supply for Bangladesh's aquaculture development. *Aquatic Living Resources, 36*, 32. https://doi.org/10.1051/alr/2023028
10. Jolly, C. M., Nyandat, B., Yang, Z., Ridler, N., Matias, F., Zhang, Z., Murekezi, P., & Menezes, A. (2023). Dynamics of aquaculture governance. *Journal of the World Aquaculture Society, 54*(2), 427-481. https://doi.org/10.1111/jwas.12967
11. Kumaran, M., Geetha, R., Antony, J., Vasagam, K. P. K., Anand, P. R., Ravisankar, T., Angel, J. R. J., De, D., Muralidhar, M., Patil, P. K., & Vijayan, K. K. (2021). Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India: A sectoral assessment. *Aquaculture, 531*, 735922. https://doi.org/10.1016/j.aquaculture.2020.735922
12. Little, D. C., Young, J. A., Zhang, W., Newton, R. W., Al Mamun, A., & Murray, F. J. (2018). Sustainable intensification of aquaculture value chains between Asia and Europe: A framework for understanding impacts and challenges. *Aquaculture, 493*, 338-354. https://doi.org/10.1016/j.aquaculture.2017.12.033
13. Mondal, H. (2026). A technical note on bibliometric analysis by Biblioshiny and VOSviewer. *Indian Journal of Radiology and Imaging, 36*(2), 167-174. https://doi.org/10.1055/s-0045-1810060
14. Nguyen, T.-T., Pham, C. M., Thai, V. V., Tan, J. Y., Pham, H.-V., & Thi, T. H. T. (2025). How has the aquaculture supply chain's competitiveness changed after the COVID-19 pandemic in emerging countries? The case of Vietnam. *Sustainability, 17*(4), 1451. https://doi.org/10.3390/su17041451
15. Nor, A. M., Gray, T. S., Caldwell, G. S., & Stead, S. M. (2020). A value chain analysis of Malaysia's seaweed industry. *Journal of Applied Phycology, 32*, 2161-2171. https://doi.org/10.1007/s10811-019-02004-3
16. Oliveira, J., Lima, J. E., da Silva, D., Kuprych, V., Faria, P. M., Teixeira, C., Ferreira Cruz, E., & Rosado da Cruz, A. M. (2021). Traceability system for quality monitoring in the fishery and aquaculture value chain. *Journal of Agriculture and Food Research, 5*, 100169. https://doi.org/10.1016/j.jafr.2021.100169
17. Pazmiño, M. L., Chico-Santamarta, L., Boero, A., & Ramirez, A. D. (2025). Environmental life cycle assessment and potential improvement measures in the shrimp and prawn aquaculture sector: A literature review. *Aquaculture and Fisheries, 10*(2), 183-201. https://doi.org/10.1016/j.aaf.2024.06.003
18. Pham, T. A. N., Meuwissen, M. P. M., Le, T. C., Bosma, R. H., Verreth, J., & Lansink, A. O. (2018). Price transmission along the Vietnamese pangasius export chain. *Aquaculture, 493*, 416-423. https://doi.org/10.1016/j.aquaculture.2017.04.028
19. Posit team. (2026). *RStudio: Integrated development environment for R* (Version 2026.4.0.526) [Computer software]. Posit Software, PBC. https://posit.co/
20. R Core Team. (2026). *R: A language and environment for statistical computing* (Version 4.5.3) [Computer software]. R Foundation for Statistical Computing. https://www.r-project.org/
21. Rejeb, A., Rejeb, K., & Keogh, J. G. (2025). The nexus of IoT and aquaculture: A bibliometric analysis. *Applied Food Research, 5*, 100838. https://doi.org/10.1016/j.afres.2025.100838
22. Rowan, N. J. (2023). The role of digital technologies in supporting and improving fishery and aquaculture across the supply chain: Quo Vadis? *Aquaculture and Fisheries, 8*(4), 365-374. https://doi.org/10.1016/j.aaf.2022.06.003
23. Saguin, K. (2018). Mapping access to urban value chains of aquaculture in Laguna Lake, Philippines. *Aquaculture, 493*, 424-435. https://doi.org/10.1016/j.aquaculture.2017.01.030
24. Senthilkumar, T., Panigrahi, S. S., Thirugnanam, N., & Kaushik Raja, B. K. R. (2025). Automation in the shellfish aquaculture sector to ensure sustainability and food security. *AgriEngineering, 7*(11), 387. https://doi.org/10.3390/agriengineering7110387
25. Thompson, B. S., & Rust, S. (2023). Blocking blockchain: Examining the social, cultural, and institutional factors causing innovation resistance to digital technology in seafood supply chains. *Technology in Society, 73*, 102235. https://doi.org/10.1016/j.techsoc.2023.102235
26. Thompson, B. S., & Rust, S. (2025). Sustainable development of seafood supply chains via blockchain technology: Innovation adoption and implementation by businesses and entrepreneurs. *Sustainable Development, 33*(4), 5661-5675. https://doi.org/10.1002/sd.3424
27. Tolentino-Zondervan, F., Ngoc, P. T. A., & Roskam, J. L. (2023). Use cases and future prospects of blockchain applications in global fishery and aquaculture value chains. *Aquaculture, 565*, 739158. https://doi.org/10.1016/j.aquaculture.2022.739158
28. Van Eck, N. J., & Waltman, L. (2023). *VOSviewer manual: Manual for VOSviewer version 1.6.20*. Leiden University. https://www.vosviewer.com/documentation/manual_vosviewer_1.6.20.pdf
29. Wei, Q. W., Zou, Y., Li, P., & Li, L. (2011). Sturgeon aquaculture in China: Progress, strategies and prospects assessed on the basis of nation-wide surveys (2007-2009). *Journal of Applied Ichthyology, 27*(2), 162-168. https://doi.org/10.1111/j.1439-0426.2011.01669.x
30. Ziegler, F., Nistad, A. A., Langeland, M., Wocken, Y., Hognes, E. S., & Mehta, S. (2024). Greenhouse gas emission reduction opportunities for the Norwegian salmon farming sector: Can they outweigh growth? *Aquaculture, 581*, 740431. https://doi.org/10.1016/j.aquaculture.2023.740431